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Study on the selection of waste streams for end-of-waste assessment

Final Report

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PREFACE

On request from the European Commission's DG Environment, IPTS has prepared a package of two reports defining the concept of End-of-waste (EoW) and the waste types suitable for this classification. The present report proposes a list of material streams that, on the basis of a number of filtering conditions, qualify for a thorough assessment on their suitability for the development of end-of-waste criteria. A separate report "End-of-waste Criteria"([1]) presents the detailed methodology and the type of specifications and requirements that one needs to follow when defining end-of-waste criteria.

The present report has been prepared in the period from March 2008 to January 2009 by a group of IPTS staff including Alejandro Villanueva, Luis Delgado, Zheng Luo, Peter Eder, Ana Sofia Catarino and Don Litten (IPTS). The authors would like to acknowledge the insightful comments received from different experts throughout the preparation of the report.

One of the basic data sources for the preparation of the report has been the background information collected in the frame of a project outsourced to a consortium of two partners: Institut für Umweltforschung – INFU (Dortmund, Germany) and Prognos AG (Berlin, Germany). The outsourced project involved specific data research on a number of waste streams candidate for EoW in the EU, covering generation, processing and recycling techniques, economic and market conditions, and related environmental impacts. This background information is presented in Annex I and referenced as INFU/Prognos (2007).

([1]) IPTS (2009) End-of-waste Criteria. Final report. IPTS-JRC. European Commission. Seville, Spain.EUR nr. 23990EN

EXECUTIVE SUMMARY

This report is a contribution to the development and implementation of the concept of End-of-waste (EoW) in EU legislation. The concept was introduced in 2005 by the Thematic strategy on the prevention and recycling of waste([2]), and was adopted by the European Parliament and the Council in 2008 in the revised Waste Framework Directive (WFD)([3]). The revised WFD introduces the possibility that certain waste streams having undergone a recovery operation and fulfilling certain criteria – so-called End-of-waste (EoW) criteria – can cease to be waste.

The purpose of defining end-of-waste criteria is to bring clarity to the interpretation of the definition of waste, as confusion has been repeatedly reported in several material streams traded in the EU. The clarification of the quality and applications of such streams also contributes to create more transparent market conditions, and promotes the recycling of the streams by reducing the consumption of natural resources and the amount of wastes sent for disposal.

This report presents a list of waste streams that are suitable candidates for a detailed assessment of EoW criteria. Suitability has been evaluated through the definition of a set of operational and transparent selection criteria, which are anchored to the vision on increased recycling in the EU outlined in the Thematic Strategy on the prevention and recycling of waste and to the four conditions specified in the Waste Framework Directive (Article 6) for waste streams which can cease to be considered waste, namely:

"(a) the substance or object is commonly used for specific purposes;
(b) a market or demand exists for such a substance or object;
(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts."

Six selection criteria have been derived from these principles, each of the criteria including a number of indicators providing specific information:

([2]) Communication from the Commission to the Council, The European Parliament, The European Economic and Social Committee and the Committee of the Regions. Taking Sustainable use of resources forward: A Thematic Strategy on the prevention and recycling of waste. COM (2005)666 final.

([3]) Directive 2008/98/EC of 19 November 2008 on waste

OPERATIONAL SELECTION CRITERIA PROPOSED

1. No marginal waste stream (amounts & value)
(1.a.) Quantity (tonnes/yr), if available also past and future
(1.b.) Geographical coverage (number of countries)
(1.c.) Market price (€/tonne)
(1.d.) Market value (€/yr)
(1.e.) International trade (tonnes/yr) in/out of the EU

2. Potential for increasing recycling and recovery through better waste management
(2.a.) Current disposal to landfills (tonnes/yr)
(2.b.) Current and best practice collection to recovery/recycling (%), if appropriate specifying the use(s)
(2.c.) Recovery/recycling potential trough better waste management (tonnes/yr and %), estimated against best practice

3. Higher resource substitution: current recycling effectiveness
(3.a.) Raw material substitution in the EU through of reuse/recycling/recovery (tonnes substituted raw material, and % of generated waste material currently substituting raw material)

4. Environmental benefit of recovery/recycling
(4.a.) Energy savings (MJ/tonne and PJ/yr in the EU27)
(4.b.) GHG emission savings (tonne CO2-eq/tonne material and Mtonnes CO2-eq/yr in the EU27)

5. Control of product quality and processing technology
(5.a.) Existence of guidelines or standards for quality/processing of secondary materials, or guidelines or standards for quality/processing of primary materials/products where it can be proven that they are used on secondary materials (exist/non-exist/specify)
(5.b.) Existence of different standards for quality/processing in different EU countries hampering cross-boundary transport (exist/non-exist/specify)

6. Legal compliance
(6.a.) Evidence of conflict in the EU (examples of ECJ cases)
(6.b.) Evidence of conflict in waste definition of international shipments (examples or reported cases)

The indicators proposed are complete in the sense that they address all four elements presented in the FWD, but are heavily conditioned by data availability. Only indicators that were able to provide information from all or most EU27 Member Sates were kept. No weighting has been used to judge whether one or the other is more important for stream selection.

The existence of reliable data at EU level has also conditioned the level of aggregation of the selected material streams. For instance, national data was generally available on *glass*, but not in all countries data was found on its subfractions *flat glass*, *coloured glass*, etc., so the potential use of relevant details on economy, environment, legislation, standards, technology, etc. of each of these subfractions had to be balanced and often sacrificed for the benefit of a complete geographical coverage.

An initial list of about 60 waste streams containing secondary materials was identified through a literature search. Based on an evaluation of data availability, this list has been reduced to a final list of 20 streams. The application of the selection criteria has resulted in a ranking of suitability of these streams as candidates for further EU-wide EoW assessment. Moreover, the ranked list of 20 streams has been split into the following three categories, grouping streams that have common EoW features with regard to the involvement of EoW criteria:

I) Streams that are in line with the basic principles of EoW and suited for further EoW criteria assessment, since there is likely a broad range of benefits to gain from a possible EoW status of the whole stream or of some subtypes of it. The process of preparation of EoW criteria of these streams will require a detailed analysis concerning the environmental, legal, technical, or economic issues of the generation and use of the streams. The category can be further split into:

I.1) Streams used as feedstock in industrial processes, a pathway that most often controls the risks of health and environmental damage via industrial permits. The streams identified in this subcategory are:

- Metal scrap of iron and steel, aluminium, copper
- Plastics
- Paper
- Textiles
- Glass
- Metal scrap of Zinc, Lead, and Tin
- Other metals

I.2) Streams used in applications that imply direct exposure to the environment. In these cases, the EoW criteria to be developed in the further assessment shall probably include limit values for pollutant content or leaching, taking into account any possible adverse environmental and health effects. The streams in this subcategory are:

- C&D waste aggregates
- Ashes and slag
- Biodegradable waste materials stabilised for recycling

II) Streams that may be in line with the EoW principles, however it is not clear in all cases that (a) their current management in the EU takes place via recycling, or (b) that recycling is a priority compared to controlled energy recovery or landfilling in suitable facilities. More detailed information is needed about their subfractions and their available outlets, before they opt for selection. On the basis of the results collected, the waste streams proposed for this category are:

- Solid waste fuels
- Wood
- Waste oil
- Tyres
- Solvents

III) Streams that are not considered appropriate for EoW classification, and are thus rejected. The only stream in this category is:

- Precious metals

EoW assessment is redundant in this case and seems unnecessary, because it is evident from the prices of precious metals that they have a very high value, and only in exceptional circumstances will they voluntarily be discarded. Therefore, they can only seldom be considered and treated as waste.

The materials under Category I are proposed as priority materials for EoW assessment: their composition is known, they are often clean and with low potential risk of environmental and health damage, most have a high intrinsic value, and they are traded in large amounts in the EU in relatively mature markets. Some of these materials are actually being traded as conventional commodities, so the potential effect and benefit of a change to EoW would probably be marginal. However, due to the large flows, recyclables in this category currently traded under imperfect market conditions would have large potential benefits from the application of EoW provisions.

In all cases, it is envisaged that one of the fist tasks of the further individual assessment of the materials towards EoW would be to undertake a refinement of material subcategories. The proposed (heterogeneous) waste streams should be disaggregated, specifying the subcategories with high value recyclables, and identifying low-value subfractions that contain contaminants detrimental to the environment or to further upgrading processing, and which shall not be candidates for EoW.

For some of the initial 60 streams considered, it has not been possible within the scope of this report to obtain enough data or data of sufficient quality to conclude about their suitability for EoW assessment and include them on the list. For instance, spent foundry sand is a stream with a clear identity, a positive market value, and known applications in cement production in Germany, where generation and flows are known. However, it has not been possible to collect data of the stream for the EU27. A list of such streams has been registered in this report, but the assessment of their suitability as EoW candidates is conditioned to the possibility of collecting more data on them.

1 CONTEXT AND OBJECTIVE

In December 2005, the European Commission launched the Thematic Strategy on the prevention and recycling of waste (TSPRW)([4]), which included a proposal for clarification of the definition of waste in the following terms:

"The Waste Framework Directive defines waste as products or materials that are discarded. In the light of extensive stakeholder consultation the Commission has concluded that there is no need substantively to amend the definition of waste, but that it is necessary to clarify when a waste ceases to be a waste (and becomes a new or secondary raw material). Therefore, an amendment to the Directive is proposed which would establish waste-stream-based environmental criteria to determine when a waste ceases to be a waste. This could both improve the environmental performance of recycled products, by encouraging businesses to produce recycled products that conform to these environmental criteria, and reduce unnecessary burdens for low-risk recycling activities."

The amended Waste Framework Directive (WFD)([5]) includes procedures to make possible that waste streams fulfilling certain criteria – so-called End-of-waste (EoW) criteria – can cease to be classified as waste and be instead covered by the legislation concerning non-wastes, be it as a secondary material, a by-product or a product. The Directive (Article 6) sets four conditions under which a waste stream that has undergone a recovery operation can cease to be considered waste:

"(a) the substance or object is commonly used for specific purposes;
(b) a market or demand exists for such a substance or object;
(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts."

The objective of this report, prepared on request from the European Commission's DG Environment, is to propose waste streams which are suitable candidates for a detailed EoW assessment. Suitability has been concluded using a set of operational and transparent selection criteria that reflect the principles and conditions quoted above.

This report provides also detailed information on a number of candidate waste streams in the EU, including generation, processing and recycling techniques, economic and market conditions, and related environmental issues. The major part of the background information, presented in Annex I and referenced as INFU/Prognos (2007), has been collected in the frame of a contracted project by a consortium of two partners: Institut für Umweltforschung – INFU (Dortmund, Germany) and Prognos AG (Berlin, Germany), under supervision by IPTS.

Relationship between waste stream selection and the EoW methodology

This report is part of a package of two reports contributing to create the knowledge base supporting the classification of streams as waste or non-waste. In these studies, IPTS has

([4]) Communication from the Commission to the Council, The European Parliament, The European Economic and Social Committee and the Committee of the Regions. Taking Sustainable use of resources forward: A Thematic Strategy on the prevention and recycling of waste. COM (2005)666 final.

([5]) Directive 2008/98/EC of 19 November 2008 on waste.

developed a general methodology that analyses the principles and proposes a framework for determination of EoW criteria under the WFD. The separate report "End-of-waste Criteria"([6]) presents the methodology, complemented with three pilot case studies.

In order to guarantee a coherent approach in both reports, there is a close conceptual relationship between the waste selection criteria here presented and the EoW criteria that are developed in the methodology report. The main relationship is that both studies use as point of departure the principles laid out in the WFD, combined with the recycling objectives addressed in the Thematic Strategy on the prevention and recycling of waste. In both reports, the term *criteria* is used, but with different meanings: in the present report, the term *selection criteria* is used to define the filtering conditions for the selection of candidate waste streams. In the methodology report "End-of-waste Criteria", the term *end-of-waste criteria* is used to define the specifications that a candidate waste stream has to fulfil in order to leave the waste domain. An illustration of the relationship between the waste selection and the methodology is given in Figure 1.

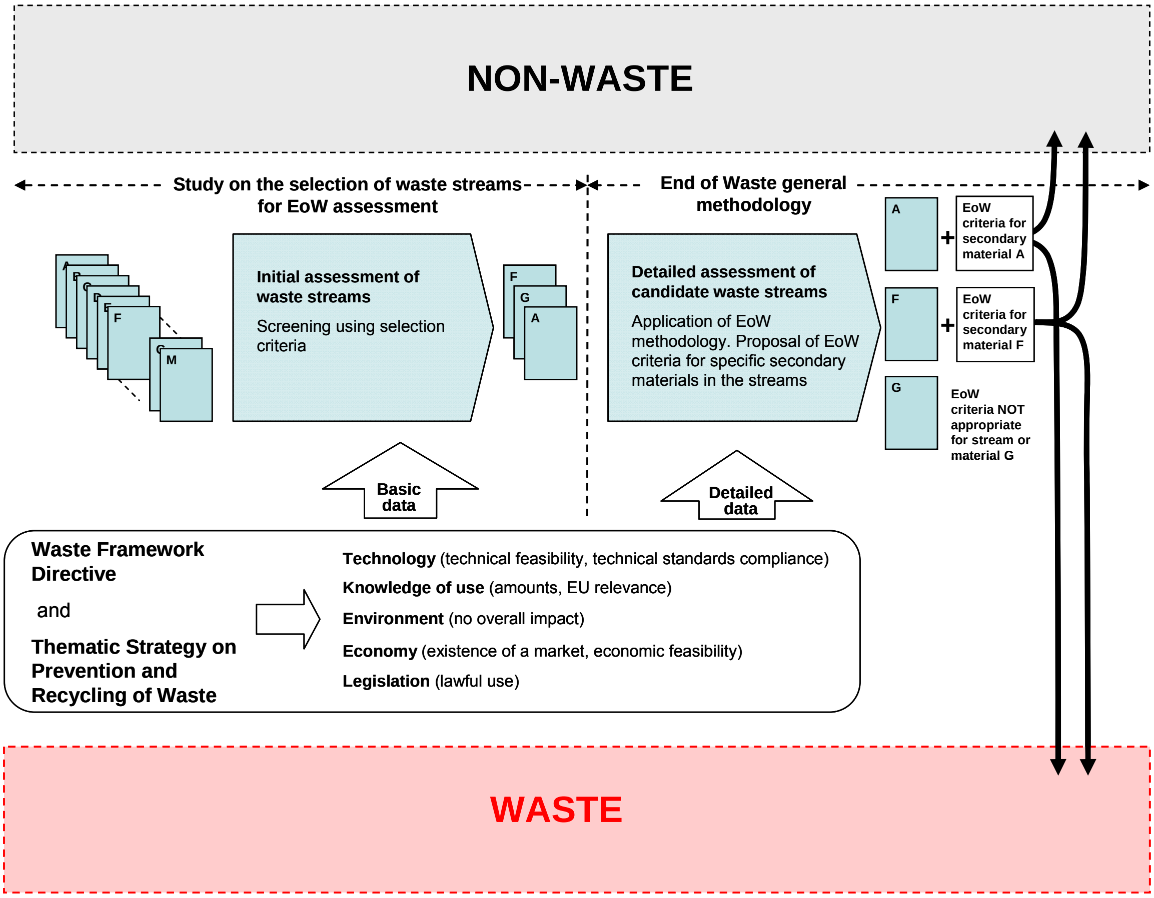

Figure 1. Relationship between the selection of candidate waste streams for EoW assessment, and the EoW assessment proper following the EoW methodology.

More specifically, the aim of this study is to carry out a screening of existing wastes, and select those which contain materials that can potentially become candidates for a thorough EoW assessment. The methodology proper specifies the procedure for such thorough

([6])IPTS (2009) End-of-waste Criteria. Final report. IPTS-JRC. European Commission. Seville, Spain.EUR nr. 23990EN.

assessment, and provides guidance for the determination of when a given waste stream or material can cease to be waste.

2 PROCEDURE, SCOPE AND OUTPUT

This report presents a list of waste streams containing secondary materials that are suitable candidates for a detailed assessment of EoW criteria. The report includes a discussion and transparent description of the principles and criteria leading to this list. These criteria are to be seen as operational basic requirements guiding the qualification of future candidate streams for a further EoW assessment.

The identification and selection of waste streams and their relevant materials has been organised as a stepwise procedure, as illustrated in Figure 2. The basic principles of the procedure are presented below, and the details are explained in the next chapters.

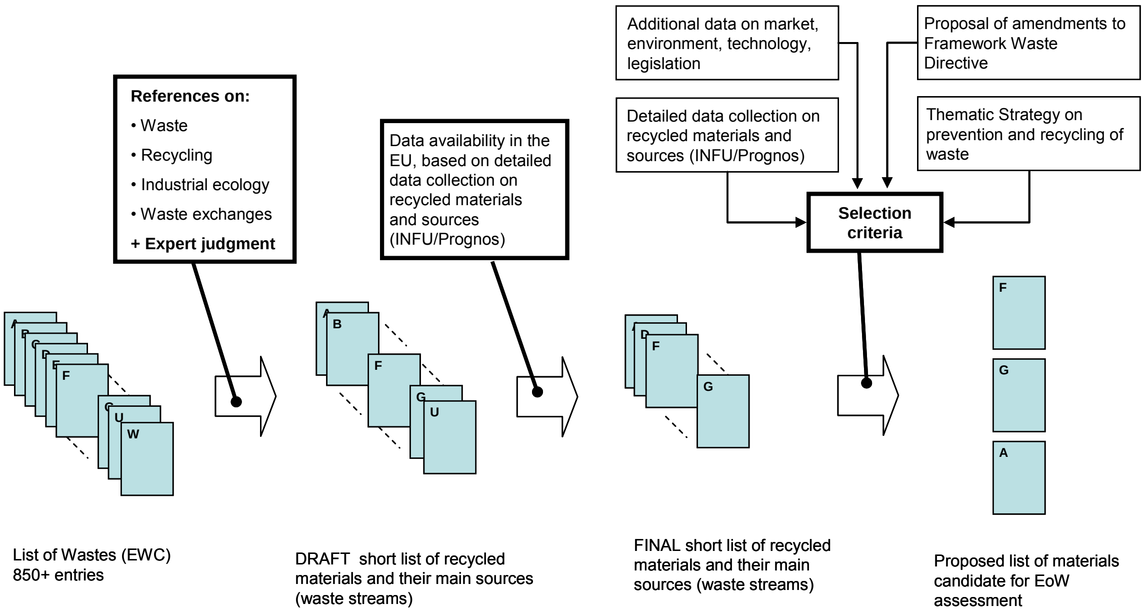

Figure 2. Stepwise procedure followed to derive a list of wastes candidates for EoW assessment.

The first step of the selection procedure has been an identification of the main groups of currently recycled secondary materials, independently of the waste stream from which they are obtained. The identification was mainly based on expert judgement of the nature of waste streams actually recycled in the EU, as reported in references such as national reports, technical and scientific articles on waste, waste exchanges, reuse, recycling, and industrial ecology. These materials are presently not discarded because they have properties that render them useful and provide them with a value, be it for direct use or through intermediate processing.

In order to ensure completeness, this was complemented with an identification of the waste streams from which the recyclable materials originate. This task was carried out by systematically screening all registered waste streams in the EU, using the European Waste Catalogue – EWC([7]) as reference, and establishing a link to the recyclable materials. Given the huge number of waste streams currently registered in the EU (the EWC has no less than 850 entries of different waste types) and the complex waste management alternatives for

([7]) 3-digit entries of waste streams in 94/3/EC: Commission Decision of 20 December 1993 establishing a list of wastes pursuant to Article 1a of Council Directive 75/442/EEC on waste some of them, it was clear at this point that many streams would encounter a data availability barrier, that would restrict the possibility of further analysis.

The next step consisted of the collection and organisation of detailed data and information on all the waste streams and secondary materials shortlisted in the previous step. The main sources for this exercise were country data as reported to Eurostat following the Waste Statistics Regulation [8](EC) (3-digit level), and national reports from Member States containing information at the 6–digit level of the EWC. This data collection activity has been outsourced by IPTS to a consortium of two partners: Institut für Umweltforschung – INFU (Dortmund, Germany) and Prognos AG (Berlin, Germany), and has resulted in the background information report presented in Annex I. As result of the data collection procedure, some waste streams have been excluded from further assessment (from draft shortlist to final shortlist, see Figure 2

Figure 2) because of lack of sufficient data to characterise their amounts and use in the EU.

It is important to understand the distinction made between *waste streams*, and the *materials* contained in them. There are cases where the processing of one waste stream gives rise to a number of output material streams, some of which may replace virgin materials and be thus called *secondary materials* and opt for non-waste status, and some of which would be waste. End-of-waste may only apply to specific applications of some of the outputs, and not generically to the original waste stream and all its outputs. By way of examples, waste tyres can either be processed into their component parts (rubber crumb, steel, fibres, residue) before becoming directly fit for a number of further uses and therefore potential candidates for End-of-waste, but they can also be used whole or just shredded, as filler material in civil works, as fuel in cement kilns, and as cushioning element in harbours and motorsport circuits. Being the contact with the environment different in these applications, not all of them may follow the same End-of-waste requirements. In this example, if End-of-waste is appropriate at all it would not apply to waste tyres as such, but to specific uses of it and of its material fractions.

The final step was the definition of a well balanced set of systematic and transparent criteria (when possible quantitative) to derive a list of waste streams which contain materials suitable for a detailed EoW assessment, and the application of these criteria to the shortlisted materials.

The selection criteria proposed are intimately linked to the conditions of the WFD, and to the vision on recycling outlined in the Thematic Strategy on the prevention and recycling of waste. The criteria include checking basic data on issues such as overall environmental performance reported in life-cycle studies, documentation of a positive market value, or the existence of quality standards for the waste stream or its materials.

In this study, both the aggregation level finally chosen for the material streams, and the selection of indicators have been heavily shaped by data availability. The existence of reliable data in the EU27 has shaped how detailed/aggregated the material streams are. For instance, national information was generally available on *glass*, but not in all countries on its subfractions *flat glass*, *coloured glass*, etc., so the relevant details of each of these subfraction's economy, environmental characteristics etc. had to be sacrificed for the benefit of a complete geographical coverage. Likewise, data availability has been determinant in the selection of indicators that were feasible and operational at EU level.

[8] (EC) No 2150/2002 Of the European Parliament and of the Council of 25 November 2002 on waste statistics, amended by Regulation (EC) No 1893/2006

The application of the criteria to the shortlisted waste streams has resulted in a list of materials candidates for further assessment towards EU-wide EoW criteria. The list has been divided into groups reflecting the material's characteristics in relation to the selection criteria.

Scope: waste types covered and excluded

End-of-Waste candidate streams may currently be used without requiring any treatment, or may be processed for reuse, recycling, and energy recovery. The term *reuse* most frequently relates to *products*, whereas *recycling* is frequently associated to the treatment and upgrading of waste *materials*.

The methodology for waste selection proposed in this study has been developed having in mind waste materials, their recycling and energy recovery. However, many aspects of the methodology proposed are also valid for products and their reuse.

There are a number of waste categories of relevance in the overall picture of waste generation in the EU, some of them potential sources of recyclable materials, but which have been excluded from further screening and analysis in this study, among others:

- All wastes explicitly excluded (c.f. Article 2) from the scope of the Waste Framework Directive (2006/12/EC), including:
  - Mining waste, representing ca. 63% in weight of total waste generation in the EU, but covered by Directive 2006/21/EC on the management of waste from extractive industries.
  - Uncontaminated soil and other naturally occurring material excavated in the course of construction.
  - Animal waste, including manure and slurry. The treatment and disposal of such waste is covered by the Animal by-products Regulation (EC No 1774/2002 laying down health rules concerning animal by-products), presently under revision.
  - Water (including steam, hot water, secondary water and wastewater). The range of conditions of temperature, pressure and content of substances in water which is currently reused is very broad, the acceptability depending on the specific characteristics of the producer and the host.
- Non-recoverable hazardous waste (ca. 3% of total generation)[9]. Non-recoverable hazardous waste is either stored permanently (i.e. landfilled) or incinerated.
- Batteries, covered by a specific Directive (2006/66/EC on batteries and accumulators and waste batteries and accumulators).
- Agriculture and vegetable waste left on land after harvest. Unless transported, this material is not registered and is not treated as waste.
- Misplaced products. These are surplus products that for some reason the buyer cannot or will not return to the supplier, such as construction materials or second-quality production batches. Such misplaced and second-quality products are not generated on a regular basis, but are the result of production errors, malfunctioning, or other exceptional circumstances, and are thus not dealt with in the present study.
- By-products. These streams differentiate from other end-of-waste candidates because they are generated in production processes, in which there are more opportunities of action towards ensuring quality, stability of supply, and environmental control, and

[9] INFU/Prognos (2007)

reduce the need for further treatment before they are used as products. The definition of the conditions to be fulfilled by these streams is set out in Article 5 of the revised Waste Framework Directive (2008/98/EC). An example of such streams is gypsum from flue gas desulphurisation (FGD gypsum), generated in coal-fired power plants. In many Northern European regions without natural gypsum, FGD gypsum is used as main source for the gypsum products industry, and the stream is considered *de facto* a by-product[10]. Conversely, in regions where natural gypsum is abundant (Spain, Portugal, Greece), the gypsum industry is located close to natural gypsum pits, and FGD gypsum has little or no demand, is classified as waste, and disposed of or stored. FGD gypsum in these areas fulfils also quality criteria for use in the gypsum industry, but because of its low specific value and the competition with cheap natural gypsum, it faces the barrier of transport costs for its actual use. A future option some producers in these regions explore is to calcine FGD gypsum from dihydrate form to hemihydrate form, which has a higher market value. Even in such cases, the treatment may still remain within the scope of a by-product regime, and out of the scope of end-of-waste.

Structure of the report

The structure of this report follows the stepwise sequence illustrated in Figure 2. Firstly, a description of the screening stage and the shortlisting of waste streams are given, including the use of life-cycle thinking. Secondly, the data collection exercise is summarised, and a discussion is provided of the selection criteria and their rationale. Thirdly, the application of the criteria to the waste streams shortlisted is discussed and the results of each waste stream and criteria presented. Lastly, a list of waste streams is proposed as candidates for further assessment of EoW criteria.

[10] FGD is used as example of by-product in the Interpretative Communication on waste and by-products (COM (2007)59 final.

3 IDENTIFICATION AND SCREENING OF WASTE MATERIALS AND WASTE STREAMS

This chapter describes the identification of secondary materials carried out, and the screening of waste streams for identification of the origin of these materials. The procedure uses life-cycle thinking concepts, which are introduced in the first place.

3.1.1 Life-cycle approach

It is broadly accepted that the environmental impacts related to waste should be addressed from a life-cycle perspective, linking wastes to the impacts caused in their origin through resource extraction, in production, and in the use and disposal of products that include the materials. This perspective enables to unmask linkages of the waste sector to other sectors in the technosphere such as agriculture (through the application of some wastes on land as fertiliser) or energy (through incineration or biogas generation), and the replacement of products and virgin materials. Thus, all phases in a material's life cycle need to be taken into account as there can be trade-offs between different phases and measures adopted to reduce environmental impact in one phase can increase the impact in another. By applying a life-cycle perspective, trade-offs are detected and minimised, priorities can be identified more comprehensively and policies can be targeted more effectively so that the maximum benefit for the environment is achieved relative to the effort expended.

In addressing the EoW question, a life-cycle approach will reveal whether closing the cycle of the material through reuse or recycling is truly beneficial for the environment, and the approach may help in detecting differences in the environmental impact of handling a stream under waste legislation or as non-waste. For instance, recycling is an environmentally preferred option in comparison to other management alternatives for many homogeneous and clean waste streams, but life-cycle studies[11] have also shown that in some cases and especially for high energy content or non-homogeneous fractions such as waste oil, mixed plastic packaging or wood packaging, incineration can have larger overall environmental benefits than recycling.

Moreover, waste streams are seldom homogeneous substances or materials. Life-cycle thinking applied to waste implies in practice undertaking a material flow analysis of its components. These components have different origins, demand different manufacturing and end-of-life treatment processes, and have distinct environmental behaviour during the lifetime of the products they are part of. This implies that the EoW criteria need to be examined at fraction level, be it material or substance. Some fractions in a stream may not be suitable at all for EoW assessment, e.g. hazardous compounds.

A detailed material/substance flow analysis as part of a life-cycle approach enables to establish the link among the sources of origin of a waste stream, its fractions, the recycled materials qualifying for EoW criteria, and the substances/material they substitute, and enables to evaluate of the impacts in all these life-cycle stages. An example of why this is of interest is provided by coal combustion bottom slag, which is a potential candidate for EoW criteria definition. The data necessary for the assessing whether bottom slag is a suitable candidate for

[11] C.f. references such as (a) Annex 1 of COM (2005)666 (Thematic Strategy on the prevention and recycling of waste).;(b) Fraunhofer Institute (1996): Life cycle analysis of recycling and recovery of households plastics waste packaging (Verwertung von Kunststoffabfällen aus Verkaufsverpackungen in der Zementindustrie). Fraunhofer Institute, Munich, 1996.; or (c) Keevalkink, J.A. and Hesseling, W.F.M. (1996): Waste Processing in a Wet Cement Kiln and a Specialised Combustion Plant. Report No. TNO-MEP-R 96/082, TNO Institute of Environmental Sciences, Energy Research and Process Innovation, Apeldoorn, Netherlands.

EoW criteria comprises estimating future generation, and the quality of the slag. Such data can only be predicted looking upstream in the process, i.e. knowing the ash content of the coal entering the plant, and the quantities of coal burned.

The arguments above illustrate that the application of life-cycle thinking to waste streams implies the inclusion of the stages of waste generation, waste collection, waste reuse, waste treatment (including energy recovery), as well as the stages after treatment of waste, i.e. processing of recycled secondary materials/products and distribution and utilisation of these materials/products. The approach is illustrated in Figure 3.

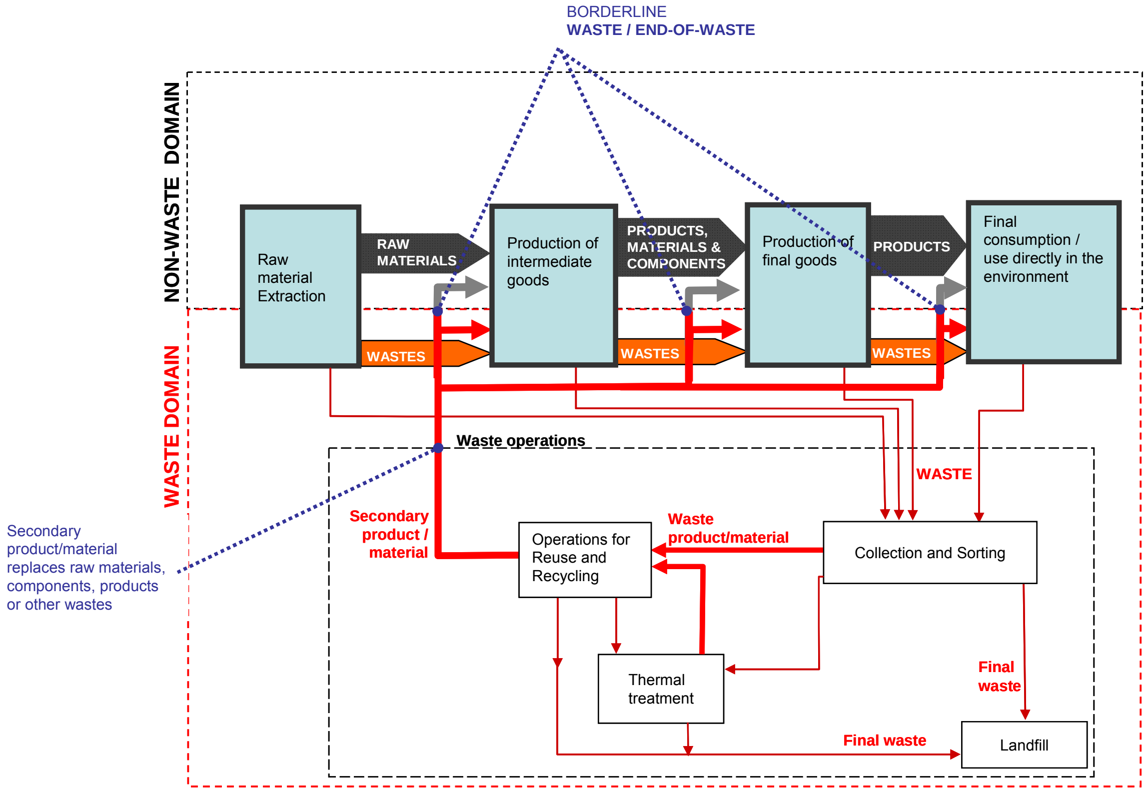

Figure 3. Scope of the EoW issue from a life-cycle perspective

The most evident examples of waste streams candidates for EoW criteria are streams that currently replace other raw materials, products or components of products. The estimation of quantities and composition requires often to use data on their origin as waste streams or even as products.

3.1.2 Secondary material/product identification and waste stream screening

The identification of the main groups of currently recycled secondary materials was undertaken based on expert judgement of the nature of waste streams actually recycled in the EU. Additionally, information on secondary materials and their origin was collected from references such as technical and scientific articles on waste, waste exchanges, reuse, recycling, and industrial ecology, and national reports. These references were fundamental in the identification of the waste streams from which the recyclable materials originate. More specifically, the references used for identification of materials and streams have been:

- Studies and legislative documents from Member States, EU institutions, and international organisations;
- Streams offered/bought in waste exchanges;
- Industrial ecology and industrial eco-park references;
- Recycling industry studies;
- A general Internet search.

Some examples of these references, their relevance and outcome are discussed in the following.

<u>Studies and legislative documents from Member States, EU institutions, and international organisations</u>

Publications and websites from national authorities have been screened using the keywords *"secondary material", "secondary raw material", "byproduct (by-product)", "secondary product", "subproduct", "waste material", "waste recovery", "waste raw material"*, and their equivalent terms in German, French, Italian, Dutch, Danish and Spanish. National legislation from Member States dealing specifically with the use of waste materials has been also scrutinised.

In addition, references from International organisations and EU Institutions have been screened for reports and documents providing examples of upgrading and trading of waste, among others COM (2007)59 final[12] providing examples of by-products, Sander et al. (2004), which report on definitions of waste recovery and disposal operations, Wielenga (2002), which in page 29 includes a list of most traded waste streams in connection with the Basel Convention, UBA (2008) reporting on the impact of REACH policy on recycling and recovery, Dall et al (2003) estimating life-cycle resource saving potentials through increased recycling, and Medhurst et al (2005), which analyse the markets and generation and recycling trends for plastics, paper, and glass from a variety of sources in the EU, in a report supporting the drafting of an impact assessment of the Thematic Strategy on the prevention and recycling of waste.

<u>Streams offered/bought in waste exchanges</u>

The concept of a waste exchange is that waste or by-products from a company can find application in another production place. Among the advantages that companies obtain from such systems are savings of search and transaction costs, disposal fees, transport, better information on the traded material, and the purchase (sometimes with profit) of a low-cost raw material. Society as a whole obtains the benefit of less waste for disposal or treatment in public systems.

There are hundreds of organised exchange networks of industrial and municipal waste in Europe. Some of these waste exchanges are organised by non-profit organisations, government, or commerce chambers, and are free or have low membership fees. Others are run by specialised companies and are financed by a fee for announcement. Some are local, some regional or national, and some international. Most of them are Internet-based.

Some of the local networks are slightly developed versions of exchange practices that have been carried out for decades in e.g. industrial clusters and large harbours, where the location

[12] COM(2007) 59 final. COMMUNICATION FROM THE COMMISSION TO THE COUNCIL AND THE EUROPEAN PARLIAMENT on the Interpretative Communication on waste and by-products.

of industrial plants was chosen deliberately in the vicinity of extraction sites, or other facilities that could supply raw materials residues and by-products such as sulphuric acid, refinery products, surplus steam, refrigeration water, process water, or biomass. In isolated sites such resources would have been disposed of or required expensive transport. Logistic elements such as good communications, the vicinity of outlet options such as a municipal waste or sewage treatment plant, a river, a lake, or arable land, can be key elements in the location of such clusters.

An inspection of a number of European waste exchanges (See listing in Annex IV) and industrial clusters has resulted in the identification of hundreds of materials and products. Materials are often grouped in a reduced number (between 10 and 20 in most cases) of material categories (e.g. inorganic chemicals, organic chemicals, acids and alkalis, oil and grease, wood, plastics and rubber). The grouping varies depending on the industrial structure of the region served and how often the different streams are on offer. Most exchanges include a category "miscellaneous" gathering odd material streams non classifiable under the other groups.

Some of the streams exchanged are products, or surplus products that for some reason the buyer cannot or will not return to the supplier. Typical examples are low specific value products such as construction materials, which are too costly to transport back to the retailer/producer. Such misplaced products are not being dealt with in the present study, because they are not generated on a regular basis, and are rather the result of errors, malfunctioning, or other exceptional circumstances.

Industrial ecology and industrial eco-park references

The operational, scientific, philosophical and theoretical sides of the mentioned industrial clusters and waste exchanges are published regularly in scientific journals. In recent years, new terminology and metaphors have been coined to help describe and analyse the exchange of waste and non-waste in industry, including the terms *"Industrial eco-parks"*, *"Industrial ecology"*, *"Industrial symbiosis"* or *"Industrial metabolism"*. The discussions rage from very technical to very philosophical, and cover the conditions that an industrial waste stream has to fulfil to be accepted by the host. Issues of legal compliance, sound economy basis, security of supply and knowledge and mutual trust are analysed. However, very few of these references (e.g. Desrochers, 2001) are policy-oriented and explore the potential of legislation changes.

Three journals publishing regularly on the issue are *Journal of Industrial Ecology, Journal of Cleaner Production,* and *Resources, conservation and recycling*. Examples of waste streams which do not end in a disposal operation have been collected from articles published in these journals. Two of the frequently quoted references in the field inspected are Ayres (1989) and Garner and Keoleian (1995).

Recycling industry studies

Specific waste recycling studies have been analysed in the search for details on the quality characteristics that make waste streams suitable for trading in the EU. Examples of these are Huisman 2004 (electric and electronic waste), Ouvertes 2005 (textiles), Gendebien et al 2003 (refuse-derived fuel - RDF), Monier et Labouze 2001 (waste oils) ETRMA 2006 and IFEU 1998 (tyres), or ISRI 2003 (metal scrap). Additional information was found in publications from the international organisations dealing with the recycling industry generically (Assure, BIR, ERC) or for specific streams (EERA on WEEE, ETRA on tyres, EUPR, Plastics Europe and EPRO on plastics, ERPA and CEPI on paper, ISRI on metals).

General Internet search

The search was completed with a general Internet search using the same keywords above mentioned for the National studies: *"secondary material", "end-of-waste (end-of-waste, EoW)", "secondary raw material", "byproduct (by-product)", "secondary product", "subproduct", "waste material", "waste recovery", "waste raw material"*, including their equivalent terms in German, French, Italian, Dutch, Danish and Spanish.

Outcome

The detailed examination of the recycling industry and the marketed secondary materials in the EU has led to the identification of 11 groups of currently recycled secondary materials. These are presented in the first column of Table 1. The second column of Table 1 specifies about 60 sources identified of these secondary material groups.

In the table, most material groups and their sources are very crudely aggregated, and contain each a spectrum of subcategories with different properties, recycling routes and application possibilities. However, as mentioned in the introduction the purpose of this study is to identify candidates for further EoW assessment. For that purpose, a balance has been struck between detail (necessary for a proper definition of recyclability, market, environment, etc) and feasibility (more easily found at an aggregated level). Column 3 in the table lists the streams where sufficient data was available at EU27 level. The last step of the screening of waste streams has been to use data availability (also constrained by the time and resources allocated to the data collection project (INFU/Prognos 2007, c.f. Annex I)) to exclude some of the streams from further assessment (from draft shortlist to final shortlist, cf. Figure 2).

Based on the availability and quality of the information collected in all EU27 Member States, it has been possible to identify 20 streams (indicated in the third and fourth columns in Table 1) which have well-established recycling channels in most EU Member States (and not only in one, or a few of them), and are thus, on account of their data availability in national records and total amounts in the EU, candidates for a further EoW assessment[13] at a EU level. For instance, spent foundry sand is a stream with a clear identity, a positive market value, and known applications in cement production in Germany (UBA, 2008), where generation and flows are known, but for which it has not been possible to collect data for in the EU27.

In Table 1, the streams of the second column with empty cells in the fourth column are thus still potential EoW candidates, but within the scope of this study it has not been possible to obtain enough data or data of sufficient quality to conclude about their suitability for EoW assessment.

The proposal of candidate streams for further EoW assessment refers to the materials contained in the 20 streams of the fourth column in Table 1, and not to the aggregated waste streams as such. For instance, the waste stream "glass" has been used for operational reasons in order to enable data collection, since only a few Member Sates have data on its subfractions. However, it is most often the recyclable/recoverable material subfractions (e.g. flat glass, brown glass, green glass, clear glass) that are of interest for a detailed EoW

[13] The availability of data about the identified waste streams has been found to vary widely between Member States. Table AII.1 in Annex II specifies the details of the sources investigated in each of the Member States.

assessment, because these are the streams with intrinsic market value and with a raw material substitution potential.

It is envisaged as the task of a detailed EoW assessment, following the methodology proposed in the separate methodology report, to define exactly the material subtypes and properties of concern for EoW assessment.

Table 1. Waste streams and secondary materials shortlisted

Groups of secondary material	Sources	Data availability (**)	Streams selected for further assessment(*)
1. Mineral wastes [Bound or un-bound secondary material used in building and civil work construction, either for its specific functionality or for use as filler material]	- Bituminous mixture	X	C&D waste aggregates
	- Bricks, tiles and ceramic	X	
	- Concrete	X	
	- Asphalt	X	
	- Spent railway ballast		
	- Spent foundry sand		
	- Slags and ashes (from combustion/incineration)	X	Ashes and slags
	- Slags (from metal processing)	X	
	- Quarry and mining soil, rocks, sand, etc.	Excluded (c.f. scope in Chapter 2)	
	- Other inert materials not considered as by-products (isolation glasswool, rockwool, glassfiber, gypsum, dust fractions collected from exhaust gases)	Some specific streams very well characterised, others not	
2. Compost and other soil improvers/growing media [Results of the stabilisation treatments of organic and inorganic material with agronomic value - composting, anaerobic digestion, filtering, drying]	- Organic residues from industry (e.g. digestate, sludge and filter cakes from food and beverage, pharmaceutical, paper, sugar, beet, olive oil, drinking water and wastewater treatment)	EU15 only (***)	
	- Inorganic residues with agronomic value (pH adjustment) from other industrial sectors (e.g. lime, gypsum)	EU15 only (***)	
	- Manure, animal raising slurry	Excluded (c.f. scope in Chapter 2)	
	- Vegetable food waste	X	Biodegradable waste undergoing stabilisation for recycling
	- Mixed biodegradable waste	X	
	- Green waste	X	
3. Chemicals [Various chemicals or mixed chemicals, organic and inorganic]	- Solvent	X	Solvents
	- Oils (mineral, vegetable), grease and waxes	X	Waste oil
	- Carbon black		
	- Catalysts		
	- Other substances (ink, dyes and pigments, extraction and separation substances such as spent kieselguhr and activated carbon, filter cakes, sludges, metal surface treatment chemicals, acids, alkalis, inorganic and organic chemicals with impurities that disable them as standard products, such as ClH with 0.5% Cl_2Fe,spent caustic soda, hydrochloric acid from flue gas purification)		

4. Fuel [Various types of fuel from waste -excluding mixed municipal waste]	- Agricultural residues	Part of them excluded (c.f. scope in Chapter 2)	
	- Wood not suitable for recycling	X	Solid waste fuel
	- Fuel derived from sludge (from paper manufacturing, sewage, bio-treatment plants, etc.)	X	
	- Secondary fuel oil (from food oil, tallow, etc.)	X	
	- Refuse derived fuel (RDF)	X	
	- Non-recyclable plastic waste	X	
	- Tyre material (shredded and whole tyres, synthetic fibre fraction from tyre recycling)	X	
5. Glass [Various types of glass]	- Contaminated glass (bulbs, cathode ray tube glass), etc.		
	- Flat glass	X	Glass
	- Coloured glass	X	
	- Clear glass	X	
	- Special glass	X	
	- Mixed glass	X	
6. Metal [Various types of sorted scrap metals]	- Aluminium scrap	X	Aluminium
	- Stainless steel scrap	X	Steel
	- Ferrous scrap	X	
	- Copper scrap	X	Copper
	- Zinc scrap	X	Zinc
	- Lead scrap	X	Lead
	- Tin scrap	X	Tin
	- Precious metal (Ag, Pt, Au)	X	Precious metals
	- Other metals (Co, Cd, Ni, ferroalloys, alkali and alkali earth metals) and mix non-ferrous scrap	X	Other metals
7. Paper/cardboard [Various types of sorted and mixed waste paper and cardboard]	- Newspaper	X	Paper and cardboard
	- Print paper	X	
	- Cardboard	X	
8. Plastics [Various types of sorted and mixed waste plastics]	- PE	X	Plastics
	- PET	X	
	- PP	X	
	- PVC	X	
	- PS	X	
9. Textiles and synthetic fibres [Various types of sorted natural and synthetic textiles for reuse and recycling]	- Fur, leather, animal hair		
	- Home textile (e.g. carpets, curtains)	X	Textiles
	- Technical textiles (e.g. car seats)	X	
	- Household textile (e.g. towels, bed linen)	X	
	- Clothing	X	
10. Rubber [Various rubber material fractions]	- Granulated tyre rubber from end-of-life tyres	X	Used tyres
	- Other rubber (e.g. toys, hoses, foams)		
11. Wood and natural fibres not used as fuel [Various wood waste]	- Construction and demolition wood		
	- Furniture	X	Wood
	- Fibre products (straw, palm)	X	
	- Wood chips, sawdust	X	

(*) Grouping here is for simplification of further reference, but any known details of the subdivisions and of sub-streams' flows are kept
(**) Availability within the time and scope allocated to this study

(***) Gendebien et al. (2001)

It is easily noticeable that the relationship between recyclable material groups and streams of origin is not one-to-one. A recyclable material group encompasses a number of fractions from very different origins (e.g. steel scrap can stem from construction and demolition waste, but also from the steel fibres in tyres). Likewise, a waste stream can have several recyclable components (e.g. a demolished building originates several aggregate fractions such as PVC, aluminium, steel, copper, or wood, and a used tyre originates steel, rubber and synthetic fibres).

The streams of the second column of Table 1 covered by the WFD (that is, excluding streams such as mining waste and agricultural waste) have five main origins:

- industrial waste
- municipal solid waste
- construction and demolition waste
- end-of-life vehicles (ELV)
- waste from electric and electronic equipment (WEEE).

This information highlights the very different origin, quality, treatment needs and expected life span of the products, materials and streams that are potential candidates to EoW assessment: some of the streams are post-consumer wastes with a clearly defined use phase (municipal waste, different packaging, ELV, WEEE, C&D waste), whereas industrial waste types (slag & ashes from coal combustion) never reach a final consumer and a use phase. Some streams are relatively homogeneous (oil waste, used tyres, some production slag and ashes), and others are not (municipal waste, RDF, WEEE, ELVs, textiles and incineration slag). Some streams will undergo collection, sorting and treatment, whereas others may not need treatment. Some have a reuse potential, whether others enter lower in the waste hierarchy, be it for material recycling, or for energy recovery.

3.1.3 Characterisation of waste streams

To determine which of the screened streams fulfil currently the four conditions of the WFD in the EU27 (evidence of use for a specific purpose, of existence of market and demand, of quality on a par with products, and overall environmental benefit), it is necessary to collect and organise data so that one can answer to questions such as, for the example of glass: how many tonnes of glass waste are currently reused and recycled in the EU? How much is this compared to the total generation of this waste type? What is the potential for recycling of this stream in the EU? What is the environmental benefit of recycling glass instead of landfilling it? What is the market value of waste glass?

The characterisation of waste streams comprises environmental data, information on alternative management options, as well as market and price of the secondary materials/products. Large amounts of data are needed to quantify in detail the flows of all candidate waste streams, including the characterisation of different separation, treatment and recycling technologies and the related environmental, economic, societal, technical and legislative issues.

No single source of information is able to provide all the data needed, and since various sources often use different methodology in data collection, there is a strong need to systematically organise and harmonise the information, and assess it for consistency. The detailed data collection exercise has been carried out as a contracted project to a consortium of two partners: Institut für Umweltforschung – INFU (Dortmund, Germany) and Prognos AG (Berlin, Germany) under the supervision of IPTS. The full report of this activity is available in Annex I, and its underlying data are the basis for the results presented in the following sections. This information has been complemented with data gathered in the context of the pilot cases[14] on metal scrap, aggregates, and compost, and additionally on used tyres (RTMA, 2008).

After an examination of different methods for organising systematically data on waste fractions, it was decided to use as a template the European waste catalogue (EWC, in latest versions being renamed as European List of Wastes - LoW). The EWC is a comprehensive list of some 850+ waste fractions, grouped into 20 broad categories related to the source (See Table AII.2 in Annex II). With the EWC, it is possible to identify comprehensively and systematically, based on the origin of waste, the potential waste fractions that are relevant to each of the secondary materials or products that are potentially the result of a recycling process. In the following, the procedure for collection of data on a waste stream and the use of the ECW is exemplified for glass.

For any given waste stream, the data collected consists of eight elements, which represent the sequence from source to the replacement of a raw material. Figure 4 illustrates this sequence for glass. The eight elements are:

1. Sources: The amounts of waste generated in the EU 27 by the sources of origin. If applicable, both dry and wet amounts are summed up.
2. Waste stream total estimated amount: The sum of a waste stream from all the sources.
3. Composition: The composition by material/substance of a waste stream. The differences of these sub-streams often imply that different recycling or recovery processes are followed for each group in elements 4 and 6 below.
4. Management alternatives I: The area "Management alternatives I" consists of:

- The amount that is sorted or pre-treated with the aim of recycling. Also included is the amount that is separately collected and directly recycled.
- The amount of the directly non-recycled waste, i.e. the amount that goes into other management alternatives.
- The "losses" (sorting residues) from sorting or pre-treatment, which is added to the non-recycled.

As far as possible, data is disaggregated for different processes
5. Management alternatives II: The total amount of the non-recycled waste refers to the directly non-recycled waste plus the losses ("losses" or "sorting residues" as described in element 4). This amount is then attributed to the respective disposal means (landfill, incineration without energy recovery, other disposal).
6. Waste stream recycling and/or energy recovery: The amount of waste is available for material recycling and/or energy recovery (after subtraction of the losses from sorting or pre-treatment). This amount was assigned to the respective main recycling processes.
7. Waste from treatment: The losses occurred in the material recycling and/or energy recovery process becomes waste for further disposal.

[14] IPTS (2009) End-of-waste Criteria. Final report. IPTS-JRC. European Commission. Seville, Spain.EUR nr. 23990EN

8. Waste stream recovery: The last area "recovery" is the sum of the final amount of waste recycled as material or recovered as energy. The amount is – if applicable – divided into material recycled and energy recovered.

In addition to the data on generation and recycling, the data collection exercise gathered information on the market of the material/stream (price, time evolution), and basic data on the potential environmental and health benefits of recycling.

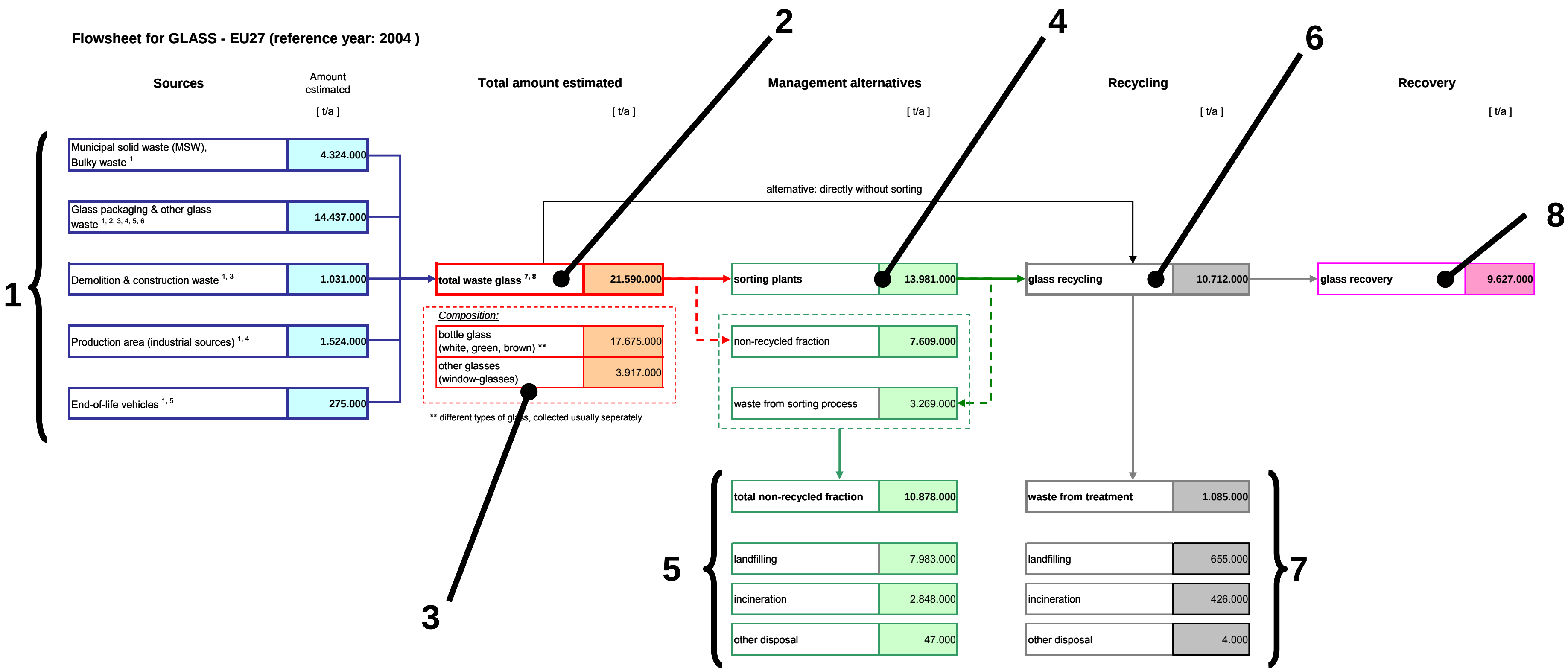

Figure 4. Illustration for glass of the eight data elements necessary for a quantification of generation, transformation to secondary material, and potential substitution in the EU. Units of the figures presented: tonnes/year

In the schematic form here presented, the exercise of data collection seems straightforward, but further insight reveals that a number of qualified estimates have to be made to harmonise existing data sources of information of a given waste stream. Examples of such assumptions for glass, as well as details of all waste streams analysed using the 8-element structure are further described in Annex I.

Table 2 below summarises the quantification of waste streams shortlisted. In Table 2, the elements included are:

- Total generation of material, prior any sorting or treatment (element no. 2 in Figure 4)
- Estimated potential generation of secondary material or secondary fuel (both in mass and energy units) (element no. 8 in Figure 4)

Table 2. Overview of stream generation, and secondary material potential recycling/recovery. Reference year: 2004.

Secondary material	Estimation of amounts of secondary materials		
	Total generation [Mt]	Total recycled as material [Mt]	Total recovery as energy [PJ(Mt)]
Glass	21.6	9.6	-
Paper &cardboard	79.5	33.0	-
Plastics	26.2	3.6	128 (4.7)
Wood	70.5	21.3	324 (24.0)
Textile	12.2	2.5	20 (1.1)
Iron & steel scrap	102.6	76.9	-
Aluminium scarp	4.6	3.0	-
Copper	1.4	0.8	-
Zinc	1.2	0.7	-
Lead	1.0	0.6	-
Tin	0.1	0.034	-
Precious metals	0.0248	0.009	-
Other metals	1.0	0.4	-
Biodegradable waste stabilised for recycling	87.9***	13**	23 (4.0)
Solvent	1.6	0.35	12 (0.6)
Waste oil	7.4	1.9	23 (0.8)
Solid waste fuel	70.1	-	211.86 (15.1)
C&D waste aggregates	433	272	-
Used tyres	3.2 (includes 0.5 reuse)	0.74 rubber*	32.3 (1.15)
Ashes & slag	131.4	72.6	-
Total	**1068**	**535**	**(51)**

(-): non-applicable
* 0.2 Mt steel from tyres is accounted for in the steel row
** estimated from ECN/ORBIT(2008) Estimated compost wet weight, i.e. including residual water but excluding all water lost during the compost process
***Includes all inputs to municipal/privately driven municipal plants , including biodegradable MSW, green waste from households and public places, and commerce and industrial waste treated in public plants

In the EU27, the total annual waste generation was in 2004 about 2800 million tonnes (wet weight)[15]. Excluding mineral wastes from extraction activities in mines and quarries (ca. 1800 million tonnes), this gives a generation of about 1000 million tonnes, which comprise household and household-like waste (ca. 200 million tonnes), industrial waste (ca. 550 million tonnes), and other waste categories such as sludge from wastewater treatment or hospital waste.

[15] INFU/Prognos (2007)

In rough figures, Table 2 indicates that out of the ca. 1000 million tonnes generated, 272 million tonnes (ca. 27%) are recyclable construction and demolition waste materials, and about 260 million tonnes are other recoverable materials, either through material recycling (210 million tonnes, 21% of the total) or energy recovery (50 million tonnes, 5% of the total).

4 SELECTION CRITERIA: DEFINITION AND USE

This section presents the set of criteria used to identify waste streams that qualify for a detailed EoW assessment. The aim has been to propose criteria that are operational, transparent, and when possible quantitative. Each criterion consists of one or more indicators, which are calculated using the detailed information collected (Annex I). The application of the criteria to the group of streams shortlisted in previous sections has resulted in the proposal of a final list of candidate streams.

4.1 Principles to determine the criteria

The criteria developed are anchored to the four conditions of the WFD, and to the vision on recycling outlined in the Thematic Strategy on the prevention and recycling of waste. However, these conditions and vision statements are not operational indicators, and can not be used as such in EoW decision-making. For instance, how can one document that "*a substance or object is commonly used for a specific purpose*"? Is it by providing reported examples of use? Which would then be the threshold for when the use is *common*? The documentation of at least one example? Or perhaps 10, or 100 examples? Or shall it be quantified as 100, 1000 or 10 000 tonnes? Would this *common* use cover one Member Sate or should the practice be documented in more than one Member State in order to qualify for further EoW assessment?

It is evident from the arguments above that the basic principles of the WFD and TSPRW have to be converted into operational indicators that can be used for waste stream selection. The following sections present and discuss individually the rationale used for the criteria and their indicators, grouped under the principles of the WFD: "Knowledge of use", "Market and economy", "Technology, quality, standardisation and legal compliance", and "Environment". Table 3 (next page) summarises the translation made of the principles into the operational criteria and possible indicators.

The operational value of the proposed selection criteria has been tested on the shortlisted waste streams, and is therefore workable at the aggregated waste stream level used. However, it can not be prejudged whether these data will also be available for any waste stream or sub-stream that may be proposed for EoW assessment in the future.

It can be noticed in Table 3 that there are a number of specific parameters of interest for the use of secondary waste streams which have not been included as key issues or criteria. Examples are the detailed composition of the secondary material, or the leachability of salts or heavy metals from the material. The exclusion is deliberate and consistent with the methodological approach proposed, as the selection criteria developed here use only basic data that qualify streams for further EoW assessment. If needed, the details of the composition and behaviour of the secondary materials should be considered at a later stage, in the proposal of EoW criteria.

Table 3. Overview of issues addressed in the proposal for a WFD and the TSPRW, and the proposed selection criteria

Issues addressed in current EU legislation	Interpretation of issues	Examples of information that can clarify this issue and/or be used to fulfil the condition	OPERATIONAL SELECTION CRITERIA PROPOSED
TSPRW text			
Waste-stream-based [EoW criteria] could both improve the environmental performance of recycled products, by encouraging businesses to produce recycled products that conform to these environmental criteria, and reduce unnecessary burdens for low-risk recycling activities.	– Knowledge of differences between current and potential feasible recycling – Reduction of administrative burdens	– Data on current collection for recycling. – Data on current recycling effectiveness. – Data on best achievable collection and recycling effectiveness. – Proof of administrative burden of absence of EoW criteria/different standards. ECJ cases.	**1. No marginal waste stream (amounts & value)** (1.a.) Quantity (tonnes/yr), if available also past and future (1.b.) Geographical coverage (number of countries) (1.c.) Market price (€/tonne) (1.d.) Market value (€/yr) (1.e.) International trade (tonnes/yr) in/out of the EU **2. Potential for increasing recycling and recovery through better waste management** (2.a.) Current disposal to landfills (tonnes/yr) (2.b.) Current and best practice collection to recovery/recycling (%), if appropriate specifying the use(s) (2.c.) Recovery/recycling potential trough better waste management (tonnes/yr and %), estimated against best practice **3. Higher resource substitution: current recycling effectiveness** (3.a.) Raw material substitution in the EU through of reuse/recycling/recovery (tonnes substituted raw material, and % of generated waste material currently substituting raw material) **4. Environmental benefit of recovery/recycling** (4.a.) Energy savings (MJ/tonne and PJ/yr in the EU27) (4.b.) GHG emission savings (tonne CO_2-eq/tonne material and Mtonnes CO_2-eq/yr in the EU27) **5. Control of product quality and processing technology** (5.a.) Existence of guidelines or standards for quality/processing of secondary materials, or guidelines or standards for quality/processing of primary materials/products where it can be proven that they are used on secondary materials (exist/non-exist/specify) (5.b.) Existence of different standards for quality/processing in different EU countries hampering cross-boundary transport (exist/non-exist/specify) **6. Legal compliance** (6.a.) Evidence of conflict in the EU (examples of ECJ cases) (6.b.) Evidence of conflict in waste definition of international shipments (examples or reported cases)
WFD text			
(a) the substance or object is commonly used for a specific purpose	– Knowledge of use – User's acceptance – Social acceptance of the use – Geographical distribution in the EU – Stability of generation	– Documentation in more than one country of the EU about generation and use for the purpose declared. – Documentation that the generation is continuous in time (past, present, and prospect). – Records of social criticism to the use.	
(b) a market or demand exists for such a substance or object	– Information exists on the conditions of the generation, trade and use	– Price and supply conditions information, including price development and possible distorting elements (taxes, subventions, externalities, bans, search and transaction costs). – Data on amounts and cost in contracts of waste stream exchanges or in bookkeeping	
(c) the substance or object fulfils the technical requirements for the specific purpose and the substance meets the existing legislation and standards applicable to products	– Quality for intended purpose – Technology/ technical specifications	– Technical standards, specifications and/or guidelines exist. – Technical specifications in contracts of waste stream exchanges	
	– Legislative compliance	– Use not banned in any EU country. – Evidence of different law interpretation in different countries.	
(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts."	– Environmental information	– Results of comparative environmental studies – Use not banned in any EU country on environmental grounds	

4.1.1 Knowledge of use

EU-wide EoW criteria need not cover exceptional cases of waste stream generation that can better be analysed on a case-by-case basis using information on local/regional/national conditions. An example of this is the applications use made of wastes from shale oil processing in Estonia, since this is the only EU country where this fuel is used.

A combination of parameters can be used to prove that a given use of a secondary material is not an exception, but a widely known and regular fact. Among these are:

1. Proof of geographical coverage. The use of a secondary material in several EU Member States would justify the need of EU-level policy, especially if there is a real possibility (if possible documented) of transboundary movement.
2. Proof of existence of guidelines or standards specifically prepared for secondary materials, for instance for ensuring quality or ensuring processing conditions (e.g. temperature or pressure). An example is the paper industry's European List of Standard Grades of Recovered Paper and Board (EN 643).
3. Record of regular production, quantified for instance in national, regional or local waste generation statistics.
4. Record of the existence of trade of the secondary material, documented in the producer's or the user's bookkeeping (see more below).
5. Record of social discontent with the use proposed for the waste stream.

4.1.2 Market and economy

A simplistic three-category split can be used to describe the market situation of a secondary material: (1) when it substitutes a valuable primary material, (2) other secondary materials, or (3) has no known competitor occupying a unique market niche.

The first situation takes place when waste streams contain a valuable material. An example is ferrous scrap in a market of increasing iron demand, for which there is no competitive alternative material. In these cases, waste streams have a long history of recycling in well established, often international markets, and the use of the secondary material is known and registered. Some of these waste streams are connected to specific technologies (e.g. electric arc furnace steelmaking from ferrous scrap). Records of such activity would be considered sufficient proof of the existence of a market and the knowledge of common use.

When the recycled secondary material is competing with a product of low or irregular demand, the market development of the secondary material needs to be examined in more detail. The market demand in the past and in the future has to be scrutinised, along with the price evolution (analysing e.g. its volatility), the maximum market share, the search and transaction costs, the transport costs, etc. Attention has to be paid additionally to the existence of legislative restrictions, subsidies, taxes and information failures that may distort the market. An example of policy intervention is the use of returnable beverage whole glass bottles, which some decades ago were common in most EU countries but now only survive the competition of alternative materials (one-use metal and plastic) in those countries where specific policy measures are in place to keep the system running.

The third market situation occurs in cases where the recycled secondary material is a new type of material and has functions that are not substituting any existing product, for example compost, which has a combination of nutrients, water retention properties and soil structure and bacterial activity improvement properties which no single substitute market product offers. The market potential of these recycled secondary materials could be indicated by an actual positive market price or an increasing demand (usually both parameters go together), reflecting an estimation of buyers and sellers of the value-added of the material in the specific use compared to the combination of products it substitutes. In any case, if the waste is to qualify for EoW assessment, proof is needed that the production of the secondary material and its further process into a product is feasible economically and technically on a level playing field with other products, without distinct hidden subsidies or taxes.

In summary, information on the market price, if needed with its evolution over time, is the central element in proving the existence of a market, a positive market value, and a demand. Part of this information can be obtained from the producer's or the user's bookkeeping. Complemented with information on amount generation, this can help quantify the dimension of recycling markets. However, it is important to consider at least three elements in the estimation of recycling market size:

1. Much recycling of materials, especially homogeneous high quality fractions, takes place within firms (e.g. use of plastic or metal cuttings and trimmings in the processing of these materials).
2. Because of the heterogeneous composition and unique generation conditions of most waste streams, the markets of many recycling materials are characterised by distortion created by asymmetric information (most transactions are unique and the producer knows more about the stream's composition than the buyer, and can misuse this information), taxes, subsidies, and hidden costs such as externalities (technical, environmental, value of the perception of risk), and high transaction and search costs (Johnstone and Tilly, 2006).
3. Many recyclables have low density (especially packaging), and their actual price for a potential buyer is very affected by transport costs. For instance, the cost of transporting shredded used tyres is 30-60% lower than transporting them as whole tyres (van Beukering, 2006).

The mentioned factors make an attempt of a general evaluation of the size of markets and economic importance of recycling problematic. Therefore, in this study only very gross market size estimates are provided to give an indication of the order of magnitude of the markets, without ambition of precision. The largest precision effort has been made in the collection and estimation of data on generated amounts, including percentages to recycling, energy recovery and final disposal.

4.1.3 Technology, quality, standardisation and legal compliance

Technology, quality and standardisation

The most basic condition for acceptance of a waste stream is that it has the quality necessary for the function intended. This function, if previously existing, is fulfilled by a raw material or another waste stream, which the new waste stream replaces.

However, it is a known fact that in certain cases, because of the material's nature, of economic reasons, or of technology, the quality of the secondary material can not be uplifted to the level of a virgin material. Examples of this are most recycled polymers, as compared to aluminium or iron, which are fully recyclable (INFU/Prognos, 2007). In other cases the opposite occurs, and the secondary material has unique characteristics which conventional products cannot deliver at a given cost. An example of this is the use of steel slag as aggregate in road construction, where it has been proved that slag mixes better with bitumen than sand or gravel due to the roughness of its surface, and has more strength to impact and crushing, all these properties making it a more desirable material than many primary aggregates for high-trafficked road layers (Motz and Geiseler, 2001). Another example is the use of rubber granulate from used tyres in sport courts. Sport courts are currently not made of natural rubber because of high costs, but the availability of tyre rubber at low price has created this new market niche.

A means to document that a secondary material competes technically with products is to test whether it fulfils standards (or guidelines) for the intended use, that is, standards which are not specific for secondary materials. These standards can be on the quality of the material or on its processing. For instance, the European standards for aggregates define the technical requirements for aggregates to be used in construction works. All materials primary, secondary or recycled aggregates have to fulfil the same technical requirements. Additional requirements are defined for secondary and recycled aggregates due to their specific properties.

The existence of quality standards/guidelines that are different in neighbouring Member States can be used as documentation of the pertinence of further EoW analysis. In any case, standards provide more transparent information and alleviate certain market imperfections such as search costs and transaction costs. They also contribute to provide confidence and reduce negative attitudes towards secondary materials.

The promotion of recycling is associated indirectly to the certainty that sufficient quality can be obtained in a secondary material/product. The higher the certainty, the higher can the recycling targets be. One of the core principles of the WFD and of the Thematic Strategy on the prevention and recycling of waste is that product reuse and material recycling ratios in the EU should be in the future (in a so-called *recycling society*) the maximum which is environmentally sensible, yet economically and technically feasible. Landfilling of valuable materials should be avoided if this makes sense environmentally, which for certain inert materials may not always be the case. A number of parameters can be used to prove that a given recycling technology is inefficient, or that the management of a given secondary material is suboptimal, including:

1. Current disposal to landfills of a secondary material (tonnes/yr) and current collection for recycling of a secondary material (%). Member States can be benchmarked on their waste management performance for each material. With these data, a waste management to recycling potential (tonnes/yr) can be calculated for each Member State and for the EU as a whole.
2. The concept of waste management performance benchmarking can also be applied to recycling effectiveness. Current recycling effectiveness in Member States can be recorded and benchmarked, using also to the theoretical maximum achievable with the use of best available techniques. Recycling improvement potential (tonnes/yr) can be derived from this for each Member State and for the EU.

<u>Legal compliance</u>
One of the reasons for introducing the concept of EU-wide EoW criteria has been the not always uniform interpretation of the EU waste definition, especially in the context of

transboundary movement of waste, where legal reference differences in different Member States have been witnessed. One of the parameters that can help identify potential EoW candidate streams is therefore the reported evidence of conflict on this issue for a given waste stream. The European Court of Justice (ECJ) has issued several judgements on the interpretation of the definition and the meaning of waste. An example of this is the Mayer Parry case, which opposed the Mayer Parry recycling company against the UK environment agency, and demonstrated the interest of a metal recycling industry in a clarification of the status of scrap categories it used in daily business of the company.

An element of judgment in EoW candidacy of a given waste stream is thus the existence of reported ECJ decisions on this particular issue, either in favour of waste characterisation, or non-waste characterisation, since such decisions are evidence of a need for clarification.

Other legislation-related proofs of exclusion from further EoW characterisation can be references of unlawful application of a given stream, even though the convenient procedure here is to bring forward the possibly technical or environmental arguments in which such a decision is usually based on, and use these instead.

Of interest for identification of potential EoW candidate streams are also national bans or legal measures that regulate/distort the waste and recyclable's market, e.g. legislation on return systems for beverages or legislation envisaged to ensure the amortisation of waste incineration investments, and which may currently obstruct or facilitate artificially the import/export of waste, and in some cases be a barrier of increased recycling.

4.1.4 Environment

While a waste stream remains under the umbrella of waste legislation, this creates provisions that minimise or control the potential environmental impacts and/or risks from its handling and disposal.

However, if at some point of the upgrading chain of recycling/reuse the material ceases to be waste, the environmental protection *safety net* of waste legislation disappears. It is thus necessary to demonstrate that the elimination of this safety net and its substitution by product legislation has no net adverse life-cycle impacts. Therefore the phrasing *'no overall adverse environmental or human health impacts'* statement of the WFD. This is a rather fundamental question to be answered, and difficult to do so, since the marginal difference between treatment within or out of the waste legislation can be subtle and difficult to trace and quantify.

Furthermore, distinction is needed between secondary materials used as input in industry (e.g. metal scrap) and secondary materials released directly to the environment (e.g. compost, aggregates used in roadmaking, desulphurisation gypsum used as sulphur soil conditioner). When used as input to industry, the processing is covered in the EU by the IPPC directive, and it can be assumed that the change from waste to non-waste will have known and controlled environmental effects on the stages of manufacturing and use. However, when released to the environment as non-waste, the environmental risks may not be known, especially in new applications such as rubber sport courts, or rubber roadmaking.

For the selection of waste streams it is important to understand the environmental impacts of the recycling process itself and to estimate the nature of potential risks related to these impacts when the regulatory regime changes from waste to non-waste. These impacts/risks have to be set in a comparative context to other available options. The life cycle of a recycled material includes collection, treatment and processing, product manufacturing, use, and indirectly also raw material extraction, and environmental data from all these phases is needed.

Life-cycle assessment (LCA) is one of the best documented methodologies currently used to undertake systematically these comparisons. A growing knowledge base on material recycling LCAs has been created in the 1990's and 2000's, providing a well founded basis for environmental judgment. However, LCA has methodological limitations when it comes to validity of results at EU level, because results are local-dependent and tightly intertwined with the regional technosphere, especially the energy systems. In the case of EoW assessments the objective is to assess the marginal environmental changes resulting from legislation coverage change, a type of information requiring detailed knowledge of the technosphere. In addition, one of the areas of most concern with respect to the recycling of materials is the accumulation of impurities (especially salts and heavy metals), which follow the secondary material in the form of residues of paint, coatings, etc. These substances are of environmental concern regarding toxicity impacts, through the long-term leaching and long-term accumulation of substances, which is one of the weakest areas of LCA modelling at present

The use of LCA and life-cycle studies is possible when the recycled secondary material has the same key physical and chemical characteristics for the given application as the replaced primary material, so a fair comparison is feasible. However, when a recycled secondary material does not replace any primary material, product or combinations of these, it can prove very difficult to document any reduced impacts of its application. Examples of such cases are novel applications like rubber sport courts, or the use of compost combining properties as soil structure improver and fertiliser.

It is highly improbable that the specific marginal life-cycle knowledge required for environmental judgment on EoW stream selection is found in existing LCA studies. Since the present EoW stream selection is a screening exercise, its scope is to use existing information, not to create new LCA models. The environmental criteria will be based on existing quantitative data of the differences between reuse, recycling, incineration and landfilling, well knowing that these differences document the benefits of one of these disposal options, but are not the answer to what environmental difference it makes to change the waste status.

The type of information found are results of LCA studies on waste management options, expressed using indicators such as energy (e.g. as MJ/tonne), raw material (e.g. as tonne raw material/tonne secondary material), GHG emissions (tonne CO_2-eq/tonne material), acidification emissions (e.g. as tonne H^+-eq/tonne material) or stratospheric ozone emissions (e.g. as tonne CFC-11-eq/tonne material).

However, in many cases, the spectrum of internationally accepted environmental indicators included in LCAs for which reliable information is available is not broad. Frequently, the information relates only to energy and its impacts, most often air emissions, and some water emissions. Toxicity information is frequently missing.

In the absence of a broad spectrum of environmental data and to ensure that the indicators used are operational, only the available energy and GHG data have been used, leaving the evaluation of other impact categories to the EoW criteria assessment.

Should the waste stream be screened and found suitable for further EoW assessment, one of the central elements of the further EoW criteria will be a tailored environment and health impact assessment that compares an 'end-of-waste criteria scenario' with a 'no action scenario', using a life-cycle approach. The assessment should conclude with an overall judgement of the net environmental and health impacts. For the proposed End-of-waste criteria to be acceptable, the overall balance must preferably be clearly positive, and in any case not negative, in which case the proposed End-of-waste criteria would have to be revised or the proposal withdrawn.

4.2 The selection criteria

The arguments presented above provide several possible indicators to document the fulfilment of the principles of the WFD and TSPRW, as also presented in the second and third columns of Table 3. The fourth column proposes a list of indicators that can be used as for selection. They have been chosen because they are based on data currently available in the EU27, and are therefore operational. Several other indicators can be proposed and have been considered (e.g. price volatility, risk of environmental damage), but have been discarded because they were not operational with the available data. The indicators proposed are thus quantifiable and operational proxies of use in the criteria, and the conclusions of the study have to be seen in the light of these boundary conditions.

The indicators have been clustered into 6 headings (criteria). Some of the indicators within a heading do not use primary data, but are a calculation of data from other indicators of the heading, e.g. indicator (2.c.) "recycling potential trough better waste management (tonnes/yr)" is estimated combining information on Member States' generation (indicator 1.a.) with indicator (2.b.) "current and best practice collection to recycling (%)".

The selection criteria are proposed as a complementary set of data, and have to be evaluated as a whole. For instance, if a waste material does not fulfil any primary material/product guideline or standard (indicator 5.b), this does not exclude it from further EoW consideration. If the stream is actually used, marketed and the rest of environmental and legislative conditions are fulfilled, this can be used as a sign of the existence of a property which makes it useful, not necessarily captured in a guideline or standard.

In the following sections, the selection criteria are presented and discussed, including their rationale, and the indicators needed for their quantification and interpretation.

4.2.1 Criterion 1: Not a marginal waste stream (amount and value)

Description

This criterion is to ensure that a given waste stream is relevant at EU level in terms of quantity and market value, and is not exceptional in time or geographically. The indicators suggested to cover this criterion are:

- (1.a.) Quantity: the quantity of the stream generated and recycled (tonnes/year)
- (1.b.) Coverage: the geographical coverage of the waste stream (number of Member States).
- (1.c.) Market price (€/tonne)

- (1.d.) Market dimension: total the economic value of the recycled material (€/yr). Is obtained by multiplication of average values in (1.b) and (1.d)
- (1.e.) International trade (tonnes/yr) in/out of the EU

Quantification

Table 4. Quantification data for Criterion 1 (1.a to 1.d only). Reference year for data: 2004

Indicator number →	(1.a.)	(1.a.)	(1.b.)	(1.c.)	(1.d.)	
	Waste quantity generated	Amounts sent to recycling and energy recovery	Geographical coverage	Market price	EU27 Market dimension of recycling / recovery (energy uses in parentheses)	Recycling/recovery Market evolution (##)
Waste stream ↓	Mt/yr	Mt/yr	Number of countries	€/tonne	€/year	-
Glass	21.6	10.7	EU27	UK Green:38±6 Brown:36±6 White: 38±12 Mix: 20±6 DE Green:18 Brown:22 White: 26	~200-300M	4% annually growing market 4% annually growing prices Growth in recycling expected to meet targets of Landfill and Packaging Directive.
Paper &cardboard	79.5	44.2	EU27	Large monthly fluctuations: 20-75	~1250-1700M	Well-established market in EU countries, where in 2006, ca. 50% of new paper is from recycled paper. 60-65% paper market growth in the EU27 expected 2005-2020. Growing recycled paper export to Asia. Growth in recycling expected to meet targets of Landfill and Packaging Directive
Plastics	26.2	4.5 (recycling) 4.7 (energy)	EU27	200-650 depending on type, growing with crude oil price rise. MSW plastics(60%) much lower price, and only suit for energy uses	~900-1500M (energy ~400M)	10% world market increase yearly. Growing recycled plastic export to Asia. Growth in recycling expected to meet targets of Landfill and Packaging Directive
Wood	70.5	21.7 (recycling) 24 (energy)	EU27	(-5)-30 Depending on type. Priciest clean wood chips, cheapest if contaminated	~200M (energy ~700M)	Growth in recycling expected to meet targets of Landfill and Packaging Directive, plus promotion of energy from renewables
Textile	12.2	2.8 (recycling) 1.3 (energy)	EU27	120-280 For mixed clothing waste, 50% of it for recycling, 50% for reuse	~500-600M (energy ~100M)	Demand is stable at low price levels. Prices have fallen due to poor quality of new clothes from Asia and Far East, unsuitable for recycling.
Iron & steel	102.6	77.7	EU27	236-242	~18500M	Expected to grow
Aluminium	4.6	3.1	EU27	800-1400	~2400-4200M	Expected to grow
Copper	1.4	0.86	EU27	4000-5000	~3200-4000M	Expected to grow
Zinc	1.2	0.68	EU27	1800-1850	~1300M	Expected to grow
Lead	1.0	0.63	EU27	500-1400	~300-800M	Increase demand from China to feed automobile production. The EU starts to limit the use of lead in all applications.
Tin	0.11	0.035	EU27	4000-16000 Depending on impurity content of other metals	~136-500M	The demand is increasing due to the growth of the Asian electronics sector and implementation of lead-free technologies.

Precious metals	0.0248	0.010	EU27	Gold: $20·10^6$ Silver: $0.6·10^6$ Platinum: $70·10^6$ Palladium: $14·10^6$	~5400M	-
Other metals	1.0	0.4	EU27	-	-	Ni: 3.3% annual growth. Cd: expected to grow (expanding battery market)
Biodegradable waste stabilised for recycling	87.9	28.8 (recycling) 4 (energy)	EU27	0-5(Compost)	~70M (Compost)	Growth of recovery expected to meet targets of Landfill Directive, plus promotion of energy from renewables, but constrained by e.g. the Sewage Sludge Directive.
Solvent	1.6	0.44 (recycling) 0.56 (energy)	EU27	0-150 (as secondary fuels)	~50M?	
Waste oil	7.4	2.24 (recycling) 0.8 (energy)	EU27	60-80	(energy ~50-60 M)	The quantity of waste oil is expected to decrease due to new technologies with lower oil consumption, high-performance-oils and synthetic oils
Solid waste fuel	70.1	15.1(energy)	EU27	40-80	(energy ~600-1200M)	Growth of recovery expected to meet targets in Landfill Directive, constrained by the Waste Incineration Directive
Ashes and slag	131.4	82.9	EU27	2-10	~160-800 M	Slag: expected to grow following growth of metal industry. Ashes: strongly dependent on the future use of coal and air pollution control equipment
C&D waste aggregates ***	433	272	EU27	3-8	~600-1500M	Growth of recycling expected following the 70% target of the WFD
Tyres	3.2 (includes 0.67 reuse*)	1.3 (recycling#) 0.8 (energy)	EU27	150-600 (recycling, depending on grade) 20-45 (as fuel**)	~120-400M (energy ~25-50M)	Growth of recovery expected to meet targets in Landfill Directive

Main source: (INFU/Prognos, 2007)
NOTES:
(*) Reuse and retreading. Generation figures may probably increase dramatically in the years following 2006 following the ban to landfilling of whole tyres (2003) and shredded tyres (2006) set out in EU Directive 1999/31/EC.
(**) Conservative assumption used of calorific value of 28MJ/kg
(***) See Annex V
(#) Includes recycling of rubber and steel
Market price: the average market price of the secondary material on the market. Being in this study the material categories so broad, large brackets are provided. In some products, variations are such that each recycler is said to produce a different product, with a different price (Owen, 1998).
Market dimension: A ballpark figure of the market's order of magnitude, calculated as multiplication of average values in "Amounts sent to recycling" (1.a.) and "Market price"(1.c.). This figure is not meant as substitute of a detailed market size estimation.
(##) All data until 2007, i.e., before the outbreak of the 2008 financial crisis.

Table 5. Quantification data for Indicator (1.e.) on trade in/out of the EU, 2004.

Waste streams	Imports (Mt)	Exports (Mt)	% of total EU27 generation
Glass	0.207	0.108	1.5%
Paper &cardboard	0.925	6.735	9.6%
Plastics	0.146	1.519	6.4%
Wood	1.49	0.332	2.6%
Textile	0.162	0.693	7.0%
Iron & steel scrap	7.553	12.034*	19.1%
Aluminium scrap	0.375	0.536	19.8%
Copper	0.265	0.738	71.6%
Zinc	0.005	0.123	10.7%
Lead	0.015	0.029	4.4%
Tin	0.003	0.007	9.1%

Precious metals	0.011	0.007	72.6%
Other metals	Ni: 0.017	Ni: 0.011	
Biodegradable waste			
Solvent			
Waste oil			
Solid waste fuel			
Ashes and slag			
C&D waste aggregates			
Tyres			

Source: INFU/Prognos (2007)
* includes trimmings, stamping and turnings

Assessment
Using the data collected, in can be concluded that:

- None of the waste streams analysed is marginal geographically, since their presence has been detected (as generation, not necessarily as recycled) in all EU Member States. In all EU27 it has also been possible to estimate quantitatively generation, and in most of them, the amounts recycled.
- Except for some specific metals (Cu, Zn, Sn, Ag, Pt, Au, other), the currently recycled amount of each of the analysed waste materials is above 1 million tonnes annually in the EU27.
- Market prices vary largely between materials, and also within a material, depending on the content of impurities. Market prices for metals are all positive and an order of magnitude above all other recyclables. Also positive are the prices for waste fuels (waste oil, RDF, but not solvents), textiles, plastics, tyres, glass and paper. All the mentioned materials would thus be candidates using the price indicator. Some of the materials have low market prices which can be even negative if the stream is very inhomogeneous or needs removal of some of its constituents (some C&D waste types, slag and ashes, biowaste and compost, some low grade waste solvents, some wood types). These materials would need case-by-case assessment.
- The largest markets are developed on (ranked in decreasing value) metals, paper, plastics, fuels, C&D waste, textiles, glass, and tyres.
- The development of the future European recycling and energy recovery markets depends closely on implementation of EU waste law. In most materials, recycling and recovery markets will grow as alternatives to landfilling of materials, in particular packaging materials (wood, metals, plastics, glass, paper), biodegradable waste, C&D waste, tyres, and fuels from waste. The generation of most recyclables will increase following globalisation of their markets and growth in developing economies.
- Iron and steel scrap, paper and plastics, are the waste streams most traded in/out of the EU. Assuming that this shipment is legal and for the purpose of recycling/recovery, the trade figures provide evidence of the demand of these materials. This can be assumed even knowing that low cost transport of some waste materials from EU consumption to e.g. Asia for re-processing is feasible because high volumes of consumer products need to be transported from East Asia to Europe, and transport vessels need to complete the cycle (Fisher et al., 2008). Because of data availability, the indicator uses only information of trade in/out of the EU, and not within the EU.

From the quantitative indicator results presented, it can be concluded that there are grades of importance in terms of size and value, but none of the waste streams analysed is marginal. Criterion 1 seems to be thus fulfilled for all analysed streams, or at least the fractions of them with positive market price and known specific use. The results conclude thus positively, albeit with clear differences in magnitude, on two of the conditions of the WFD, namely that (a) the substance or object is commonly used for a specific purpose, and (b) a market or demand exists for such a substance or object.

Market size figures are ballpark references and a proxy of market demand, but no more than that. The figures on market sizes have to be seen in the context of other costs of the system they are part of: collection, sorting, processing, and final disposal, plus the reference of the costs of alternative disposal routes. Thus, a recyclable may have a large market size but its operation may be fragile because there are competing alternatives which make operation run on the limit of profitability. The figures presented are thus no substitutes of a formal market size estimation.

Some references (see e.g. Ingham, 2006) use price volatility as an indicator of the robustness of the market of recyclables, and compare it to that of primary materials. It is argued that price volatility is a cause of inefficiency in the market of recyclables, and a consequence of the barriers, failures and inefficiencies of the recyclable's market. Variability tends to increase in low quality materials. In the definition phase of this study, price volatility was considered as a potential criterion candidate, but it was abandoned after detecting poor data availability on this issue in the EU27 for all the materials analysed.

4.2.2 Criterion 2: Potential for increasing recycling and recovery through better waste management

Description

A condition for promotion of the reuse[16], recycling, or energy recovery of a waste product/material is to document that these are environmentally better options to the existing waste disposal alternatives, be these landfilling or incineration without energy recovery.

A criterion is here presented quantifying the potential for improving waste management. The larger the potential for recycling, reuse and energy recovery of a given material, the more relevant becomes the cluster of policies promoting these practices, among them EoW provisions.

Current differences in performance of individual countries suggest that there is a potential for improvement of waste management systems towards higher rates of reuse, recycling, and energy recovery. Simple and operational indicators to document this potential are thus the reported national data on amounts of each material disposed of in landfills, collected separately for reuse, recycling and energy recovery. If available for a sufficiently large number of Member States and harmonised, such indicators can be used to benchmark country performance, and estimate improvement potential based on the levels achieved in other member Sates. This approach disregards many local, regional or national details explaining

[16] The exact waste management terminology employed to define the concept of *reuse* in the WFD proposal is *"preparation for reuse"*, and implies operations such as sorting or washing.

performance, but is useful as a basic estimate and proxy of an improvement potential that can be investigated in detail in a later phase. The indicators proposed for this criterion are:

- (2.a.) Current disposal (landfills and incineration without energy recovery) (tonnes/yr)
- (2.b.) Current and best practice collection to recovery/recycling (% of the quantity of waste generated), if appropriate specifying the use(s).
- (2.c.) Recovery/recycling potential trough better waste management (tonnes/yr and %), estimated against best practice. Best practice has been estimated as the average of the loss in management of the three best performing Member States. The potential figures take into account the constraints of technology, that is, the minimum fraction of non-recyclable material.

Quantification

Table 6. Generation, separate collection, losses and potential through better waste management of the shortlisted waste streams

Indicator→			(2.a.)		(2.b.)	(2.c.)	
	Waste quantity generated	Amounts sent to reuse/ recycling/ recovery	Amounts lost in management (avg. EU27)	Lost in management (avg. EU27)	Lost in management Top-3 best management practice within EU27	Recovery /recycling potential	Recovery /recycling potential
Waste stream ↓	Mt/yr	Mt/yr	Mt/yr	% of generated	% of generated	Mt/yr	% of generated
Glass	21.6	10.7	10.9	51%	DK:21,0%;AT:29,8%;DE:32,7%	4.9	23%
Paper &card	79.5	44.2	35.3	44%	SE:31,3%;DE:31,3%;BE:32,2%	10.1	13%
Plastics	26.2	4.5 (recycling) 4.7 (energy)	17	65%	DK:31,4%;SE:40,6%;LU:43,6%	6.9	26%
Wood	70.5	21.7 (recycling) 24 (energy)	24.7	35%	FI:13,5%;SE:17,7%;DK:18,8%	12.9	18%
Textile	12.2	2.8 (recycling) 1.3 (energy)	8.3	68%	DE:47,1%;DK:47,6%;BE:50,8%	2.3	19%
Iron & steel	102.6	77.7	24.9	24%	NL:14,6%;DK:17,0%;DE:17,6%	8.0	8%
Aluminium	4.6	3.1	1.6	35%	LU:14,3%;FI:25,6%;GB:27,6%	0.5	11%
Copper	1.4	0.86	0.5	36%	SE:25,7%;DK:26,7%;NL:33,3%	0.13	9%
Zinc	1.2	0.68	0.5	42%	EE:25,0%;LU:25,0%;AT:33,3%	0.16	14%
Lead	1.0	0.63	0.37	37%	AT:25,0%;DE:25,6%;LU:27,8%	0.11	11%
Tin	0.11	0.035	0.079	72%	CZ:53,6%;SI:57,1%;FI:60,0%	0.014	12%
Precious metals	0.0248	0.010	0.015	61% (!)	AT:37,5%;EE:41,7%;LV:42,9%	0.005	19%
Other metals	1.0	0.4	0.6	60%	LU:40,0% ;SE:51,6%;FI:52,9%	0.12	12%
Biodegradable waste stabilised for recycling	87.9	28.8 (recycling) 4 (energy)	55.1	63%	DE:30,5%;LU:31,1%;NL:40,2%	25.2	29%
Solvent	1.6	0.44 (recycling) 0.56 (energy)	0.63	39%	GB:30,5%;DE:30,7%;LU:31,3%	0.13	8%
Waste oil	7.4	2.24 (recycling) 0.8 (energy)	4.3	58%	DK:32,4%;CY:38,6%;BE:38,9%	1.65	22%
Solid waste fuel	70.1	15.1(energy)	55	79%	SE:44,7%;IT:64,0%;DK:65,5%	14.3	20%
Ashes and slag	131.4	82.9	48.4	37%	DE:14,5%;NL:15,5%;AT:21,8%	25.7	20%
C&D waste aggregates **	433	272	161	37%	DE: 9%;NL:5%;DK:7%	131	30%
Tyres	3.2 (incl. 0.67 to reuse*)	1.3 (recycling(1)) 0.8 (energy)	0.41	13%	AT,BE,DK,FI,FR,DE,PT, NL,SE,HU,SK: 0%	0.41	13%

NOTES:
(1) Includes recycling of rubber and steel

(*) Reuse and retreading
(**) Estimated from Böhmer et al. (2008).

Assessment
Expressed as quantity, the materials with a largest "better management potential" are C&D waste, paper, wood, iron and steel, biowaste, solid waste fuel, plastics, ashes and slag. C&D waste is by far the material with largest improvement potential both in terms of quantities and percentage of generation. In some of the rest of materials mentioned, the potential for improvement seems already well exploited, as can be detected from the expression of the potential as percentage (iron and steel, paper). In the rest of fractions, the potential is still high both in terms of quantities and percentage of generation.

Other materials with large improvement potential in terms of percentage, but not in amounts, are waste oil, precious metals (!), textiles, and glass.

The avoidance of disposal of the packaging share of some of these materials is already covered in the EU packaging policy (plastics, wood, glass, paper, metals) and the landfill directive (biodegradable waste). The new WFD includes recycling targets for household waste (with large effects on solid waste fuel) and construction and demolition waste. Therefore, progress can be expected to have taken place since the year used as reference for most of the data is 2004, while the WFD is from 2008/9). Further progress is also expected in the near future (5-10 years), which is the time scope of the targets of the mentioned directives.

It is relevant to mention one obvious limitation of the indicator (2.c.) proposed: by using the country efficiency data (a technical criterion) for benchmarking, an unfair comparison may take place in some cases on economic grounds. This is because some countries may have chosen to operate waste management systems (e.g. dual system in Germany) eventually achieving high recycling rates, but which are very expensive (up to the double than systems in other countries which also achieve high recycling rates). In the interpretation of this technical performance criterion one has to bear in mind this limitation on the different background economic conditions. The influence of outliers is partly compensated by using in the benchmarking the average of three best performers, and not only a single country.

4.2.3 Criterion 3: Higher resource substitution: current recycling effectiveness

Description
This criterion complements the information supporting the progress towards more reuse, recycling and energy recovery provided by Criterion 2, and it has likewise its rationale in the relevance of policies promoting these practices (among them through EoW provisions) if it is possible to prove that the practices are beneficial for the environment.

The criterion here presented estimates how much of the current total material generation is actually recycled. The indicator proposed is formulated as:

- (3.a.) Raw material substitution in the EU through reuse/recycling/recovery (measured as tonnes substituted raw material, and as % of generated waste material currently substituting raw material)

Quantification

Table 7. Generation, separate collection to recycling, and estimates of current raw material substitution in the EU of the shortlisted waste streams

Indicator reference→					(3.a.)
Waste stream ↓	Waste quantity generated	Amounts sent to reuse/ recycling/ recovery	Amounts substituting primary material	Amounts substituting fuel	Substitution of primary material
	Mt/yr	Mt/yr	Mt/yr	PJ/yr (Mt/yr)	% of total generated
Glass	21.6	10.7	9.6		44%
Paper &cardboard *	79.5	44.2	33.0		42%
Plastics	26.2	4.5 (recycling) 4.7 (energy)	3.6	128 (4.7)	14%
Wood	70.5	21.7 (recycling) 24 (energy)	21.3	324 (24.0)	30%
Textile	12.2	2.8 (recycling) 1.3 (energy)	2.5	20 (1.1)	20%
Iron & steel	102.6	77.7	76.9		75%
Aluminium	4.6	3.1	3.0		65%
Copper	1.4	0.86	0.8		57%
Zinc	1.2	0.68	0.7		58%
Lead	1.0	0.63	0.6		60%
Tin	0.11	0.035	0.034		31%
Precious metals	0.0248	0.010	0.009		36%
Other metals	1.0	0.4	0.4		40%
Biodegradable waste stabilised for recycling	87.9	28.8 (recycling) 4 (energy)	13	23 (4.0)	15%****
Solvent	1.6	0.44 (recycling) 0.56 (energy)	0.35	12 (0.6)	22%
Waste oil	7.4	2.24 (recycling) 0.8 (energy)	1.9	23 (0.8)	26%
Solid waste fuel	70.1	15.1(energy)	0	211.86 (15.1)	0%
Ashes and slag	131.4	82.9	72.6		55%
C&D waste aggregates ***	433	272	216		50%
Tyres	3.2 (includes 0.67 reuse**)	1.3 (recycling(#)) 0.8 (energy)	0.74 rubber 0.2 steel	32.3 (1.15)	27% rubber 7% steel

(*) Average value. Graphic paper:15-25% Tissue: 28-40% Market DIP: 32-40% Fluting: 3-6% Board:4-9%
(**) Reuse and retreading
(***) Estimated from Böhmer et al. (2008).
(#) Includes recycling of rubber and steel
**** NOTE: Biowaste is a very special case, of stream because of its large water content, which is in general not relevant for material substitution. Through composting, about a half of the wet weight of biowaste is lost through evaporation and leaching. The figures on biowaste should thus be looked at independently.

Assessment

In Table 7, it is possible to observe that the materials with largest current substitution of raw materials in the EU, expressed as quantity, are C&D waste, iron, ashes and slag, paper, biowaste, wood, waste fuel and glass. The results of the indicator allow several interpretations. Based on this information, one could argue that these streams are a priority for a detailed assessment, because the gains would be large should there be in any of them significant administrative burdens, price reductions, or perception of quality losses caused by their classification as waste. Conversely, these same data can be interpreted as signs of an actually well-functioning recycling/energy recovery of these materials in their current status as waste. If this is the case, the benefits of an end-of-waste status would probably be small despite the large amounts.

In terms of percentage, most metals (except tin and precious metals) have currently high recycling percentages. The substitution percentage values are moderately high in ashes and slag, C&D waste, glass, paper, slag and tyres. Low values in percentage combined with large amounts generated (waste oil, plastics, textiles and solvents) can be a sign of technological or material recycling limitations, but should be checked also with priority to ensure that their characterisation as waste is not hindering additionally recycling effectiveness. Again, a double interpretation is possible: high values can be interpreted as evidence of a working recycling system under the waste regime, so end-of-waste status would imply low risks, but probably also low benefits.

If data were available, a valuable indicator would be the recycling effectiveness improvement potential, understood as the extent to which a waste material can be recycled with today's known best recycling technology, given the material's physical and chemical constraints. Even for the best sorted recyclables, there is always a minimum fraction of non-recyclable material, which varies between materials. For glass packaging, it is on average ca. 96-98%, the remaining 2-4% comprises plastics, metals, food rests, paper, and other residual materials. However, such figure depends specifically on material types, the quality of sorted materials in specific regions, and the technology and performance of individual plants. In order to present such an indicator, one would need to identify individually in each of the Member State's recycling plants which are the causes of low performance and the leverage points to improve it (e.g. technology, collection practice, sorting practice).

4.2.4 Criterion 4: The environmental benefit of reuse, recycling and energy recovery vs. alternative management

Description

This criterion collects readily available information on the environmental effect of the treatment of the waste streams shortlisted. For the purpose of evaluating the overall environmental impact of a waste to non-waste status change, the information available at the aggregation level for waste materials/streams used would only be qualitative, and consist of a description of areas of environmental impact which would have to be studied in detail in a further EoW assessment. At quantitative level, the only related environmental information available is data of the potential environmental benefit compared to landfilling of reuse, recycling and energy recovery in the EU27. The following indicators are proposed:

- (4.a.) Energy savings of reuse/recycling/recovery (MJ/kg material, and total MJ in the EU27)
- (4.b.) Greenhouse gas (GHG) emission savings of reuse/recycling/recovery (kg CO_2-eq/kg material, and total kg CO_2-eq in the EU27)
- (4.c.) Estimated environmental impact categories of concern in a status change from waste to EoW (specify qualitatively)

The information of these indicators complements the environmental information provided by Criteria 2 and 3.

Indicators (4.a.) and (4.b) are means of identifying the streams where the largest potentials could be harvested if larger amounts of the streams were reused, recycled or recovered. These streams are of interest for End-of-Waste policies, to the extent that EoW policy may contribute to increase the waste management option that proves most beneficial from an environmental standpoint. The information provided by these indicators does in general not elucidate the environmental difference between a waste and non-waste status. This is envisaged as the task of the detailed EoW criteria assessment.

Some of the main sources of information for the indicators proposed are existing Life Cycle Assessments (LCAs). Coefficients expressing energy and GHG savings per kg of material, as reported in a number of reviewed LCA studies, are presented in Table 8. Figure 169 and Figure 170 in Annex VI provide a graphical representation of the results of Table 8. These figures quantify the benefits of reuse, recycling, and energy recovery of waste materials. The coefficients are expressed as the difference (in absolute or relative terms) between recycling and an alternative disposal option (landfilling, incineration with energy recovery). When a waste stream is disposed of, one assumes that a raw material is used instead.

Unfortunately, most LCA studies reviewed cover mainly or exclusively energy and energy-related impacts (greenhouse gas potential, acidification, nutrient enrichment), which is an important, but not complete part of the overall environmental impact. The mentioned impact coefficients are used in this study as a proxy of the environmental impact potential, being well aware that in order to get a broader picture of the total impact, it is desirable to include other categories such as toxicity impacts derived from heavy metal emissions.

In the absence of such data and to ensure having operational indicators for this study, the available energy and GHG data are used, leaving the evaluation of other impact categories to the EoW criteria assessment.

Combining the information of the coefficients (saving per kg material) with recorded data on current raw material substitution in the EU (Indicator 3a), it is possible to estimate the current total savings of energy and GHG emissions in the EU27 attributable to recycling of the materials shortlisted. Below, Table 8 (Figure 169 and Figure 170 in Annex VI) express the coefficients per kg of material, while Table 9 uses minimum and maximum values of these coefficients to estimate total maximum and minimum savings in the EU27. The minima are estimated using current recycling practice data. The maxima are estimated using the potential material recycling and energy recovery if all 27 Member States adopted of waste management practice reported by the best performing Member States (as presented in Table 6). In the assumption of best performance, adoption of better recycling technology is not included. Had the effect of better recycling technology been included, the potential would be even larger. However, such estimation would require site-specific knowledge which is not available in the context of this report.

Quantification

Table 8. Coefficients on savings per kg material of recycling, as reported in comparative LCA references.

Waste stream	**Alternative management options of the comparison**	**LCA coefficients of saving (>0) or loss (<0) of recycling compared to the alternative management option of incineration or landfilling (*)**	**Reference**	**Conclusion of the comparison of treatment options for the waste stream (**)**
Glass	Landfilling	Absolute savings: **0.18** kg CO_2-eq/kg**(MIN)**	Prognos, INFU and IFEU (2007)	R
	Landfilling	Absolute savings: **3.7** MJ/kg**(MIN)** 0.35 kg CO_2-eq/kg	Nolan-ITU (2005)	R
	Landfilling	Absolute savings: **3.8** MJ/kg**(MAX)** 0.39 kg CO_2-eq/kg	DoE(2002)	R
	Landfilling	Absolute savings: **0.5**±0.5 kg CO_2-eq/kg**(MAX)** Relative savings: 40±30% energy	Vrgoc et al (2006)	[R][L]

	Landfilling	Absolute savings: 0.3 kg CO_2-eq/kg	AEA(2001)	R
	Landfilling	Relative savings: 40-64% energy , 35% chlorine in wastewater, 74% SO_2-eq	INFU-Prognos (2007)	R
Paper &cardboard	Landfilling	Absolute savings: **0.82** kg CO_2-eq/kg**(MAX)**	Prognos, INFU and IFEU (2008)	R
	Paper and cardboard - Landfilling	Absolute savings: **18** MJ/kg**(MAX)** **0.4** kg CO_2-eq/kg**(MIN)**	Nolan-ITU (2005)	R
	Newspaper- Landfilling	Absolute savings: **10.1** MJ/kg**(MIN) (MAX)** **2.31** kg CO_2-eq/kg**(MAX)**	DoE(2002)	R
	Mixed paper- Landfilling	Absolute savings: **14.7** MJ/kg**(MIN)** 0.49 kg CO_2-eq/kg	DoE(2002)	R
	Cardboard - Landfilling	Absolute savings: **7.6** MJ/kg**(MIN) (MAX)** **2.68** kg CO_2-eq/kg**(MAX)**	DoE(2002)	R
	Cardboard - Landfilling	Absolute savings: **1.4** ± 1.5 kg CO_2-eq/kg**(MIN)** Relative savings: 47±12% energy	Wenzel and Villanueva (2006)	R
	Cardboard -Incineration	Absolute savings: 0.2± 1.2 kg CO_2-eq/kg Relative savings: 45±18% energy		[R][I]
	Newsprint – Landfilling	Absolute savings: **1.2** ± 1.1 kg CO_2-eq/kg**(MIN)** Relative savings: 48 ±13 % energy		R
	Newsprint – Incineration	Absolute savings: 1.0±1.4 kg CO_2-eq/kg Relative savings: 40±25% energy		[R][I]
	Mixed paper - Incineration	Absolute savings: 1.2± 1.3 kg CO_2-eq/kg Relative savings: 50 ± 14% energy		R
	Mixed paper – Landfilling	Absolute savings: **0.6** kg CO_2-eq/kg**(MIN)**	AEA(2001)	R
Plastics	PE/PP- Landfilling	Absolute savings: **0.16** kg CO_2-eq/kg**(MIN) (MAX)**	Prognos, INFU and IFEU (2008)	R
	PET - Landfilling	Absolute savings: 1.64 kg CO_2-eq/kg	Prognos, INFU and IFEU (2008)	R
	PS - Landfilling	Absolute savings: **1.7** kg CO_2-eq/kg**(MIN) (MAX)**	Prognos, INFU and IFEU (2008)	R
	PVC - Landfilling	Absolute savings: 0.74 kg CO_2-eq/kg	Prognos, INFU and IFEU (2008)	R
	PET - Landfilling	Absolute savings: 49.6 MJ/kg 1.52 kg CO_2-eq/kg	Nolan-ITU (2005)	R
	HDPE -Landfilling	Absolute savings: 46.8 MJ/kg **0.5** kg CO_2-eq/kg**(MIN)**	Nolan-ITU (2005)	R
	PET - Landfilling	Absolute savings: 30.2 MJ/kg **2.42** kg CO_2-eq/kg**(MAX)**	DoE(2002)	R
	HDPE -Landfilling	Absolute savings: 18.2 MJ/kg **1.47** kg CO_2-eq/kg**(MAX)**	DoE(2002)	R
	LDPE -Landfilling	Absolute savings: 25.8 MJ/kg **1.94** kg CO_2-eq/kg**(MIN) (MAX)**	DoE(2002)	R
	Incineration	Absolute savings: 1.9± 1.2 kg CO_2-eq/kg Relative savings: 28 ± 30% energy	Willum et al (2006)	R
	Landfilling	Absolute savings: **1.0**± 1.0 kg CO_2-eq/kg**(MIN)** Relative savings: 41 ± 31% energy	Willum et al (2006)	[R][L]

	Landfilling	Absolute savings: 68-97 MJ/kg 1.4-4 kg CO_2-eq/kg 0.019-0.025 kg SO_2-eq/kg Relative savings: Energy: 85-90% CO_2: 60-85% SO_2: 75-80%	Helker Lundström (2002)	R
	HDPE - Landfilling	Absolute savings: 0.5 kg CO_2-eq/kg	AEA(2001)	R
	Mixed plastics - Landfilling	Absolute savings: **1.8** kg CO_2-eq/kg**(MAX)**	AEA(2001)	R
	PET - Landfilling	Absolute savings: **0.5** kg CO_2-eq/kg**(MIN)**	AEA(2001)	R
Wood	Incineration	Absolute savings: (-0.84) kg CO_2-eq/kg	Prognos, INFU and IFEU (2008)	[R][I]
	Landfilling	Absolute savings: **0.05-0.06** kg CO_2-eq/kg**(MIN) (MAX)**	Prognos, INFU and IFEU (2008)	[R][I]
Textile	Landfilling	Absolute savings: **3.2** kg CO_2-eq/kg**(MIN)**	AEA(2001)	R
	Landfilling	Absolute savings: 16 kg CO_2-eq/kg (!)	Sander (2008)	R
	Incineration	Absolute savings: **7** kg CO_2-eq/kg **(MAX**(!)**)**	Sander (2008)	R
Iron & steel	Landfilling	Absolute savings: **32.9** MJ/kg**(MAX)** **0.8** kg CO_2-eq/kg**(MIN)**	Nolan-ITU (2005)	R
	Landfilling	Absolute savings: **23.6** MJ/kg**(MIN)** **2.13** kg CO_2-eq/kg**(MAX)**	DoE(2002)	R
	Landfilling	Absolute savings: 1.5 kg CO_2-eq/kg Relative savings: Energy: 74%	AEA(2001)	R
	Landfilling	Absolute savings: 1.3± 0.8 kg CO_2-eq/kg Relative savings: 55 ± 38% energy	Villanueva et al (2006)	R
Aluminium	Landfilling	Absolute savings: 171 MJ/kg **15.7** kg CO_2-eq/kg**(MAX)**	Nolan-ITU (2005)	R
	Landfilling	Absolute savings: **160** MJ/kg**(MIN)** 14.33 kg CO_2-eq/kg	DoE(2002)	R
	Landfilling	Absolute savings: **9.1** kg CO_2-eq/kg**(MIN)** Relative savings: Energy: 95%	AEA(2001)	R
	Landfilling	Absolute savings: 14±17 kg CO_2-eq/kg Relative savings: 87 ± 8% energy	Bey et al (2006)	R
	Landfilling	Absolute savings: **212** MJ/kg**(MAX)** 12 kg CO_2-eq/kg 0.13 kg SO_2-eq/kg Relative savings: Energy: 93% CO_2: 94% SO_2: 97%	Helker Lundström (2002)	R
Copper	Landfilling	Absolute savings: **208** MJ/kg**(MIN) (MAX)** **20** kg CO_2-eq/kg**(MIN) (MAX)** 1.4 kg SO_2-eq/kg Relative savings: Energy: 95% CO_2: 97% SO_2: 99%	Helker Lundström (2002))	R
	Landfilling	Relative savings: Energy: 85%	AEA(2001)	R
Zinc				(-)
Lead	Landfilling	Relative savings: Energy: 65%	AEA(2001)	R

Tin				(-)
Precious metals				(-)
Other metals				(-)
Biodegradable waste stabilised for recycling	Landfilling	Absolute savings: **(-0.01)-0.42** kg CO_2-eq/kg**(MIN) (MAX)**	Sander (2008)	[R][I][L] Lower range values for garden waste, highest for kitchen waste
	Incineration	Absolute savings: (-0.24)-0.12 kg CO_2-eq/kg	Sander (2008)	
	Landfilling	Absolute savings: 0.01-0.09 kg CO_2-eq/kg	DoE(2002)	[R][L] Lower value for food waste, highest for yard waste
	Landfill	Absolute savings: 0.4-0.7 kg CO_2-eq/kg	AEA (2001)	R
	Landfilling	Absolute savings: 0.008-0.14 kg CO_2-eq/kg	Prognos, INFU and IFEU (2008)	[R][L] Highest savings for composting with an anaerobic digestion pre-step
Solvent				(-)
Waste oil	Incineration	Absolute savings: (-15)-4.6 MJ/kg (-1.2)-0.68 kg CO_2-eq/kg Relative savings: Energy: (-15) -10% CO_2-eq: (-34)-18%	Monier and Labouze (2001)	[R][I] Depends on conditions of study and on impact category
	Incineration	Absolute savings: (-0.159) kg CO_2-eq/kg 0.000485 kg SO_2-eq/kg (-0.000015) kg PO_2^{3+}-eq/kg 0.00003 kg As/kg Relative savings: CO_2-eq: (-21)% SO_2-eq: 16% PO_2^{3+}-eq: (-14)% As-eq:17%	TSPRW(2005)	[R][I] Depends on conditions of study and on impact category
Solid waste fuel				(-)
Ashes and slags				(-)
Mixed C&D waste aggregates	Landfilling	Absolute savings: **~0** kg CO_2-eq/kg **(MIN)**	Prognos, INFU and IFEU (2008)	[R][L]
	Landfilling	**0.0097** CO_2-eq/kg **(MAX)**	Bey et al (2006)	[R][L]
Tyres	Incineration	Absolute savings: 6-15 MJ/kg 0.2-1.1 kg CO_2-eq/kg 0.003-0.005 kg SO_2-eq/kg Relative savings: Energy:12-65% CO_2:14-36% SO_2:5-9%	Villanueva et al. (2007)	[R][I]
	Incineration	Absolute savings: 0.8 kg CO_2-eq/kg	Prognos, INFU and IFEU (2008)	[R][I]

NOTE: the figures in bold, followed by (MIN, MAX) highlight the figures that have been used for the potential saving scenario calculations (c.f. Table 9).

(*) In some LCA reviews, when available, figures have been expressed as x±y symbolising (average)±(standard deviation) of all scenario results included in the LCA studies. The term *absolute* is used when weight or energy units are available. Else, *relative* values are used, as percentages.

(**) R: benefit to recycling; L: benefit to landfilling; I: benefit to incineration; square bracket letter [ ]: depends on boundary conditions; (-): no data found.

Table 9. Minimum and maximum saving of energy (PJ/yr) and GHG emissions (kg CO2-eq/yr) in the EU27 by reuse, recycling and energy recovery of materials.

NOTE: The minimum is based on current recycling practice. The maximum is the potential based on adoption of practice recorded best performing Member States. The ranges in each cell reflect variations in LCA references in reported life-cycle energy and GHG saving coefficients per kg of material (cf Table 8).

	Waste quantity generated	Amounts sent to reuse/ recycling/ recovery	Amounts substituting primary material	Amounts substituting fuel	Minimum (=current) saving in the EU27 - Energy	Maximum (=potential) saving in the EU27 - Energy	Minimum (=current) saving in the EU27 - GHG	Maximum (=potential) saving in the EU27 - GHG
Waste stream ↓	Mt/yr	Mt/yr	Mt/yr	PJ/yr (Mt/yr)	PJ/yr	PJ/yr	Gg CO2-eq/ yr	Gg CO2-eq/ yr

Glass	21.6	10.7	9.6	-	35.5-36.5	46-47.5	2-5	2-7
Paper &cardboard	79.5	44.2	33.0	-	485-594	634-776	13-27	17-35
Plastics	26.2	4.5 (recycling) 4.7 (energy)	3.6	128 (4.7)	M.R.O: 65-169 M&E: 194-297	M.R.O: 191-491 M&E: 319-619	M.R.O: 3-7 M&E: 12-16	M.R.O: 10-19 M&E: 19-28
Wood	70.5	21.7 (recycling) 24 (energy)	21.3	324 (24.0)	M.R.O: 8-20 M&E: 332-344	M.R.O: 13-32 M&E: 337-356	M.R.O: ~1 M&E: ~21	M.R.O: ~1.7 M&E: ~22
Textile	12.2	2.8 (recycling) 1.3 (energy)	2.5	20 (1.1)	M.R.O: 93-151 M&E: 113-171	M.R.O: 180-290 M&E: 200-310	M.R.O: 8-12 M&E: 9-15	M.R.O: 15-23 M&E: 16-27
Iron & steel	102.6	77.7	76.9	-	1800-2500	2000-2800	60-165	68-180
Aluminium	4.6	3.1	3.0	-	480-636	560-742	27-47	32-55
Copper	1.4	0.86	0.8	-	~165	~195	~16	~19
Zinc	1.2	0.68	0.7	-	-	-	-	-
Lead	1.0	0.63	0.6	-	-	-	-	-
Tin	0.11	0.035	0.034	-	-	-	-	-
Precious metals	0.0248	0.010	0.009	-	-	-	-	-
Other metals	1.0	0.4	0.4	-	-	-	-	-
Biodegradabl e waste stabilised for recycling	87.9	28.8 (recycling) 4 (energy)	28.2	23 (4.0)	M.R.O: (-5)-90 M&E: 17-115	M.R.O: (-10)-175 M&E: 13-200	M.R.O: 0-12 M&E: 1-15	M.R.O: 0-22 M&E: 1-26
Solvent	1.6	0.44 (recycling) 0.56 (energy)	0.35	12 (0.6)	-	-	-	-
Waste oil	7.4	2.24 (recycling) 0.8 (energy)	1.9	23 (0.8)	M&E: ~23	M&E: ~23	M&E: 0-5	M&E: 1-7
Solid waste fuel	70.1	15.1(energy)	0	211.86 (15.1)	M&E: ~212	M&E: ~410	M&E: 11-27	M&E: 22-53
Ashes and slag	131.4	82.9	72.6	-	-	-	-	-
C&D waste aggregates ***	433	272	216	-	-	-	-	-
Tyres	3.2 (includes 0.67 reuse**)	1.3 (recycling) 0.8 (#) (energy)	0.74 rubber 0.2 steel	32.3 (1.15)	M.R.O: ~ 8 M&E: ~32	-	M.R.O: ~ 0.4 M&E: 1.7-4	-

(-) No information available
(**) Reuse and retreading
(***) See Annex V.
(#) Includes recycling of rubber and steel
M.R.O: Material recycling only
M&E: Material recycling and energy recovery
1Gg = 1 Giga gram = 10^9 grams = 1 Million tonnes = 1Mt
1PJ = 1 Petajoule = 10^{15} Joules

Table 10. Qualitative estimated environmental impact categories of concern in a status change from waste to EoW (Indicator 4.c.).

Waste stream ↓	Direct exposure to the environment? Yes/No *	Impact category of concern in a waste to non-waste status change
		-
Glass	-	-
Paper &cardboard	-	-
Plastics	-	-
Wood	-	Leaching from preserved wood (only wood for recycling, i.e. wood for combustion excluded).
Textile	-	-
Iron & steel	-	-
Aluminium	-	-
Copper	-	-
Zinc	-	-

Lead	-	-
Tin	-	-
Precious metals	-	-
Other metals	-	-
Biodegradable waste stabilised for recycling	Yes. Use on land	Leaching of heavy metals and organic compounds (e.g. LAS,phenol ethoxylates, PCBs, medicin rests)
Solvent	-	Leaching from storage in non-proof container
Waste oil	-	Leaching from storage in non-proof container
Solid waste fuel	Not in general	Air emission potential from untreated organic fraction. Leaching potential of heavy metals and organic compounds
Ashes and slag	Yes, in construction applications	Leaching of heavy metals and salts
C&D waste aggregates	Yes, in construction applications	Leaching of heavy metals and salts
Tyres	Yes, in construction applications	Leaching of Zn

* In all fractions, there is environmental concern if the materials include leachable impurities, e.g. non-permanent coating, solvents or oil that can wash out from the material

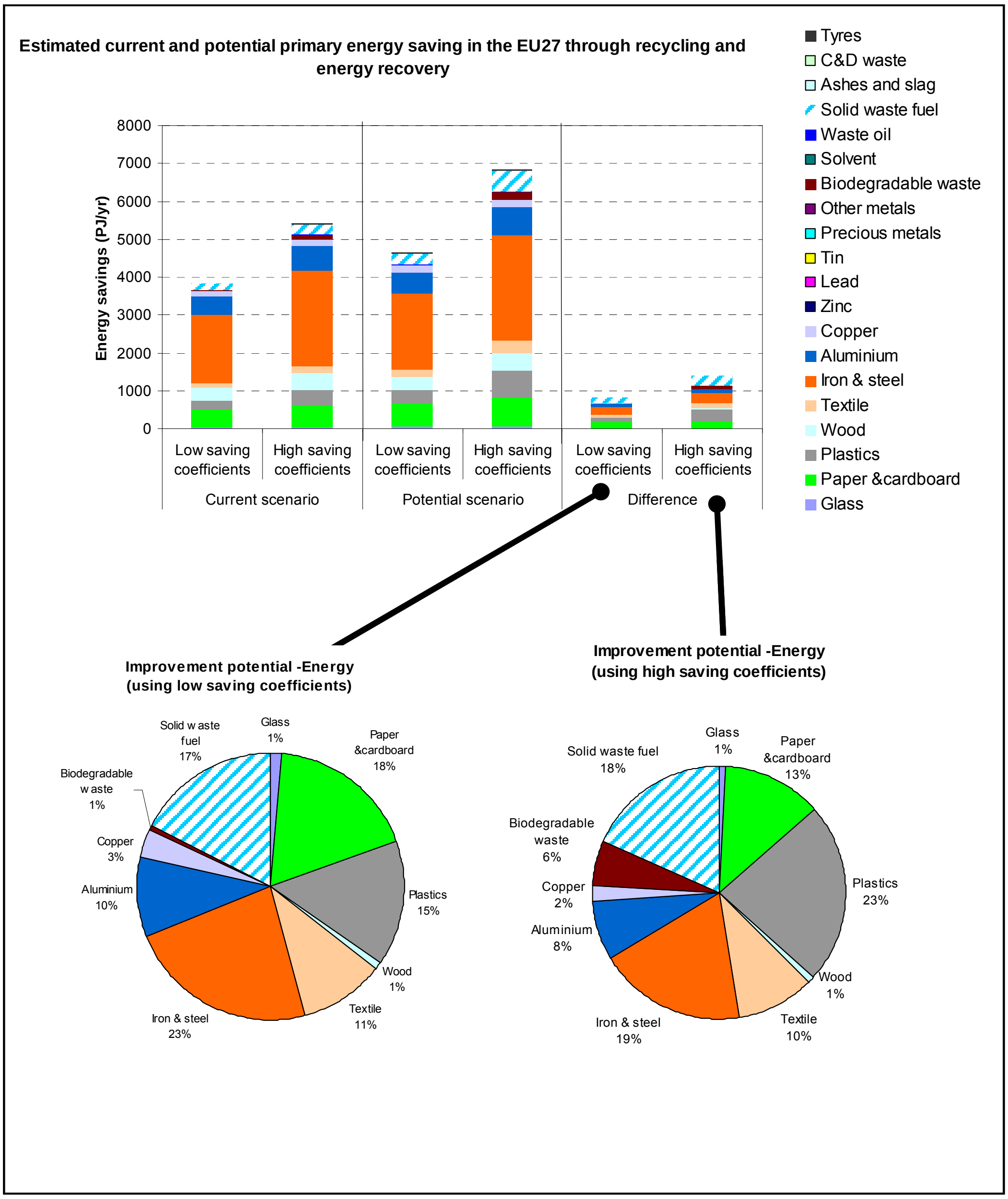

Figure 5. Saving potential of energy (PJ/yr) in the EU27 by reuse, recycling and energy recovery of materials.

NOTE: The potentials are the difference between the maximum (best performance) and minimum (current performance) scenarios presented in Table 9. Two sub-scenarios have been estimated for each indicator (energy, GHG), to reflect the range of life-cycle based energy and GHG saving coefficients per kg of material reported in LCA references (cf Table 8).

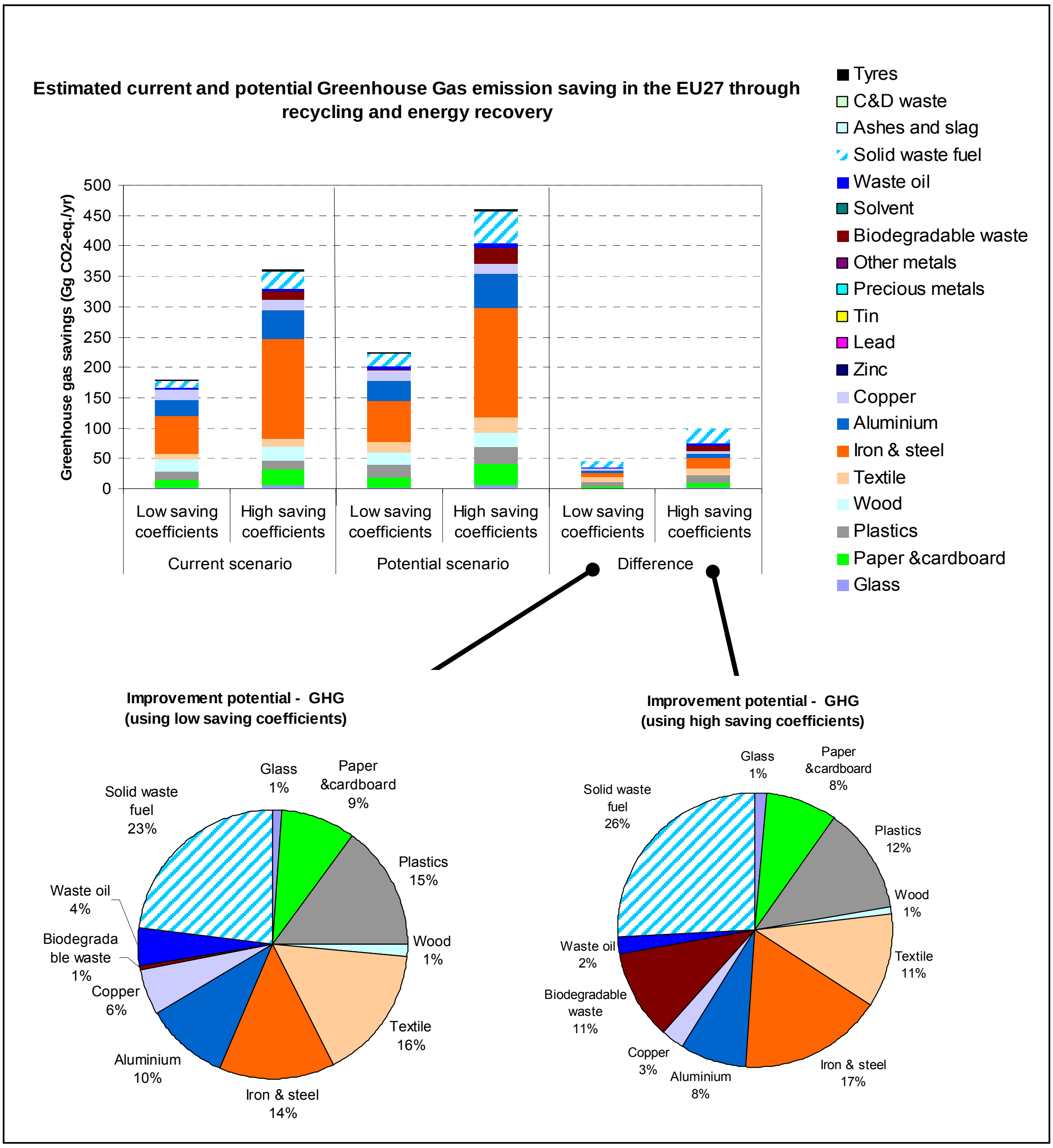

Figure 6. Saving potential of GHG emissions (Gg CO2-eq/yr) in the EU27 by reuse, recycling and energy recovery of materials.

NOTE: The potentials are the difference between the maximum (best performance) and minimum (current performance) scenarios presented in Table 9. Two sub-scenarios have been estimated for each indicator (energy, GHG), to reflect the range of life-cycle based energy and GHG saving coefficients per kg of material reported in LCA references (cf Table 8).

Assessment

The quantitative information collected documents the environmental benefit (positive or negative) of the practice of recycling and energy recovery compared to landfilling. Most LCAs reviewed report only energy and GHG emissions, and therefore only these indicators have been included.

The data presented document the cases where collection/preparation for reuse, recycling or energy recovery is environmentally justified. In many cases, energy savings by replacing primary materials, be it via reuse, recycling or energy recovery, are also observed in monetary terms through savings. In such cases, the energy balance gives a notion of the relative desirability of the recycled secondary material. This information does not answer directly what environmental difference it makes to change waste status for a given material, as expressed in the fourth WFD principle, because such question requires a specific assessment, a task that is more adequate for the detailed EoW assessment.

The materials with largest reported benefits per kg of material are metals (c.f . Table 8 and Figure 169 and Figure 170 in Annex VI). Important benefits are observed for textiles, glass, most plastics and most paper types. In the rest of materials where information was found, the savings seem case-sensitive, including rubber from tyres, waste oil, biodegradable waste, RDF, and wood. There is not enough information for drawing any robust conclusion on solvents, C&D waste aggregates, and slag & ashes, and the metal categories zinc, lead, tin, precious metals, and other metals.

Of higher relevance for prioritisation in the context of waste policy is to know the overall savings in the EU27, as depicted in Figure 5 and Figure 6. Regarding savings of primary energy (Figure 5), and restricting the conclusions to the materials where information was available (12 out of 21, see above), it is possible to conclude that the recycling and energy recovery of the following materials contribute currently to the largest energy savings in the EU27: iron and steel (43-47%), paper (11-13%), aluminium (12-13%), wood (8%), plastics (6-7%), copper (3-4%), and solid waste fuel (4-5%). The total current savings (4000-5400 PJ/yr) represent 5-7% of the total annual energy consumption in the EU27 (ca. 75 000 PJ in 2004).

From these materials, some have still an unexploited potential of increased recycling/energy recovery. Figure 5 illustrates that the magnitude of this potential would be about 25% of the current energy savings. This potential not only depends on better waste management (which relates to the amounts not currently recycled/recovered) but also on the coefficients of energy saving used in the estimation. LCA references report wide variations in these coefficients for some materials (cf. Table 8), attributable to the boundary conditions (energy substitution mainly) and characteristics of alternative waste management, which depend on local/regional conditions. The materials with highest improvement potentials (% of the total potential, not of the current savings) are iron and steel (19-23%), plastics (15-23%), solid waste fuel (17-18%), paper (13-18%), textiles (10%), and aluminium (8%). In regions where the energy system is such that fossil fuels are substituted, biodegradable waste (6%) can also be an important energy saving source.

Regarding savings of GHG emission (Figure 6), the following materials contribute currently to the largest emission savings in the EU27: iron and steel (34-45%), aluminium (13-15%), wood (6-12%), solid waste fuel (6-8%), paper (7-8%), plastics (4-7%), and copper (4-9%). The total current savings (175-350 Gg CO2-eq/yr) represent 3-6% of the total annual emissions of GHG in the EU27 (about 5 191 Gg CO2-eq in 2004).

From these materials, some have still an unexploited potential of increased recycling/energy recovery. Figure 6 illustrates that the magnitude of this potential would be similar to that of energy, i.e. about 25-30% of the current GHG savings. LCA references report even wider variations in saving coefficients than for energy, since energy sources can result in very different GHG release. The materials with highest improvement potentials are (% of the total potential) solid waste fuel (23-26%), iron and steel (14-17%), textiles (11-16%), plastics (12-15%), aluminium (8-10%), and paper (8-9%). To a lesser extent, also waste oil (6%) and copper (6%). As with energy, biodegradable waste (up to 11%) can be of interest in certain regions.

The order of magnitude of these results on energy and GHG match well with recent related assessments carried out in Germany (Dehoust et al., 2005), Denmark (Dall et al, 2003) and in the EU (Prognos, INFU and IFEU, 2008).

Regarding the qualitative impact issue identification of Table 10, it serves in this study mainly for the purpose of flagging out streams where additional environmental information from detailed environmental assessments is judged necessary in the context of definition of EoW criteria. The streams of most concern are mainly post-consumer waste streams, that is, streams where there are few or no control over their composition, in particular if combined with a use that implies direct contact with the environment, without any intermediate processing. Conversely, the streams for which no environmental concern is indicated are mostly clean fractions (in particular if they stem from pre-consumption stages) not contaminated with soluble, leachable, or putrescible matter such as paint, chemical treatments, coatings or oil, which may result in gaseous emissions or leaching, which have no special storage needs.

In addition to this, in a Global market, a raising an environmental concern not spelled out in Table 10 but affecting all materials of the list is the possible loss of control over the actual recovery/recycling of an exported stream, if it becomes non-waste. In the past, EU waste legislation objectives have concentrated much on ensuring a safe end disposal. However, with the inclusion of life-cycle thinking and the hierarchical prioritisation of resource recovery, a key objective is also to provide a consistent legislative framework to ensure that, to the extent possible, reusable, recoverable and recyclable materials are not disposed of (landfills, incineration without energy recovery) after leaving the EU boundaries.

4.2.5 Criterion 5: Control of product quality and processing technology

Description

The existence of EU-wide or international quality standards on secondary materials provides the receiver of the material with a reference on the quality of the material and the fulfilment of certain properties. These may be properties of interest for a specific application (e.g. brightness, nutrient content, particle size, density) or relevant for environmental protection (e.g. content and leaching of heavy metals). Some authors report significant benefits to the market of recyclables (e.g. plastics, Ingham 2006) by standardised grading, resulting in more transparent information and communication between sellers and buyers, of large importance in heterogeneous commodities.

EU-wide quality standards or guidelines are thus a step towards harmonisation, avoiding differences in interpretation, and helping define a level playing field for the production and use of secondary materials, be it under the waste or the non-waste regime. They are by definition the result of consensus projects, and in practice used as a warranty of quality, that help avoid conflicts of interpretation (e.g. for cross-boundary transport), help eliminate interpretation burdens, and reduce search costs, transaction costs and costs derived from unsuitability of the material.

The existence of an EU-wide quality standard/guideline is not a necessary condition for the successful exchange of a secondary material between a seller and a buyer. However, if the quality of the stream or material in the exchange is to be acknowledged in the EU, a common reference of quality is needed, and the means to ensure this is to refer to broadly accepted standards or guidelines.

EU-wide standards, guidelines or any similar reference document are therefore seen as a necessary element in the proposal of EoW criteria (cf. methodology report "End-of-waste Criteria"). In the context of selection of EoW candidates, the absence of a standard/guideline is not an exclusion criteria, but its existence is seen as a valuable element in judging whether a material is currently perceived as a product with known properties and thus a suitable candidate. Additionally, standards are set up to harmonise the conditions of offer and demand of these materials, and contribute thus as evidence of the real-life use of the materials.

The indicators proposed to cover this criterion are:

- (5.a.) Existence of guidelines or standards for quality/processing of **secondary** materials, or guidelines or standards for quality/processing of **primary** materials/products where it can be proven that they are used on secondary materials (exist/non-exist/specify).
- (5.b.) Existence of different standards for quality/processing in different EU countries hampering cross-boundary transport (exist/non-exist/specify). Existing differences can highlight the need of further harmonisation, be it through standards and guidelines only, or through EoW criteria.

Quantification /Details

Table 11. Examples of standards and guidelines on secondary materials, or on quality/processing of primary materials/products used on secondary materials.

Waste stream	5.a	5.b
	Standards existing? Specify	**EU-wide standard or guideline? Yes/No**
Glass	There are no European standards for glass cullet. Guidelines are defined at national level, and each company has its own requirements to the quality of the cullet they buy.	No
Paper & cardboard	– EN 643 - European list of standard grades of recovered paper and board	Yes
Plastics	Draft EN standards: – prCEN/TR 15353 Plastics – Recycled Plastics – Guidelines for the development of standards relating to recycled plastics – prEN 15347 Plastics – Recycled Plastics – Characterisation of waste plastics – prEN 15346 Plastics – Recycled plastics – Characterisation of poly vinyl chloride (PVC) recyclates – prEN 15343 Plastics – Recycled plastics – Plastics recycling traceability and assessment of conformity ISO 15270 - Plastics - guidelines for the recovery and recycling of plastic waste	Yes
Wood	– There are no European standards for waste wood. – The UK's Publicly Available Specification (PAS) 104 sets the minimum acceptable standards for wood chip destined for wood based panel manufacturing.	No
Textile	No standards.	No
Iron & steel scrap	– NARI standards, developed by the Institute of Scrap Recycling Industries (ISRI) and used internationally, provide the norms for classification of ferrous scrap metal. – There is no EN standard for steel scrap.	Yes

Aluminium scrap	– NARI standards, developed by the Institute of Scrap Recycling Industries (ISRI) and used internationally, provide the norms for classification of non ferrous scrap metal. – EN 13920 - aluminium and aluminium alloy – scrap. The EN standard covers all types of aluminium scrap and provides the norm for scrap classification.	Yes
Copper	– EN 12861 - Copper and copper alloys – scrap – The 'British secondary metals association' has guidelines for identifying non-ferrous metal scrap	Yes
Zinc	– EN 14290:2004 Zinc and zinc alloys - Secondary raw material	Yes
Lead	– EN 14057:2003 Lead and lead alloys - Scraps - Terms and definitions	Yes
Tin	– Scrap specifications circular, developed by the Institute of Scrap Recycling Industries (ISRI)	Yes
Precious metals	– Scrap specifications circular, developed by the Institute of Scrap Recycling Industries (ISRI)	Yes
Other metals	– Scrap specifications circular, developed by the Institute of Scrap Recycling Industries (ISRI)	Yes
Biodegradable waste stabilised for recycling	– EU ecolabels on soil improvers and growing media. – Many independent national specifications on Compost, e.g. French standard for product quality requirements for compost produced from MSW, NF U44-051, or UK specification for composted materials, BSI PAS 100: 2005.	Only partly
Solvent	No standards.	No
Waste oil	No standards.	No
Solid waste fuel	– The CEN/TC 343 working group is currently working on the development of relevant European Standards for the market for solid recovered fuels. – EURITS (European Association of Waste Thermal Treatment Companies for Specialised Waste) has published criteria for waste co-incinerated in cement plants as substitute fuel. – Finland, Switzerland, and Italy have national quality criteria and official standards.	No
Ashes and slag	– The European standards for aggregates (EN 12620, EN 13139, EN 13043, EN 13055, EN 13383) include specific requirements for slags and ashes to be used as aggregates construction material. – EN 197-1 Cement. Reference to blast furnace slag and fly ash to be used in cement mixtures. – EN 450 -1 Fly ash for concrete	Depends on type. No in some of them
C&D waste aggregates	– The European standard ‘EN 13242 - Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction’, includes clauses for recycled aggregates	Depends on type. No in some of them
Tyres	– There is a CENs Workshop agreement (CWA 14243:2002 Post-consumer tyre materials and applications). – Currently under development - prCEN/TS 14243 End-of-life tyre - Recycling - Materials, expected to be issued in 9-2008	Yes, but draft

Assessment

The conclusions that can be extracted from the collected data are conditioned by the high level of aggregation of waste streams used, which make it difficult or impossible to obtain answers valid for all sub-streams included in them. Based on the information collected, harmonisation work in the form of standards and/or quality guidelines exists currently for a number of streams:

- Metals (iron and steel, aluminium, copper, zinc, lead, tin, but also other)
- Paper
- Plastics
- Some types of slags and ashes
- Some types of C&D materials

Standards are underway for:

- Tyre granulates
- Solid waste fuel

The existence of EU-wide standards and guidelines for the mentioned waste streams/materials prove that these have currently known uses and properties that have been found convenient to specify formally, in line with products (even though they are classified as waste). These arguments support the candidacy to a more thorough EoW assessment.

4.2.6 Criterion 6: legal compliance

Description

A criterion is proposed to document instances in the EU of incorrect application of EU waste law in a Member State or conflict in its interpretation, concerning the definition of waste. This criterion is thus based on the collection of cases and examples and not on the systematic and detailed stream analysis of INFU/Prognos (2007).

The definition of waste has long been subject of discussion between national authorities, industry, and the Commission. The ECJ has been asked several times to intervene to clarify if a material is waste or not. In most cases, the situation observed is that a producer does not consider a material to be waste, but national authorities have a different interpretation and consider it waste. The producer appeals to the national courts, which have to interpret national framework waste legislation (which in the MS transposes the WFD), and ask further the ECJ for an opinion on the waste definition for specific cases.

From the perspective of the producer, the classification of a stream as waste and not as a product implies additional costs and permit requirements. A clearer interpretation would among other consequences provide a more solid base for investments in the waste management sector, would favour marketing the secondary material due to better image of the secondary material, would create trust along the recycling chain, and would avoid cases of unintentional illegal shipping that may undermine the credibility of some of the elements of EU waste policy. As example of administrative burden associated with the waste status, is the use of fly ash in road construction. Industry claims that several times the approval of the use of fly ash in construction has been delayed, hindered or avoided due to the waste status of the material. As a result, some contractors opt to use primary aggregates.

The following indicators provide useful data in this regard:

- (6.a.) Evidence of conflict in the EU (examples of reported ECJ cases)
- (6.b.) Evidence of conflict in international shipments (examples or reported cases, if possible related to interpretation of the waste definition)

Quantification / Details

Table 12. Examples of reported ECJ cases that affect the waste streams covered

Waste streams	Reported ECJ cases	Description
Glass		
Paper &cardboard		
Plastics		
Wood	EPON (C-419/97)	Waste wood from the construction and demolition sector, to be used as a fuel to generate electricity.
Textile		
Iron & steel scrap	Niselli (C-457/02) Mayer Parry (C-444/00)	Ferrous metal scrap Ferrous scrap
Aluminium scrap		
Copper	Savini (C-224/95)	Copper scrap and mixed scrap
Zinc		
Lead		

Tin		
Precious metals		
Other metals		
Biodegradable waste stabilised for recycling	Giovanni Muzi and others (C-342/94)	Olive oil residues
Solvent		
Waste oil	ARCO Chemie Nederland (C-418/97)	LUWA bottoms are one of the by-products of the manufacturing process used by ARCO, are destined for use as a fuel in the cement industry.
Solid waste fuel		
Ashes and slag		
C&D waste aggregates		
Tyres		
-- other streams --		
Mining and quarrying waste	Palin Granit (C-9/00) AvestaPolarit Chrome Oy (C-114/01) Tombesi (C-304/94)	Leftover stone resulting from stone quarrying which is stored for an indefinite length of time to await possible use. / Left over rock and residual sand from ore-dressing operations. / Marble rouble and debris
Petrochemical industry residues	Saetti and Frediani (C-235/02)	Petroleum coke, used as fuel to power the integrated combined heat and power station which supplied the refinery's steam and electricity needs.

Table 13. Examples of common destinations of international shipping of waste streams (Czarnomski et al, 2006)

Waste stream	Destination
Plastics	Tends to be exported to Asia
Electronic goods (computers, music and video devices) and domestic appliances (fridges with CFCs)	Refrigerators and CFC products tend to go to Africa
End of life vehicles, vehicle engines	Tends to be exported to Africa and also to Eastern Europe
Electronic waste	Tends to be exported to West and East Asia
Demolition waste	Bricks, iron, earth – Netherlands, Belgium
	Cable waste – East Asia
Tyres	France, Germany , eastern Europe
Wood	England and Wales
Waste with high calorific values	Germany and Wallon, cement and steel industry
Old cloths	Lithuania
Metal scrap	Spain
Lead batteries	Spain

Assessment

Table 12 shows the existence as of 2008 of ten documented ECJ cases on unclear interpretation of the waste definition, six of them on waste streams covered by this study, and the remainder on petrochemical residues and mining waste. This reflects that a clarification on the definition of waste is timely. The low number of streams covered makes it difficult to justify that the streams concerned by ECJ cases should have priority for assessment of EoW criteria. The examples provided should rather be considered as indicators of the existence of a conflict.

Regarding illegal shipment of waste, metal scrap, plastics, tyres, wood, textiles, solid waste fuel, and demolition waste were involved in 2003 in some form of illegal shipment (not necessarily *shame recovery*, but also misinterpretation of legislation), along with other non-covered streams such as electronic waste and end-of-life vehicles (Table 13). In this report it has not been possible to collect information on the status of all streams, therefore the existence of the examples reported is not considered sufficient basis for prioritisation of the mentioned streams, but merely a proof of conflict. The potential relevance of the problem is supported by the data on trade in/out of the EU provided in Table 5, which reflect that the percentage of amounts traded compared to the total generation of waste streams can be very high, up to 70% for some waste streams such as copper scrap.

If EoW provisions on streams currently shipped illegally could trigger a simplification and clarification of administrative costs, contribute to ensure the quality of the recyclable, and increase its value, this could result in savings in the treatment of the streams, and could additionally provide environmental benefits by avoiding shippings of recyclables for disposal caused by law misinterpretation.

5 PROPOSED LIST OF WASTE STREAMS

Table 14 below presents a condensed version of the results of the key indicators and criteria proposed for selection of waste streams. In addition to the figures in the cells, cells have been shaded/coloured according to the values, the redder (darker in B/W) shade being an indication of a stronger argument in favour of a detailed assessment of EoW criteria. Blank cells indicate missing, insufficient or unreliable information. Criteria 1 to 4 use quantitative data, whereas criteria 5 and 6 have a qualitative character. Some of the indicators presented in the report providing intermediate figures or supporting information have been omitted in Table 14 (indicators 1.b., 1.d., 2.a., 2.b., 4.c., 5.a., 6.b.) to enable an overview presentation format.

The systematic data collection summarised in Table 14 is an attempt to provide an objective background to the selection process. The indicators proposed are quantifiable and operational proxies of the criteria, and are complete in the sense that they address all four elements presented in the FWD, but the final number of indicators presented was conditioned by data availability. Several other indicators have been evaluated (e.g. price volatility, risk of environmental damage), but have been eventually discarded because they were not operational with existing data. The figures have to be analysed taking into account that the selection criteria are proposed as a complementary set of data, and have to be evaluated as a whole. Thus, a low score in one category does not exclude a stream from further EoW consideration. No judgement has been made on whether one or the other is more important for stream selection, i.e. weighting based on an equal scoring has been used for transparency and simplicity.

Another important consideration is that the further assessment of EoW criteria is to be undertaken on the materials contained in the selected streams, and not to the streams as such, which for reasons of data availability have been defined as broad, aggregate categories. For instance, data is available in many countries on the waste stream category "*glass*", but few of the countries collect or provide data on the existing glass subfractions (e.g. flat glass, brown glass, green glass, clear glass, electronics glass, and when relevant their subcategories). Nevertheless, it is the recyclable/recoverable material subfractions that are of interest in a detailed EoW assessment, because these are the streams with a market value and with a potential to substitute virgin materials or other products.

The presented list of streams is also heterogeneous in its level of detail: some streams cover materials from largely heterogeneous product origins (e.g. steel, from a broad range of industrial and post-consumer sources) and some streams are from a narrow product origin (e.g. glass, mainly from beverage packaging and most of it from post-consumer municipal waste). Two streams are even composed of products containing several materials: waste textiles (a product group) and waste tyres (a single product type).

In addition, when applicable, EoW criteria will be restricted to specific applications and not to all the outputs of a stream. For instance, criteria would not likely be defined on used tyres as such, but on whole tyres, on shredded tyres, on rubber granulate, on the steel scrap fraction, and if appropriate on the textile fraction. Slag is another example of a generic stream group: slag from blast furnaces has very different properties than waste incineration slag, or than any metal processing slag. While some of the slags are almost always recyclable without much further processing, some others are not.

In light of the arguments above, one of the first steps proposed for the further EoW assessment is a breakdown and specification of the subtypes or homogeneous constituent materials of concern, and a specification of the expected applications.

With the mentioned limitations on aggregation and available indicators as summarised in Table 14, it is proposed to position the 20 streams in the list based on cumulated highest values in the indicators using equal weighing, with darker/redder shades in Table 14 placed at the top of the list (e.g. ferrous metal scrap), and lightest shaded streams at the bottom (e.g. solvents, waste oil). The remaining materials of the list are placed in-between along a continuum following the high/low values of the indicators.

The indicator figures of Table 14 are the best available information collected, and are the basis for the classification. However, in some streams it is possible to make reasonable estimates on missing data, e.g. the probably high energy and GHG savings from recycling of *other metals* (Cd, Co, Ni, Hg, and alkaline), similar to the values reported in other metals such as steel, aluminium and copper. Based on such estimations, this group of other metals, and also the streams *wood* and *precious metals*, have been slightly re-positioned, as justified individually below.

On top of the positioning of streams on the list, it is proposed to group the streams of the list into three categories, based on common EoW properties:

I) Streams that are in line with the basic principles of EoW and suited for further EoW criteria assessment, since there is likely a broad range of benefits to gain from a possible EoW status of the whole stream or of some subtypes of it. In the streams under this category that have applications implying direct contact with the environment, the EoW criteria shall include limit values for pollutants where necessary, taking into account any possible adverse environmental and health effects.

II) Streams that may be in line with the principles, however it is not clear that recycling is feasible and the best option environmentally, and the management of a major fraction of these streams in the EU takes currently place via energy recovery or controlled landfilling in appropriate facilities.

III) Streams that are not considered appropriate for EoW classification, and are thus rejected.

The cut-off criteria used between categories I and II is that materials under Category II are characterised by an uncertain environmental benefit of recycling, when compared to other management practices currently operated extensively in the EU for these materials such as energy recovery or disposal in controlled landfills. This is a reflection of (a) a high potential of these materials as secondary fuels, due to high calorific values and/or their renewable origin, and (b) the possible presence of contaminants disturbing the recycling process, which are not as problematic technically in appropriate incineration processes or controlled landfills. In this study, allocation to categories I and II has been decided based on the information available. However, this is a flexible threshold, and it is assumed that a further detailed assessment of EoW can reveal that some subcategories of e.g. wood and of tyres may qualify for an upgrade to EoW candidacy in Category I, and conversely that some subfractions of e.g. plastics, textiles or biomass shall best be downgraded to Category II.

The final listing of streams, grouped in the three mentioned categories, is detailed in the following:

I) Streams that are in line with the basic principles of EoW and suited for further EoW criteria assessment, since there is likely a broad range of benefits to gain from a possible EoW status of the whole stream or of some subtypes of it. The process of elaboration of EoW criteria of most of them will require a detailed analysis concerning one or more of the environmental, legal, technical, or economic issues of the generation and application of the whole stream, or a part of it. Moreover, two subcategories can be clearly distinguished:

> I.1) Streams used as feedstock in industrial processes, a pathway that controls the risks of health and environmental damage.
>
> I.2) Streams used in applications that imply direct exposure to the environment. In these cases, the EoW criteria to be developed in the further assessment shall include where necessary limit values for pollutants, taking into account any possible adverse environmental and health effects.

On the basis of the results collected, the streams proposed for this category are presented below, supplemented with data needs and key issues for reference in the further EoW assessment:

Subcategory I.1	**Breakdown into subtypes and materials**	**Remarks**
▪ Metal scrap of iron and steel, aluminium, copper	e.g. different grades of ferrous scrap, different grades of aluminium scrap, different grades of copper scrap	Only certain fractions contaminated with coatings or oil need additional data on leachability of concern in transport and storage operations.
▪ Plastics	PET, PVC, HDPE, LDPE and PS are the main recyclables.	The sub-streams candidates for EoW criteria would cover mostly highly homogeneous and clean pre-consumer plastics fractions from industry, but also post-consumer household and commerce separate collection fractions for recycling. All other post-consumer plastics and pre-consumer mixed plastics are covered by the "solid waste fuel" stream under Category II.
▪ Paper	e.g. cardboard/ newsprint/ graphic paper	
▪ Textiles	for reuse/ for recycling/ natural fibres/synthetic fibres/industrial fractions/ household fractions	EU-wide quality harmonisation not detected, even though recycling and especially reuse are commonplace in the EU. Mixed fibre textiles are covered by the "solid waste fuel" stream under Category II.

▪ Glass	e.g. flat / beverage clear / beverage coloured / electronics	EU-wide quality harmonisation not detected, even though recycling of glass takes place in the EU (in particular packaging glass pursuing targets under the Packaging Directive 94/62/EC)
▪ Metal scrap of Zinc, Lead, and Tin	e.g. different grades of Zinc waste, different grades of Lead waste	Environmental issues concerning leaching during storage need to be specifically documented.
▪ Other metals	Cd, Co, Ni, Hg, alkaline with further breakdown	No environmental information available, but it is assumed that recycling has large benefits, as reported for other better documented metals. Environmental issues concerning leaching under storage need to be specifically documented.

Subcategory I.2

▪ C&D waste aggregates	e.g. concrete / ceramics / tiles / sand / stones	Environmental issues concerning leaching are key and will need to be specifically documented.
▪ Ashes and slag	e.g. coal power plant bottom ash, coal power plant boiler slag, municipal waste incineration bottom slag	Environmental issues concerning leaching are key and will need to be specifically documented
▪ Biodegradable waste materials stabilised for recycling	e.g. different compost types, different anaerobic treatment digestates	Environmental issues concerning leaching are key and will need to be specifically documented. EU-wide quality harmonisation currently discussed, but not yet achieved

II) Streams that may be in line with the principles, however it is not clear that recycling of the materials has an environmental benefit, when compared to other management practices currently operated extensively in the EU for these materials such as energy recovery or disposal in controlled landfills.

The categories covered are streams and materials with limited recyclability due to intrinsic property loss (e.g. wood, which can be reused in some cases, and recycled by downgrading to chipboard), high energy use in the recycling process (tyres, solvents, waste oil), or due to the heterogeneous nature (solid waste fuel) or content of pollutants (solid waste fuel, preserved wood). Pollutant content may result in potential environmental impact if the stream is not managed appropriately, i.e. in a way not less strict than under waste legislation.

Conversely, the streams in this category have high potential uses as energy sources, be it for their high heating value (tyres, solvents, waste oil, solid waste fuel) or for being of renewable origin (wood, partially tyres), which means CO2 emissions are neutral and can potentially replace the use of fossil fuels. Incineration processes may be able to handle better than recycling the heterogeneity of the stream and its content of pollutants.

In addition, since no EU harmonisation reference exists for these fractions, their low value, especially if mixed and heterogeneous, bears a risk that they are considered waste by the owner/producer and are disposed of (including incineration without energy recovery and in home stoves) instead of reuse, recycling or energy recovery in appropriate waste incinerators.

In all cases, more detailed information is needed about the subfractions and their current management routes, before they opt again for selection. On the basis of the information collected, the streams proposed for this category are presented below, supplemented with data needs and key issues for reference in a further detailed study to evaluate upgrading to EoW candidacy:

	Breakdown into subtypes and materials	**Remarks**
▪ Solid waste fuel	e.g. RDF, wood, plastics, tyres, etc. cf Table 1	Feasibility of recycling compared to energy recovery needs to be assessed. Environmental issues of gaseous emissions and leaching are of concern and need to be specifically documented.
▪ Wood	e.g. impregnated with protection chemicals, massive, chipboard, with or without metal contamination	Feasibility of recycling compared to energy recovery needs to be assessed. Environmental issues concerning leaching are key in chemically protected wood. The environmental benefit of recycling is very small, and possibly not much larger in incineration, taking into account that it is a renewable resource with CO2-neutral emissions and may substitute fossil fuel combustion
▪ Waste oil	to be developed	Feasibility of recycling compared to energy recovery needs to be assessed. Environmental issues concerning leaching under storage need to be specifically documented.
▪ Tyres	passenger car tyres/truck tyres, whole tyres, shredded tyres, material breakdown into rubber/steel/textile fractions	This is a relatively homogeneous waste stream with well-defined applications and value. However, the amounts generated are small and explain the low placement in the list. Existing LCA studies show that applications substituting rubber and using rubber's properties are better environmentally than incineration; therefore such applications may clearly upgrade to Cat. I.1. Conversely, applications as aggregate not using rubber's properties have no demonstrated benefit over incineration, so only some cases may upgrade to Cat. I.2. Environmental issues on direct exposure applications will need to be specifically documented. Leaching of Zn has so far been reported.
▪ Solvents	to be developed	Feasibility of recycling compared to energy recovery needs to be assessed. Environmental issues concerning leaching under storage need to be specifically documented.

III) Streams that are not considered appropriate for EoW classification, and are thus rejected.

On the basis of the results collected, the only stream in this category is:

- Precious metals

EoW assessment is redundant in this case and seems unnecessary, because it is evident from the prices of precious metals that they have a very high value, and only in exceptional circumstances will they voluntarily be discarded. Therefore, they can only seldom be considered as waste.

A number of materials and material stream sources have been excluded from the study because of lack of data at the aggregation level used. For instance, spent foundry sand is a stream with a clear identity, a positive market value, and known applications in cement production in Germany (UBA, 2008), where generation and flows are known, but for which it has not been possible within the scope of this study to obtain enough data or data of sufficient quality in the EU27 to conclude about their suitability for EoW assessment. Fractions like this could opt in the future for EoW candidacy if this information was more generally available. Known examples of these streams were presented in Table 1 and are summarised below:

Material stream sources	**Data availability** (as in Table 1)
- Spent railway ballast	?
- Spent foundry sand	?
- Other inert materials not considered as by-products (isolation glasswool, rockwool, glassfiber, gypsum, dust fractions collected from exhaust gases)	Some specific streams very well characterised, others not
- Other biodegradable residues from industry (e.g. digestate, sludge and filter cakes from food and beverage, pharmaceutical, paper, sugar, beet, olive oil, drinking water and wastewater treatment)	EU15 only
- Inorganic residues with agronomic value (pH adjustment) from other industrial sectors (e.g. lime, gypsum)	EU15 only
- Carbon black	?
- Catalysts	? Too many types
- Other substances (ink, dyes and pigments, extraction and separation substances such as spent kieselguhr and activated carbon, filter cakes, sludges, metal surface treatment chemicals, acids, alkalis, inorganic and organic chemicals with impurities that disable them as standard products, such as ClH with 0.5% Cl_2Fe,spent caustic soda, hydrochloric acid from flue gas purification)	Too many types. Will need breakdown.
- Contaminated glass (bulbs, cathode ray tube glass), etc.	?
- Rubber other than in tyres (hoses, toys, foams)	?
- Construction and demolition wood	?

Table 14. Overview of the results of the key indicators used for waste streams selection

Criterion	**1. No marginal waste stream (amounts and value)**			**2. Potential for more recycling & recovery by better waste management**		**3.Resource substitution effectiveness**	**4.Environmental benefit of recycling (energy recovery not included)**		**5. EU harmonisation for quality**	**6. Legal compliance**
Indicators	(1.a.) Amounts generated	(1.c.) Value	(1.e.) EU27 recycling & recovery market dimension)	(2.c.) Improvement potential	(2.c.) Improvement potential	(3.a.) Current replacement of raw materials	(4.a.) Energy benefit	(4.b.) Greenhouse gases savings	(5.b.) Existing EU-wide standard or guideline?	(6.a.) ECJ case registered?
Waste streams ↓	Mt/yr	€/t	€/year	Mt/yr	% of generated	% of total generated	PJ/yr.	Gg CO2-eq/ yr.	Yes/No	Yes/No
Glass	21.6	18-38	~200-300M	4.9	23%	44%	18-19	1-2,5	-	-
Paper &cardboard	79.5	20-75	~1250-1700M	10.1	13%	42%	149-182	4-8,3	Yes	-
Plastics	26.2	200-650	~900-1500M (energy ~400M)	6.9	26%	14%	126-323	6,9-12,4	Yes	-
Wood	70.5	(-5)-30	~200M (energy ~700M)	12.9	18%	30%	6-12	~0,6	-	Yes
Textile	12.2	120-280	~500-600M (energy ~100M)	2.3	19%	20%	86-139	7,4-11	-	-
Iron & steel scrap	102.6	236-242	~18500M	8.0	8%	75%	189-263	6,4-17	Yes	Yes
Aluminium scrap	4.6	800-1400	~2400-4200M	0.5	11%	65%	80-106	4,6-7,9	Yes	-
Copper	1.4	4000-5000	~3200-4000M	0.13	9%	57%	~27	2,6	Yes	Yes
Zinc	1.2	1800-1850	~1300M	0.16	14%	58%	-	-	Yes	-
Lead	1.0	500-1400	~300-800M	0.11	11%	60%	-	-	Yes	-
Tin	0.11	4000-16000	~136-500M	0.014	12%	31%	-	-	Yes	-
Precious metals	0.0248	0.6-70*10^{6}	~5400M	0.005	19%	36%	-	-	Yes	-
Other metals	1.0	-	-	0.12	12%	40%	-	-	Yes	-
Biodegradable waste	87.9	0-5(Compost)	~70M (Compost)	25.2	29%	15%	(-5)-83	(-0,3)-10,6	-	Yes
Solvent	1.6	0-150 (as fuel)	~50M?	0.13	8%	22%	-	-	-	-
Waste oil	7.4	60-80	(energy ~50-60 M)	1.65	22%	26%	-	-	-	Yes
Solid waste fuel	70.1	40-80	(energy ~600-1200M)	14.3	20%	-	-	-	Under development (Working group)	-
Ashes and slag	131.4	2-10	~160-800 M	25.7	20%	55%	-	~0	Depends on sub-type	-
C&D waste	433	3-8	~600-1500M	131	30%	50%	-	~0	Depends on sub-type	-
Tyres	3.2	Rec.:150-600 Ener: 20-45	~120-400M (energy ~25-50M)	0.41	13%	27% (rubber)	~8	~0,4	Yes (draft)	-

NOTE: Data has been simplified in the table for readability, the details of cells can be checked in the corresponding chapters in the report

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7 ANNEX I - WASTE STREAM PROFILES

7.1 Glass

Main findings

- The amount of waste glass generated in the EU 27 can be estimated at 21.6 Mt in 2004.
- Of these, an estimated 10.7 Mt were recycled in glass manufacturing (nearly 50%)
- Glass recycling uses less energy than manufacturing glass from sand, lime and soda.
- Glass can be reused, e.g., as returned bottles or it can be recycled as cullet.
- The glass recycling market is an international market. It is expected to grow in the next year, despite the existence of obverse trends due to returnable glass packaging.

7.1.1 Characterisation of the waste stream[17]

Overview

General characteristics
In the Glass Industry the term is usually used to refer to silicate glasses, substances containing a high proportion of silica (SiO_2) which naturally form glasses under normal conditions of cooling from the molten state.

The four main groupings of glass types are:

- soda-lime glass,
- lead crystal and crystal glass,
- borosilicate glass, and
- special glasses.

The first three of these categories account for over 95 % of all glass produced. The thousands of special glass formulations produced mainly in small amounts account for the remaining 5 %.

A typical soda-lime glass is composed of:

- 71 - 75 % silicon dioxide (SiO_2 derived mainly from sand),
- 12 - 16 % sodium oxide (‘soda’ Na_2O from soda ash – Na_2CO_3),
- 10 - 15 % calcium oxide (‘lime’ CaO from limestone – $CaCO_3$), and low levels of other components.

A typical lead crystal glass-composition is:

- 54 - 65 % SiO_2,
- 25 - 30 % PbO (lead oxide),
- 13 - 15 % Na_2O or K_2O,

[17] Basic data from EIPPCB, Reference Document on Best Available Techniques in the Glass Manufacturing Industry (December, 2001).

Plus various other minor components. Lead oxide can be partially or totally replaced by barium, zinc or potassium oxides in glasses known as crystal glass.

A typical Borosilicate glass-composition is:

- 70 - 80 % SiO_2,
- 7 - 15 % B_2O_3,
- 4 - 8 % Na_2O or K_2O, and
- 7 % Al_2O_3.

The special glass sector is extremely diverse, covering a wide range of products that can differ considerably in terms of composition.

Waste recycling

Collection and sorting.
Especially container glass is collected at local bottle banks. Most collection points have separate bins for clear, green and amber/brown glass. Such crushed glass can be recycled to new glass products. Special glasses have to be collected separately. Used bottles can also be collected separately and after cleaning are reused directly.[18]

Pre-treatment and recycling technologies.
The collected glass (crushed glass) already is of high quality, but to meet the high standards demanded by the glassworks, it must undergo further processing. Large objects are removed by manual sorting. Subsequently, the glass is crushed to a similar particle size and sorted by optoelectronic sorting systems. These systems are used to fulfil the following functions:

- Product refining

In glass recycling plants, impurities such as CSP (ceramics, stones, porcelain), ferrous metals, non-ferrous metals (aluminium, copper, lead) have to be removed from the collected glass.

Product separation
Mixed value materials have to be separated cleanly from each other.

Internal recycling
The rejected streams still contain high percentages of glass. Therefore, the materials from the previous sorting stages are processed into saleable mixed glass by reducing the reject rates to a minimum.

Before delivering the cullet to the glass factories, several quality tests are made. Only 20 g of foreign material is allowed in 1 tonne of cullet.

Preconditions and technical limitations
Collected glass should be sorted by colours and the misplacement quota should be as low as possible.

[18] Glass Recycling UK (www.glassrecycle.co.uk).

Glass recycling has no technical limitations and is economically viable since recycling requires less energy than primary glass production. But the sensitivity of the sorting systems, especially the challenge to separate difficult-to-classify material, limits glass recycling especially when high purities are required (e.g. colour purity to produce white container glass: 99,7 %). Quality considerations for special glasses highly restrict the use of external and post-consumer cullet of this glass type.[19]

The misplacement quota for separated collection is at about 2 % (range of fluctuation: 1 - 10%, depends on the sensitivity of the sorting system).

Following misplacement quotas are tolerable (requirements of the glass industry) for different types of glass:

- white glass < 0.50 %
- green glass < 15.%
- brown glass < 10.%[20]

Alternative management
Waste glass is also landfilled, incinerated without energy recovery or exported for reuse or recovery.

Environmental and health issues related to waste management:

Key issues
For every tonne of waste glass used in a furnace there is a saving of 1.2 tonnes of primary raw materials.

Per tonne of cullet used, 2 – 2,4 GJ of energy can be saved (which means 25 – 30 %), based on the fact, that the general energy consumption of the glass production is around 8 GJ/tonne.

In the EU, around 65 % of the raw material used in glass production is recycled glass.
Special glasses, lead crystal and crystal glass contain lead oxide or oxides of arsenic and antimony or fluoride (optical glasses frits), which are toxic chemicals and need to be handled accordingly.

Waste recycling process
Furnace emissions contain dust (arising from the volatilisation and subsequent condensation of volatile batch materials) and traces of chlorides, fluorides and metals present as impurities in the secondary materials.

By recycling mineral wool, emissions occur in the melting furnaces, curing oven emissions will contain volatile binder components, binder breakdown products, and combustion products from the oven burners.

[19] Eckhard Zeiger, Glass Recycling with Mogensen Sorting and Screening Systems, Aufbereitungs Technik 46 (2005), Nr. 6.

[20] AEVG- Abfall-, Entsorgungs- und Verwertungs-GmbH, Fehlwürfe in der kommunalen Abfallwirtschaft; Tolerierbar oder unzumutbar? (December, 2005).

In the recycling of ceramic fibre, emissions of particulate matter that may contain fibre can occur; this ceramic fibre is classified as category 2 carcinogen, and can therefore cause serious health problems.

Market

Glass industry
In 2005, 32.6 Mt of glass were produced and 195,800 people were employed in the EU glass Industry (EU 25, estimates). The most important EU glass producers are Germany, France and Italy.

The European glass market represents 27 % of the world market, followed by the US (over 20 %) and Japan (18 %).

The EU glass industry is divided in following sectors:

- Container glass production is the largest sector of the EU Glass Industry (60 % of the total glass production) The sector covers the production of glass packaging, i.e. bottles, jars and some machine-made tableware, made from a basic soda lime formulation. The average rate of utilization of post-consumer waste within the EU Container Glass Sector is approximately 50 % of total raw material input, with some installations utilizing up to 90 % waste glass.
- The flat glass sector represents around 22 % of the total glass production and covers the production of flat glass and rolled glass with a basic soda lime formula.
- The production of continuous filament glass fibre is one of the smallest sectors and covers the manufacture of continuous glass filaments for the reinforcement of composite materials.
- The domestic glass sector covers the production of glass tableware, cookware and decorative items and is one of the smaller sectors of the Glass Industry with approximately 4 % of total output.
- The special glass sector produces around 6 % of the Glass Industry output. Most internally produced cullet is recycled on-site. However quality considerations have restricted the use of external and post-consumer cullet in the process.
- The mineral wool sector represents approximately 6 to 7 % of the total output of the Glass Industry. The sector covers the production of glass wool and stone wool insulating materials. The most important market for mineral wool is the building industry, which takes up to 70 % of output.
- Ceramic fibre is mainly used as a high temperature insulation material.

The principal application of glass frit is in the manufacture of ceramic glazes and pigments.

Over the past 20 years, glass demand has grown more quickly than the GDP. In 2005, a strong global growth was observed, bolstered by China. In the long run, glass demand will still be growing at a rate of over 4 % per annum.

Recycling market
As glass recycling uses less energy than manufacturing glass from sand, lime and soda, the demand for glass waste is growing.

Different types of glass can be recycled, but only container glass can be turned into furnace-ready cullet. Each type of glass has a different chemical make-up that alters its capability to be recycled. The success of glass recycling depends on the collection system and the processes to free glasses from contamination.

The European glass recycling market has a long tradition. Some 30 years ago, the glass industry began to take back used glass and to recycle it into new bottles and jars.

The main markets for cullet are manufacturers of recycled glass containers. Most of the glass that is recycled is turned into new bottles or jars. But glass is also used as source of aggregate fill for construction sites or roads.

The demand for glass and glass collection is growing in all EU member states. The main drivers are:

- the EU Packaging Directive demanding to recycle up to 60 % in 2008, but also
- the Landfill Directive, as well as
- the EU document “Management of Construction and Demolition Waste” published in 2000.

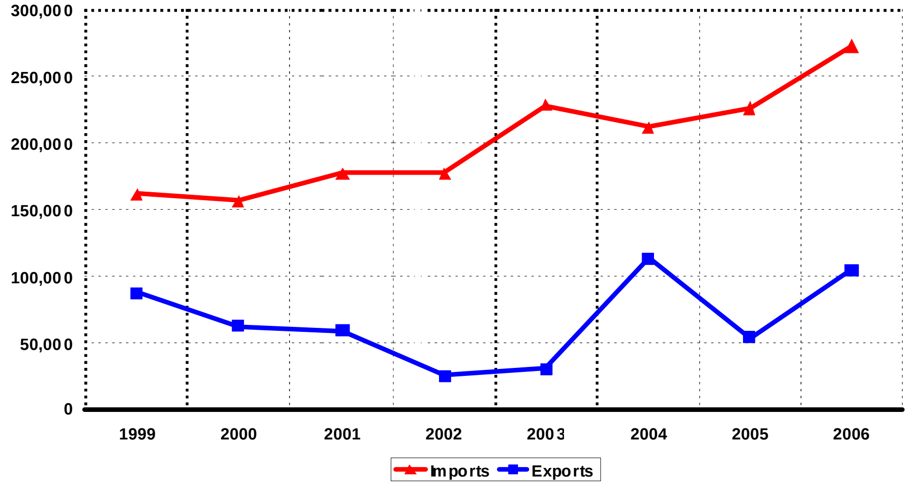
Collection and recycling of waste glass is supported by several national specific regulations, especially regarding separate collection systems.

The glass recycling market is an international market.

Since 1999, EU 27 imports of cullet and other waste and scrap of glass have been significantly exceeding exports. Imports have seen an increase of 68 % between 1999 and 2006. In 2006, EU 27 imported about 273,000 tonnes of cullet and other waste and scrap of glass.

Over the last 8 years, exports have fluctuated. From 1999 to 2002 exports decreased from around 87,000 tonnes to 24,000 tonnes. A catch-up in 2004 was followed by a drop of 52 % in 2005. In 2006, exports reached nearly the same level as in 2004.

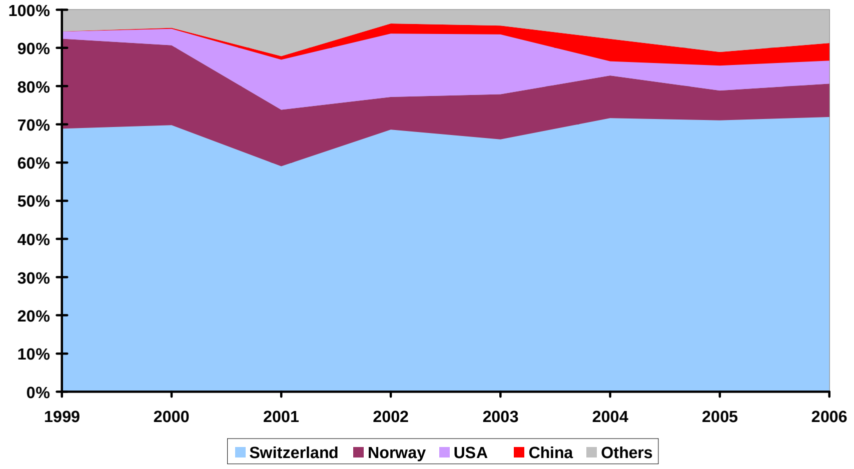
Figure 7: EU 27 cullet and other waste and scrap of glass trade 1999-2006 (tonnes)



Source: COMEXT

Since 1999, Switzerland has been the main supplier of cullet and other waste and scrap of glass to the EU 27. While imports from Norway decreased from 24 % of total EU 27 imports (1999) to 9% (2006), Switzerland consolidated its position as the major exporter to the EU. With 196,169 tonnes in 2006 it accounted for 72 % of total EU 27 imports.

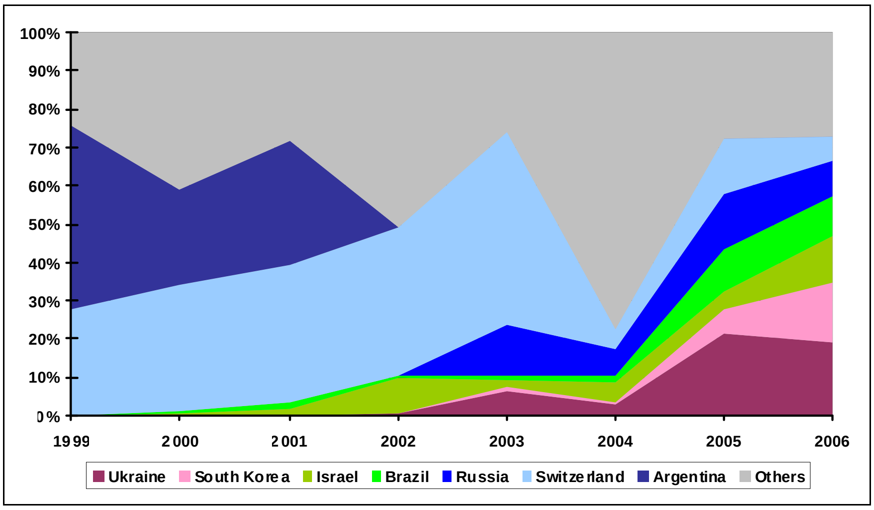
Figure 8: Share of EU 27 cullet and other waste and scrap of glass imports 1999-2006 by origin



Source: COMEXT

As regard exports, in 1999, Argentina (45 %) and Switzerland (26 %) were the main destinations for EU cullet and other waste and scrap of glass exports. In 2003, exports to Switzerland accounted for around one third of total EU 27 exports representing 10,500 tonnes. In 2006, EU 27's main destinations were Ukraine at 18,482 tonnes (18 %), South Korea at 14,823 tonnes (14 %) and Israel at 11,909 tonnes (11 %).

Figure 9: **Share of EU 27 cullet and other waste and scrap of glass exports 1999-2006 by destination**



Source: COMEXT

Market prices

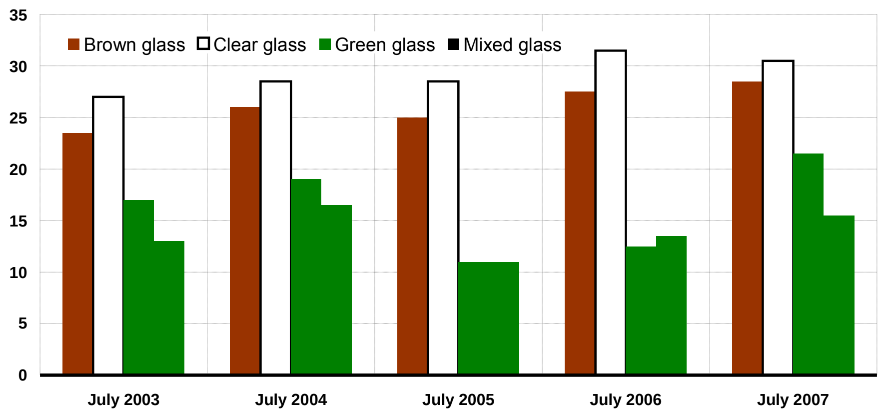
As an important secondary raw material, waste glass has a positive market price. The market price mainly depends on the quality and type of glass (the highest prices are reached for white glass). Even if the market prices differ depending on country and glass waste quality, the market prices show an upward trend.

Example:

After the decrease in glass container prices in 2004 and 2005, the prices for container glass in the UK slightly went up. Especially the price for green glass increased strongly between 2005 and 2007. In July 2007, the average prices were the following (in brackets: changes relative to 2005):

- Green glass: £ 31 per tonne (+ 182 %),
- Brown glass: £ 29 per tonne (+ 16 %),
- White glass: £ 31 per tonne (+ 7 %),
- Mixed glass: £ 16 per tonne (+ 45 %).

Figure 10: **Evolution of glass container prices in the UK**



Source: www.letsrecycle.com

Between 2003 and 2005, the following fixed compensations for container glass in Germany were paid by the GGA (Gesellschaft für Glasrecycling und Abfallvermeidung mbH) according to the price sheet for waste glass[21]:

- Green glass: 17,72 € per tonne,
- Brown glass: 22,14 € per tonne,
- White glass: 25,83 € per tonne.

7.1.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream glass. As different statistical data sources were used, the equivalent waste groups on a EWC-STAT basis were identified according to the official equivalence table.

Table 15: Waste sources for the waste stream glass

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazardous
II	150107	glass packaging		**07.1**	Glass wastes	☠/⚐
	101111	waste glass in small particles and glass powder containing heavy metals (e.g. from cathode ray tubes)				
	101112	waste glass other than those mentioned in 10 11 11				
	160120	glass				
	170202	glass				
	191205	glass				
	200102	glass				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170204*	glass, plastic and wood containing or contaminated with dangerous substances	☠	**12.1******	Construction and demolition wastes	☠/⚐
	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03				
IV	101109	waste preparation mixture before thermal processing containing dangerous substances	☠	**12.3******	Waste of naturally occurring minerals	☠/⚐
	101110	waste preparation mixture before thermal processing other than those mentioned in 10 11 09				
	101115	solid wastes from flue-gas treatment containing dangerous substances	☠	**12.4**	Combustion wastes	☠/⚐

[21] Bundeskartellamt, Beschluss im Verwaltungsverfahren B 4 – 37203 – Kc – 1006/06 (31.05.2007).

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazardous
	101116	solid wastes from flue-gas treatment other than those mentioned in 10 11 15				
	101103	waste glass-based fibrous materials		**12.5******	Various mineral wastes	☠/⚐
	101105	particulates and dust				
	101113	glass-polishing and -grinding sludge containing dangerous substances	☠			
	101114	glass-polishing and -grinding sludge other than those mentioned in 10 11 13				

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered glass waste amounts were estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of waste glass is necessary. The considered glass waste amounts were estimated as described in the Introduction.
*** Allocation of waste sources to the sources group in the flow sheet
I Municipal solid waste (MSW) and bulky waste
II Glass packaging and other glass waste (including separate collected fractions from MSW and separate recorded glass waste from industry, construction & demolition such as treatment processes (as described in the table "waste sources"). For member states with EWC-6-digit-level data basis are considered only separate selected fractions 200102 and waste from treatment 191205).
III Demolition and construction waste (including code 170202 for member states with EWC-6-digit-level data basis)
IV Production and industrial sources (including codes 101111, 101112 and 150107 for member states with EWC-6-digit-level data basis)
V End-of-life-vehicles (including code 160120 for member states with EWC-6-digit-level data basis)
**** Data available only for the aggregated group "12.1 to 12.5 not 12.4"

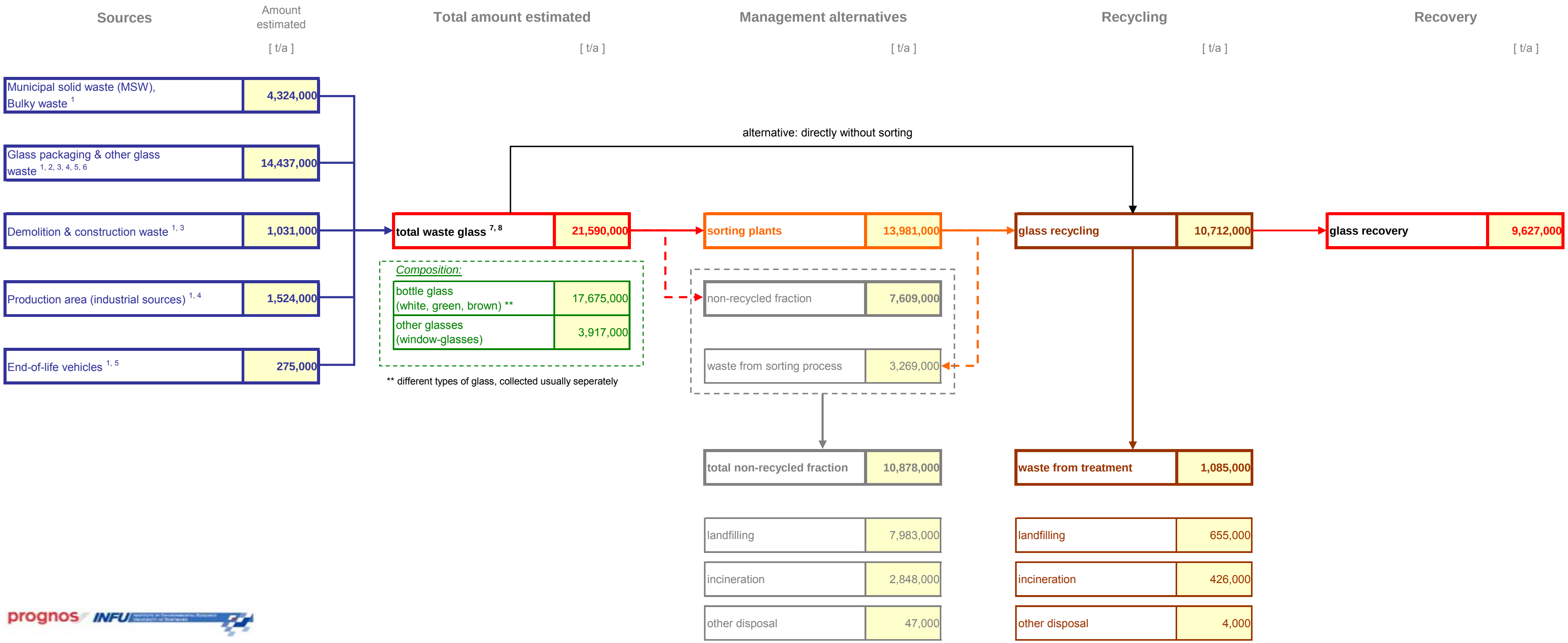
7.1.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream glass could be compiled.

Notes related to the flow sheet:

1. Sorting or separation of these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "glass packaging & other glass waste". Separate data available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI, DE). Their share amounts to 4.1 Mt.
3. Glass collected separately from construction & demolition waste (170202) is included in the group "glass packaging & other glass waste" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "construction & demolition waste".
4. Glass collected separately from production and industry (101111, 101112, 150107) is included in the group "glass packaging & other glass waste" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "production and industrial sources".
5. Glass collected separately from end-of-life-vehicles (160120) is included in the group "glass packaging & other glass waste" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "end-of-life-vehicles".
6. Includes also glass waste from treatment processes, which are part of the aggregated group "glass packaging & other glass waste". Separate data is available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI, DE). Their share amounts to approx. 231,000 tonnes.
7. Data for Latvia and Portugal is available only for municipal and commercial waste, no information available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic was compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.

Figure 11: Estimation of waste glass flow (all figures rounded to thousands)



The main sources for waste glass as the starting point of the waste flow sheet is on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as the following.

Due to the usage of at least two different data sources (EWC and EWC-STAT)

- Glass packaging waste collected separately from municipal solid waste is not reported separately, but included in the group “glass packaging & other glass waste”, as separate data are only available for member states with EWC data base.

- Glass from construction and demolition sources covers potentials from mixed C&D fractions and C&D fractions with dangerous substances. Separately collected fractions (170202) are included only for member states with EWC data base. For all member states with EWC-STAT data base, these amounts are included in the group “glass packaging & other glass waste”, because an disaggregating data is not possible due to lack of information.

- Glass from production and industry sources covers potentials from minerals and combustion wastes. Separately recorded fractions (101111, 101112 and 150107) are only included for member states with EWC data base. For all member states with EWC-STAT data base, these amounts are included in the group “glass packaging & other glass waste”, because disaggregating data is not possible due to lack of information.

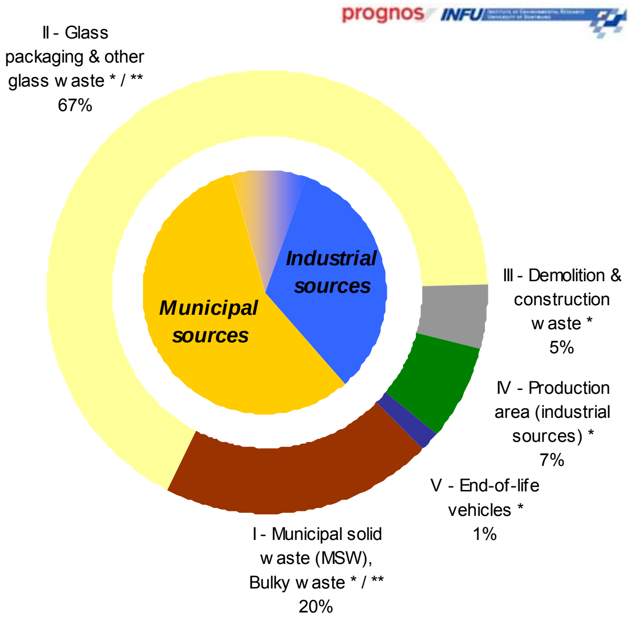
- Glass from end-of-life-vehicles covers potentials from mixed end-of-life-vehicle fractions and end-of-life-vehicle fractions with dangerous substances. Separately collected fraction (160120) is only included for member states with EWC data base. For all member states with EWC-STAT data base these amounts are included in the group “glass packaging & other glass waste”, as disaggregating data is not possible due to lack of information.

- Glass from waste treatment processes is not reported separately, but also included in the group “glass packaging & other glass waste”, as separate data is only available for member states with an EWC data base.

In total, the amount of waste glass generated in the EU 27 was 21.6 Mt in 2004, of which 57% to 67% is originated from MSW[22].

[22] No better estimates can be provided because the aggregated group “glass packaging & other glass waste” includes glass fractions from both MSW and from production and commercial sources.

Figure 12: Estimated waste glass generation by sources



* please take into consideration also notes referring to Table 25and Figure 11
** includes waste fractions from MSW

The amount of waste glass collected separately or collected and then separated in sorting plants with the objective of recycling[23] was estimated at nearly 14 Mt in 2004. Taking into account the losses during the sorting process, about 10.7 Mt of glass waste were returned to glass manufacturing industry for recycling. With the consideration of any further losses during the recycling processes, the total recycled secondary glass amounted to about 9.6 Mt in 2004. Therefore, the estimated share of the waste glass for recycling as compared to the total estimated waste glass generation (rate of recycling) was about 50% at the level of the EU 27, also shown in

[23] Total generated glass waste amount less directly disposed glass waste fractions.

Figure 13.

At country level, the generation and rate of recycling differ from country to country, as also shown in

Figure 13. Austria, Belgium, Denmark, Germany, and the Netherlands record the highest waste glass recycling rate of more than 60 %.

Figure 13: Recycling potentials in kg per capita. (2004)

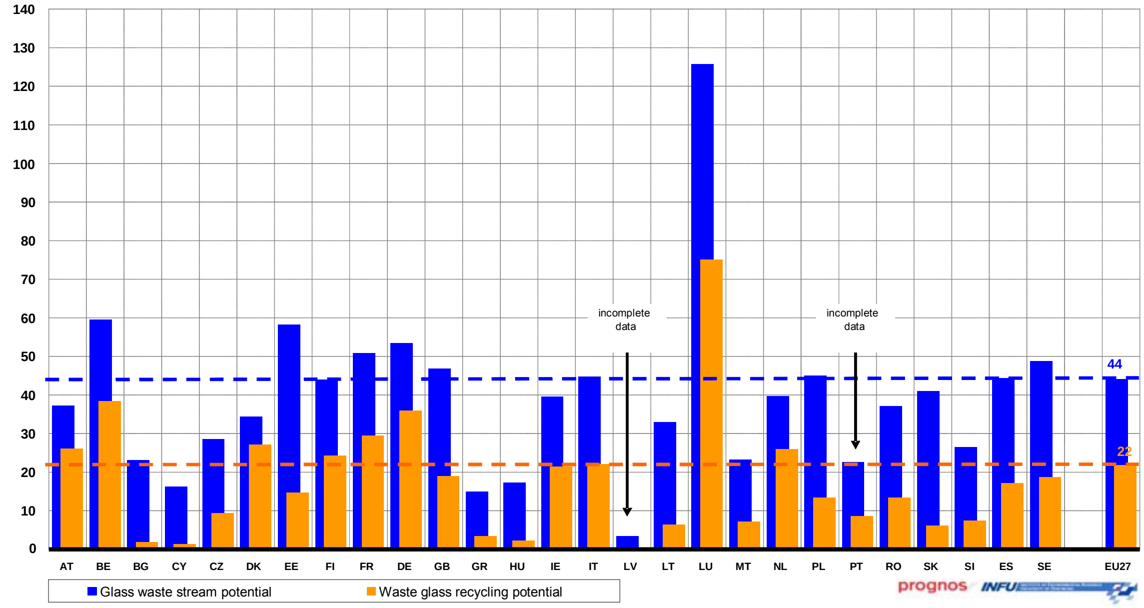


Figure 14 shows the estimated total amount of waste glass by different waste management alternatives, and the

Figure 15 presents the same data but in percentage. The figure shows that landfilling of glass still account for 37% of the waste glass generated and, in many member countries; it is the dominating waste management alternative accounting for as high as more than 90%.

Figure 14: Management alternatives for waste glass (in '000 tonnes)

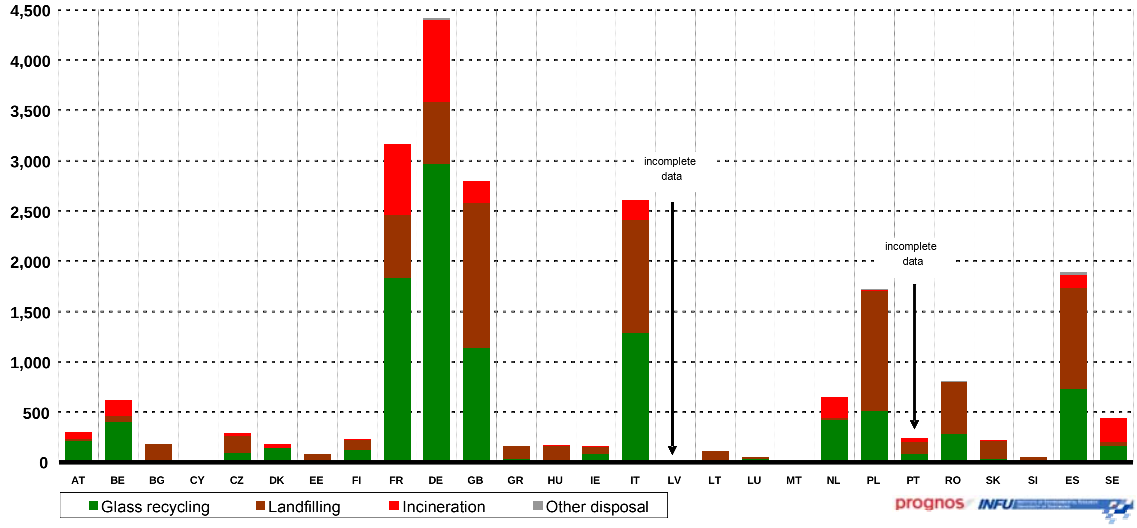
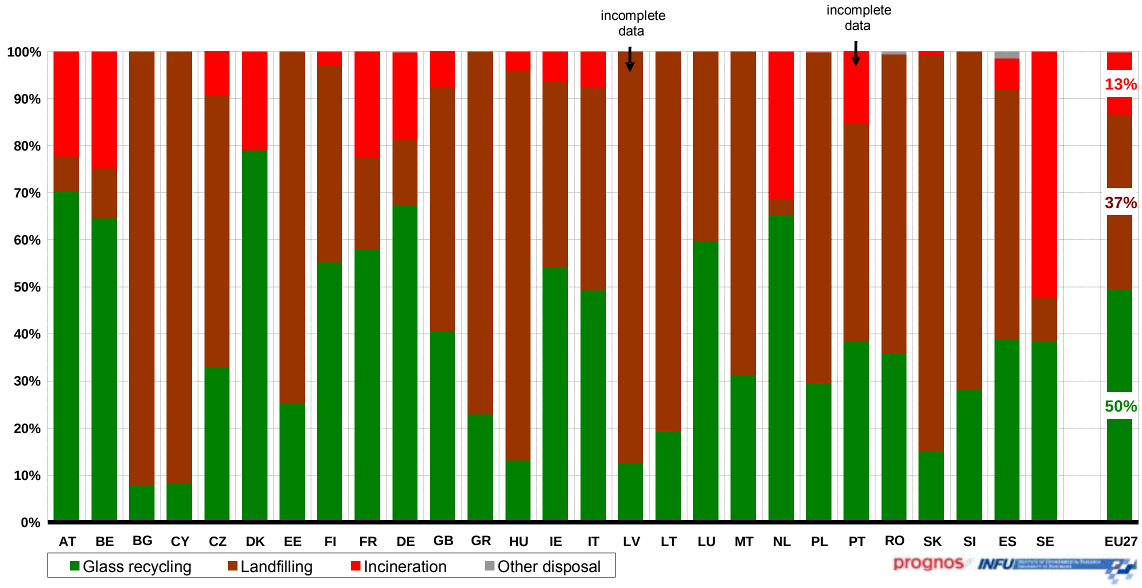


Figure 15: Estimated share of alternatives in waste glass management (2004)



7.2 Paper and cardboard

Main findings

- The amount of waste paper generated in the EU 27 can be estimated at 79.5 Mt in 2004.
- Of these, an estimated 44.2 Mt were recycled in paper manufacturing (55.6%).
- Paper generally has a low hazard potential. Recycling of paper uses less energy than virgin paper production.
- The paper recycling market is an international market and expected to grow during the next decade. Potentials are mainly in the new member states. Further investments will be made in several European countries into research for innovative waste paper recycling technologies as well as material utilization of residual materials. The development is also reflected in growing market prices.

7.2.1 Characterisation of the waste stream

Overview

General characteristics
Waste paper is sorted and graded and then delivered to a paper mill. The fibres are progressively cleaned. After cleaning, the fibres are ‘slushed’ into pulp and large non-fibrous contaminants are removed (for example staples, plastic or glass). Afterwards they are filtered and screened through a number of processes to make them more suitable for paper production.

For certain uses (like the production of graphic and hygienic papers), the fibres have to be de-inked.
On average, the collected waste paper in Europe consists of the following quality categories:

- 42% de-inked paper,
- 37% corrugated paper,
- 21% mixed other paper.

The share of the types of paper in the collected paper waste constitutes the following (in Europe):

- 17% in graphic paper,
- 70% in packaging paper,
- 43% in sanitary paper,
- 41% in other paper[24].

Waste recycling

Collection and sorting
The collection methods applied to waste paper depend on the respective paper source. Sources with huge amounts of paper waste like industries or commercial businesses have their own

[24] Grossmann, H.;Bilitewski, B.:”Closing the material loops – paper recycling in Germany and Europe”; TU Dresden, 2005.

collection equipment. Some countries collect old newspapers and magazines from households separately from paper and board packaging; others collect all sorts of paper together. Separate collection is important, since it is imperative that paper and board for recycling is collected separately from e.g. other household waste in order to maintain an adequate level of purity.

Pre-treatment and recycling technologies

- Processes with exclusively mechanical cleaning, i.e. without de-inking. They comprise products like test liner, corrugating medium, board and carton board.
- Processes with mechanical and chemical unit processes, i.e. technologies with de-inking (optional processes with flotation de-inking, wash de-inking and ash removal and a final bleaching). They comprise products like newsprint, tissue, printing and copy paper, magazine papers (SC/LWC), some grades of carton board or market DIP. After repulping, the recovered paper has a pulping consistency fit for subsequent treatment. Some chemicals such as de-inking agents and NaOH are often added as pulping additives. Usually the detachment of inks already begins in the repulping stage. The removal of mechanical impurities is based on the differences in physical properties between fibres and contaminants - such as size or specific gravity - relative to fibres and water. The rejects of these cleaners as well as of the pulper disposal system, high content of inorganic material, usually have to be disposed of by landfilling or have to be further treated.

The amount of residues (including both rejects and sludge) in refractory ceramic fibre (RCF) based paper mills is the result of the quality of the waste paper used as raw material and the effort and expense made in preparation of secondary fibres for certain product and process requirements. The generated rejects and sludge amount to about 15 to 40 % of the input of raw material.

Figure 16: Amount of residues related to the input of raw material [%] depending on qualities of recovered paper used and paper grade produced

			Rejects		Sludge		
Product	**Recovered paper quality**	**Total losses**	**Coarse/Heavy**	**Fine/Light**	**Deinking**	**Process Water Clarification**	**Waste water**
Graphic paper	Newspaper, magazines, higher qualities	15 - 20 10 - 25	1 - 2 <1	3 - 5 <3	8 - 13 7 - 16	2 - 5 1 - 5	1
Tissue	Office recovered paper, files, ordinary and medium qualities	28 - 40	1 - 2	3 - 5	8 - 13	15 - 25	=1
Market DIP	Office recovered paper	32 - 40	<1	4 - 5	12 - 15	15 - 25	=1
Testliner/ Fluting	Shopping centre waste, recovered paper from housholds, kraft qualities	4 - 9 3 - 6	1 - 2 <1	3 - 6 2 - 4	_ _	0 - (1) 0 - (1)	=1
Paper board	Shopping centre waste, recovered paper from housholds	4 - 9	1 - 2	3 - 6	_	0 - (1)	=1

Source: Best Available Techniques in the Pulp and Paper Industry, 2001, page 249

Preconditions and technical limitations

Number of re-use cycles:

Every time fibres are recycled they lose strength and after being re-used six times they are no longer strong enough for paper making.

For an effective use of recovered paper it is necessary to collect, sort and classify the materials into suitable quality grades. These are:

- packaging paper and paperboards (testliner and corrugated medium)
- newsprint, simple printing and writing papers
- lightweight coated paper/supercalendered paper (LWC/SC) papers, high-grade printing and writing paper
- tissue and market de-inked pulp (DIP).

The material grade loss indicates the ratio at which the recycled material can displace virgin material will decrease. This ratio is not more than 1:0.8 for any paper or cardboard category.

Alternative management

Non collectable quantities

There is an amount of at least 5 - 6 % (of all the paper on the market) of non-collectable paper and board (archives, wall papers, hygiene papers, etc.) which is transferred to landfills, incinerators or other waste treatment systems.

Environmental and health issues related to waste management-

Key issues

Waste paper generally is not considered hazardous waste. Dust may occur during the treatment and recycling process. In some cases, very sensitive persons can be affected by additives such as dyes containing heavy metals, biocides or brighteners.

Recycling of paper uses less energy than virgin paper production. The Energy Information Administration (EIA) states that "a paper mill uses 40 percent less energy to make paper from recycled paper than it does to make paper from fresh lumber."[25] The Bureau of International Recycling (BIR) estimates the energy saving at 64% - a figure significantly higher than the EIA's estimate. Furthermore, BIR expects 35% less water pollution (chlorine) and 74% less air pollution (sulphur dioxide).[26]

Paper recycling saves timber as a basic resource. Every tonne of paper that is recycled saves 17 trees of being cut down for virgin paper production.[27]

Waste recycling process

[25] EIA, Recycling Paper & Glass Accessed October 18, 2006.

[26] BIR, Information about Recycling. (May 20, 2007).

[27] Environmental Protection Agency, 1990, Pamphlet: Let’s reduce and recycle: Curriculum for solid waste awareness (http://books.google.com/books?vid=ISBN0941375412&id=yPPeL376t2AC&printsec=frontcover&dq=recycling+landfill&as_brr=1#PP P1,M1).

The waste paper, which is disposed or incinerated, contains impurities like metals, plastic, glass, textiles, wood, sand and building materials, synthetic materials and "synthetic papers". The quantity of impurities separated depends on the collection system: separate collection: 0 - 4 % of the total paper waste; mixed collection 8 - 30 %, (Average: 5 - 10 %).

In most cases, wastewater from the production of paper out of virgin pulp has a higher chemical oxygen demand (COD) than wastewater from the production of recycled paper. Basic environmental differences between the two main recycling technologies are: with de-inking (8 - 15 m3 wastewater/t, COD: 2 - 4 kg O2/t) or without de-inking (<7 m3 wastewater/t, COD: 0.5 – 1.5 kg O2/t).

Emissions to the atmosphere are mainly a result of electricity power generation that uses fossil fuels onsite.

Paper is a biodegradable material, which means that it produces methane at the landfill site. Methane is a potential greenhouse gas and has 23 times more Global Warming Potential than that of carbon dioxide at 100 years time horizon.

Market

Paper industry
The European paper production has been constantly growing over the last 10 years. This applies mainly for packaging and other graphic papers, while newsprints, sanitary and household papers have been growing at a slower pace. Paper consumption in Europe has been growing analogously.

The European paper industry is a growing sector operating in a global market. European countries have a share in world paper production of about 30% and a share in world paper consumption of 27%.

Two different market-development-scenarios drawn up by ETC/RWM 2005 for the EU 15 envisions an increase of paper consumption of 60 % to 65 % in the next 15 years in the baseline scenario and 40 % to 45% in the low growth scenario. The major growth rates are forecast for Spain and Portugal (90% - 100 %), but also Austria and the UK can expect to see considerable increases. In contrast, the development in Denmark is estimated to be very low with less than 10 %.[28]

Recycling market
Waste paper and cardboard are already significant sources of (valuable) raw material.
The ERPC (European Recovered Paper Council) informed in October 2007, that the current paper recycling rate is 63%.

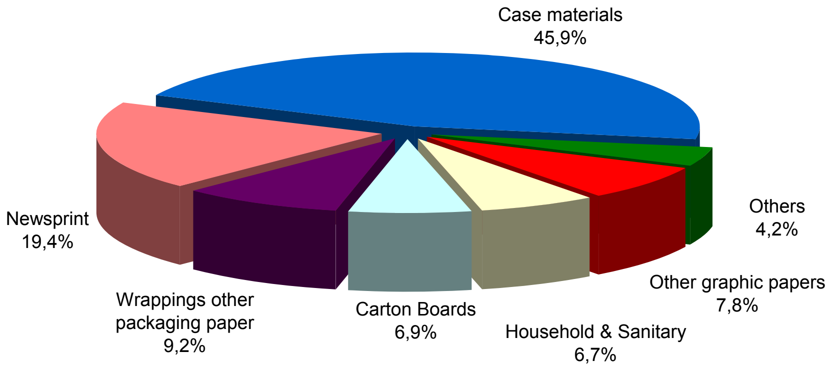
According to the last CEPI Statistics[29] about 47.8 % of paper produced in CEPI countries is from recycled waste paper. The recycled paper in CEPI countries are utilised at different rate depend on the type of paper products. The highest share of utilisation was observed for case

[28] ETC / RWM, Outlook for waste and material flows, Baseline and alternative scenarios, July 2005.

[29] CEPI Key Statistics 2006, 2007.

materials (packaging) (91.3 %) and newsprint (84.4 %), while the lowest share is 9.7% for other graphic paper.

Figure 17: Market for recycled paper (utilisation) in CEPI countries in 2006



Source: CEPI, Key Statistics 2006, 2007.

Recycling is not only a significant part of paper manufacturing, but also a large industry in itself.

Europe already has a leading position in waste paper recycling worldwide.

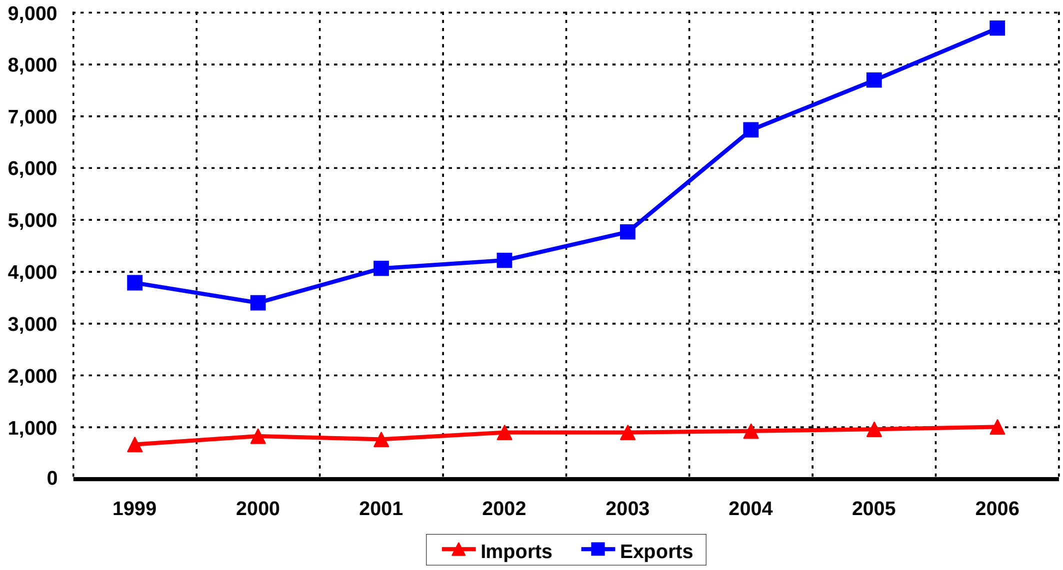
Most European countries are experiencing a high demand for recycled paper, but stocks are low (2007). Especially the export of recycled paper from Europe increased strongly during the last years, and the market is expected to grow even more in the years to come. The main importing country is China, which uses 60 % of the total European exports (2005). Another 35 % are exported to other Asian countries. Asia's demand for recycled paper will be driven continuously by per capita growth in paper consumption.

Furthermore, recycling and use of waste paper as secondary material became alternatives to costly disposal. For the near future a growing amount of recycled waste paper can be expected as a consequence of the implementation of the Landfill Directive, the Packaging Directive etc. EU member states must introduce systems for the return and/or collection of used packaging, so that the implementation of EU directives is and will remain one of the main driving forces of change. However, there are differences between the new and old member states. In the new member states, the use of waste paper as secondary material is still going through several transition periods for the implementation of the landfill and packaging directive and landfilling costs still low; in comparison, investments into separate collection and sorting are still high.

Therefore, ERPC members committed themselves to increase the recycling rate until the year 2010 to 66 %. This commitment includes all 27 EU member countries. Simultaneously, the signers of the declaration committed themselves to invest into research for innovative technologies. This includes the waste paper recycling as well as a further material utilisation of residues from paper recycling processes.

Traditionally, EU waste and scrap of paper or paperboard exports have been far bigger than imports. Since 1999, exports have increased by 230 % to 8.7 Mt in 2006. In the meantime imports have also increased on a lower level from 668,000 tonnes in 1999 to 1 Mt in 2006.

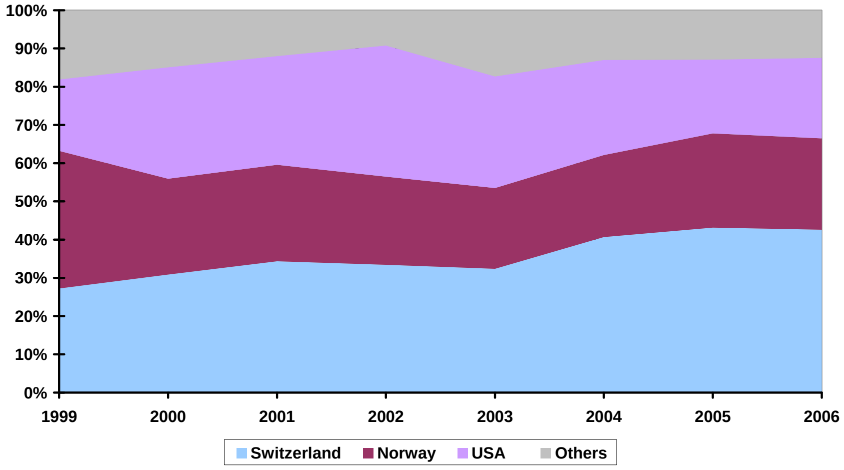
Figure 18: EU 27 waste and scrap of paper or paperboard trade 1999-2006 (1,000 tonnes)



Source: COMEXT

Over the last 8 years, the three main suppliers of waste paper or paperboard to the EU were Switzerland, Norway and the USA. In 2006, imports from these countries accounted for 88 % of total EU 27 imports.

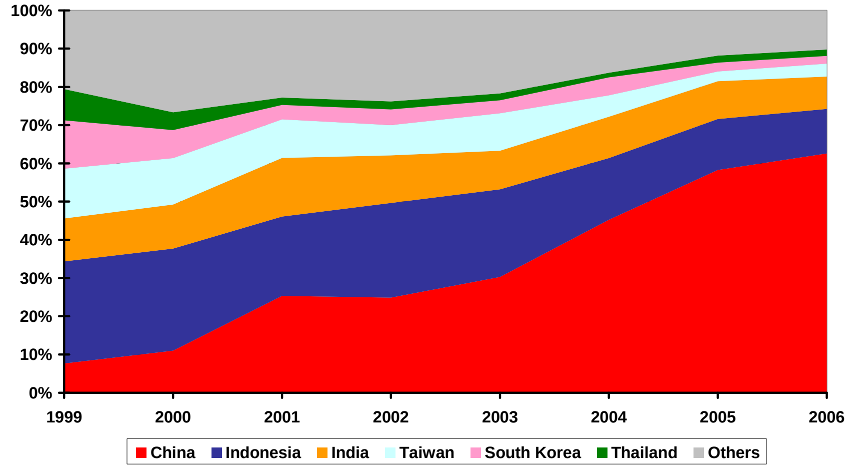
Figure 19: Share of EU 27 waste paper or paperboard imports 1999-2006 by origin



Source: COMEXT

The major change in export destinations from 1999 to 2006 was the growing importance of China. Exports to China have increased dramatically by 819 % from 290,000 tonnes to 5.4 Mt and accounted for 62 % of total EU 27 exports in 2006. At the same period, the share of exports to Indonesia decreased from 27 % to 12 % of the total amount.

Figure 20: Share of EU 27 waste paper or paperboard exports 1999-2006 by destination



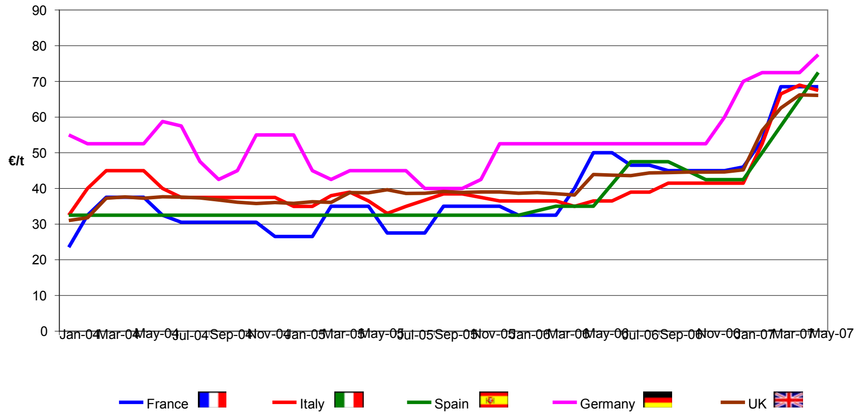
Source: COMEXT

Market prices

After comparing country specific information and several studies, it must be stressed that the market price for paper fluctuates significantly over time, as well as by country, type of waste paper and quality.

The average market prices for mixed waste paper in selected European countries (see below) show an upward trend. This finding can be generalized for the EU 27 market even though data is not available for all countries.

Figure 21: Average market price for mixed waste paper for selected European countries



Source: EUWID Recycling und Entsorgung, Märkte

[Note: Data for the UK converted into € on the basis of average exchange rates determined via www.oanda.com]

7.2.2 Waste sources

On the basis of the European Waste catalogue (C (2000) 1147) the following waste fractions have been selected as relevant sources for the waste stream paper and cardboard. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT base were identified according to the official equivalence table.

Table 16: Waste sources for the waste stream paper and cardboard

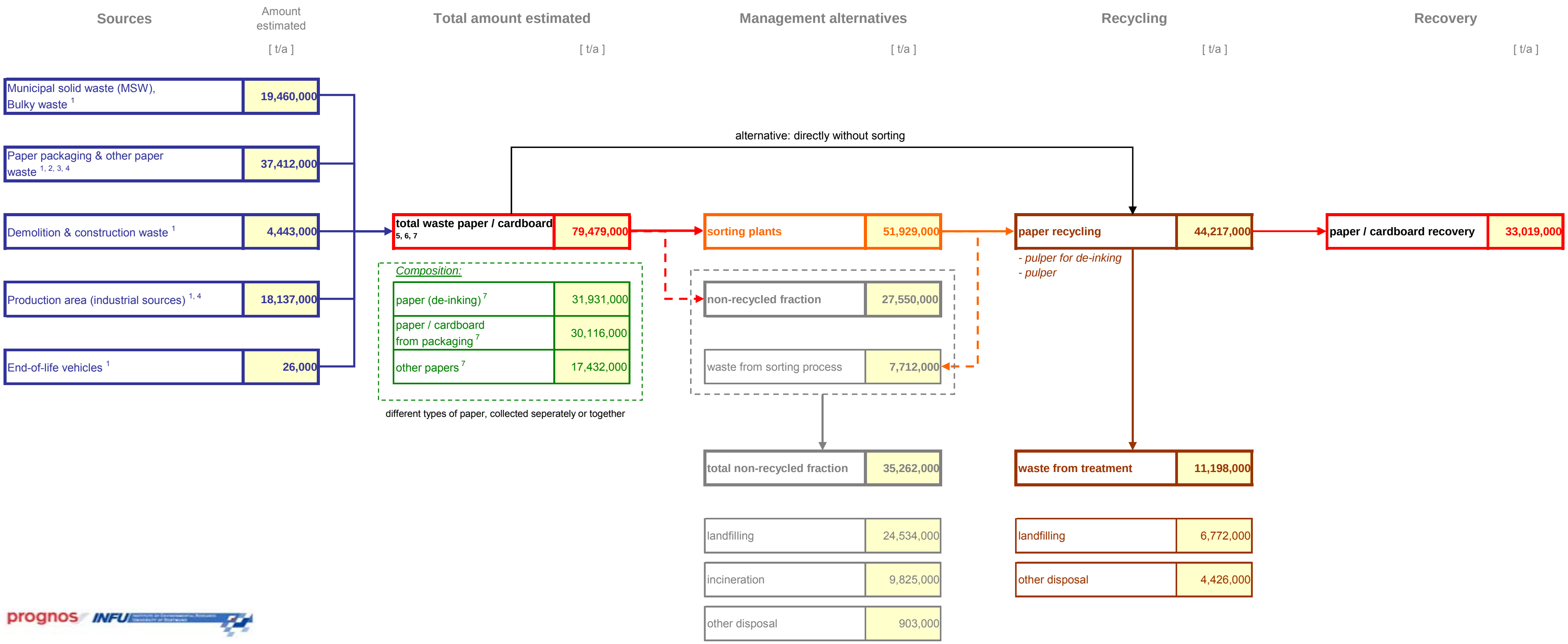
Group-ing***	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
II	150101	paper and cardboard packaging		**07.2**	Paper packaging & other paper waste	
	191201	paper and cardboard				
	200101	paper and cardboard				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
IV	150105*	composite packaging		**10.2**	Mixed and undifferentiated materials	(☠/⚐) ****
	150106*	mixed packaging				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1**	Construction and demolition wastes	

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions; sorting or separation is necessary. The considered paper and cardboard waste amounts where estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of waste paper and cardboard is necessary. The considered waste paper and cardboard amounts where estimated as described in the introduction.
*** Allocation of waste stream sources to the sources group in the flow sheet
I Municipal solid waste (MSW) and bulky waste
II Paper packaging & other paper waste (including separately collected fractions from MSW and Paper and cardboard waste from treatment processes (excepted code 150101 for member states with EWC-6-digit-level data base)
III Demolition and construction waste
IV Production and industrial sources (including code 150101 for member states with EWC-6-digit-level data base)
V end-of-life-vehicles
**** The aggregated data basis of the EWC-STAT group 10.2 contains non-hazardous as well as hazardous waste fractions. For the waste stream paper and cardboard, only non-hazardous fractions where taken into consideration.

7.2.3 Key figures

As a result of adjusting the available data basis the following flow sheet for the waste stream paper and cardboard could be compiled.

Figure 22: Estimation of waste paper and cardboard flow (all figures rounded to thousands)[30]



30 To avoid double counting wherever possible, only a share of waste paper with potential for material recycling was considered in the paper waste stream, polluted fractions from waste paper were considered for Solid fuels.

Notes related to the flow sheet:

1. Sorting or separation of these mixed wastes is necessary.
2. Also includes separately collected fractions from municipal solid waste, which are part of the aggregated group "Paper packaging & other paper waste". Separate data available only for the member states with a data base on at EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI, DE). Their share amounts of up to 8.4 Mt.
3. Also includes paper waste from treatment processes, which are part of the aggregated group "Paper packaging & other paper waste". Separate data available only for the member states with a data base on at EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI, DE). Their share amounts up to approx. 0.44 Mt.
4. For member states with the EWC-STAT base, mixed paper from industrial sources collected separately (150101) is included in the group "Paper packaging & other paper waste"; for member states with the EWC-6-digit-level, the data base is allocated to the group "Production area (industrial sources)".
5. Data for Latvia is only available for municipal and commercial waste, no information available for other economic sectors.
6. Data for Poland, Slovakia, and the Czech Republic was compiled from several other sources due to missing or fragmentary EWC-6-digit data for MSW or C&D.
7. Due to fragmentary data the amount for Portugal is only a rough estimate.

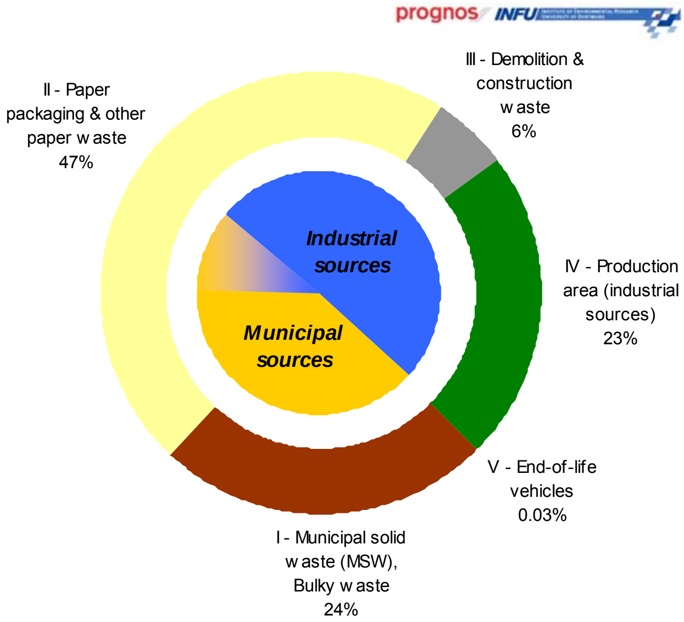
The main sources for waste paper and cardboard as the starting point of the waste flow sheet is on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows:
Due to the usage of at least two different data sources (EWC and EWC-STAT)

- Paper waste collected separately from municipal solid waste is not reported separately, but included in the group "Paper packaging & other paper waste", as separate data is only available for member states with the EWC data base.
- Paper from waste treatment processes is not reported separately, but also included in the group "Paper packaging & other paper waste", as separate data is only available for member states with the EWC data base.
- Paper from the production area (industrial sources) covers potentials from mixed packaging and composite packaging. Separately collected fractions (150101) are only included for member states with the EWC data base. For all member states with the EWC-STAT data base, these amounts are included in the group "Paper packaging & other paper waste", as an allocation is not possible due to the lack of information.

In total, the amount of waste paper and cardboard generated in the EU 27 was 79.5 Mt in 2004, of which 39% to 49% originated from MSW[31].

[31] No better estimates can be provided because the aggregated group "paper packaging & other paper waste" includes paper fractions from both MSW and from production and commercial sources.

Figure 23: Estimated waste paper generation by sources



* please take into consideration also notes referring to Table 16 and Figure 22
** includes waste fractions from MSW

The amount of waste paper fraction collected separately or collected and then separated in sorting plants with the objective of recycling32 was estimated at 51.9 Mt in 2004. Taking into account the losses during the sorting process, about 44.2 Mt of waste paper were returned to the paper manufacturing industry for recycling. Including further losses during the recycling processes, the total recycled secondary paper amounted to about 33.0 Mt in 2004. The estimated share of waste paper & cardboard for recycling within the total estimated waste paper & cardboard generation (rate of recycling) reached nearly 56 % at the level of the EU 27, also shown in

[32] This equals to the total generated paper & cardboard waste minus directly disposed materials in the EU

Figure 26.

At country level the generation and rate of recycling differ from country to country as shown in Figure 24. Denmark, Sweden, Germany, Belgium and Austria record the highest waste paper recycling rate in comparison to the estimated waste paper & cardboard generation potentials (> 65 %).

Figure 24: Recycling potentials in kg per capita. (2004)

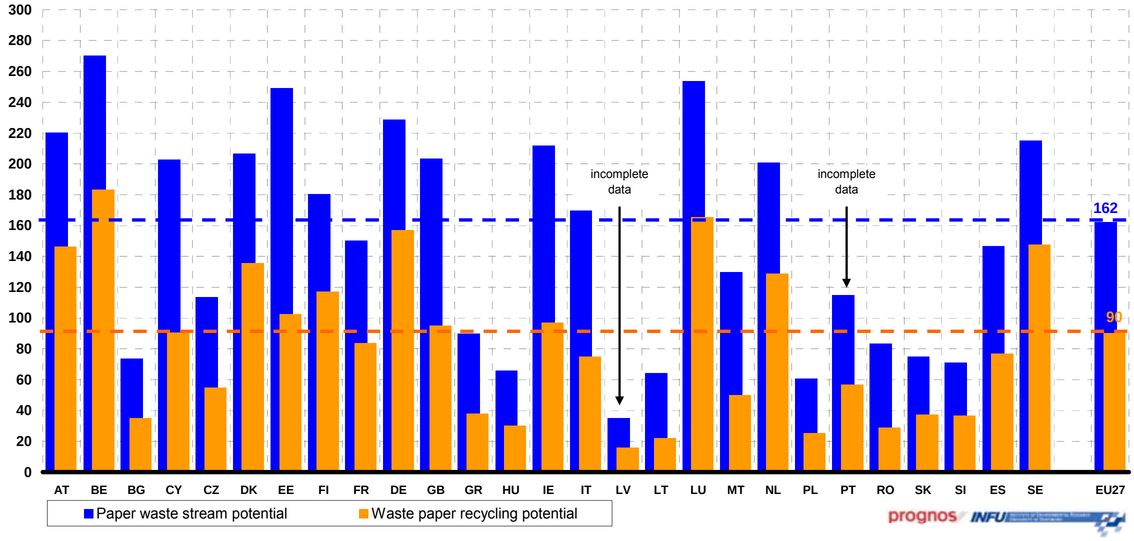


Figure 25 shows the estimated total amount of waste paper by different waste management alternatives, and

Figure 26 presents the same data but in percentage. While most member countries recycle more than 40% of the waste paper, landfill still account for 31% at the EU level.

Figure 25: Management alternatives for waste paper & cardboard (in '000 tonnes)

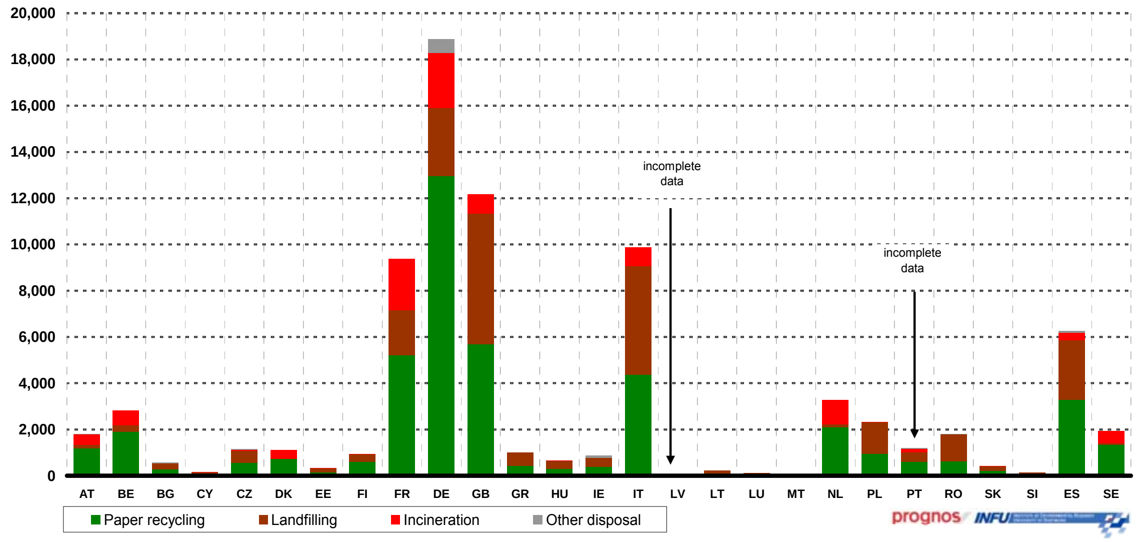
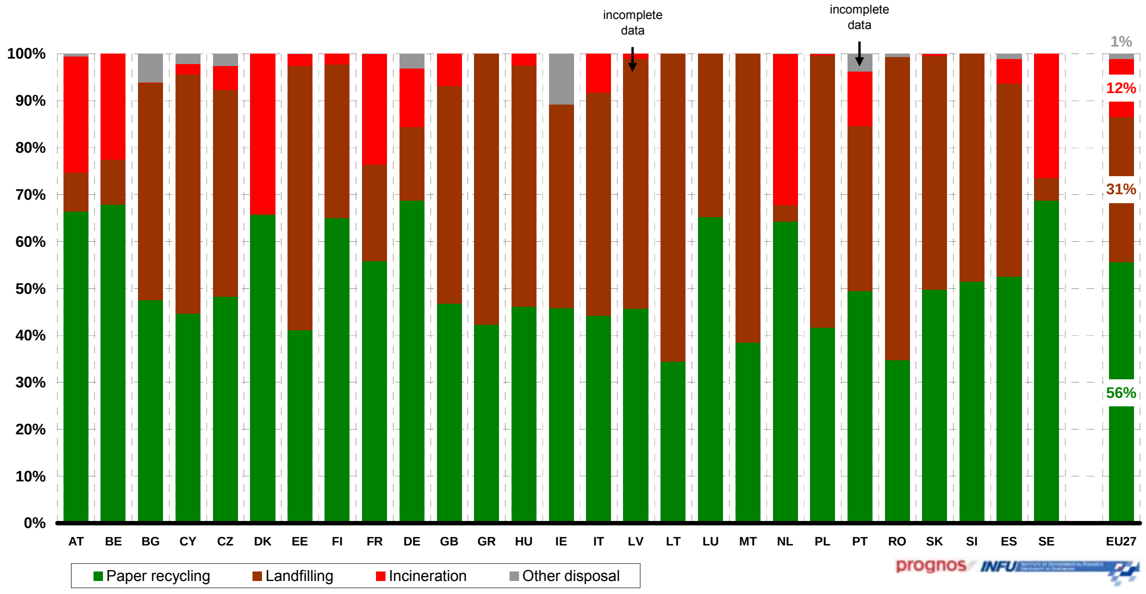


Figure 26: Estimated share of alternatives in waste paper & cardboard management (2004)



7.3 Plastics

Main findings

- The amount of waste plastic generated in the EU 27 can be estimated at 26.2 Mt in 2004.
- Of these, an estimated 9.2 Mt were recycled in plastic manufacturing or recovered as energy (35%).
- Because of the property loss during their lifetime, recycled polymers can not completely substitute for virgin materials. Plastics can also be contaminated with hazardous substances.
- The plastic market is a global market and expected to grow.
- The price index has almost doubled during the last 5 years and due to the rising prices of crude, oil another strong increase in prices for plastics is expected.

7.3.1 Characterisation of the waste stream

Overview

General characteristics
The important consumption sectors of plastics, which are also the main origins of waste plastics, are:

- packaging (38.1 %),
- household and domestic (22.3 %), and
- building and construction (17.6 %).

The most significant plastic waste sources are municipal solid waste, distribution and industry waste, electrical/electronic waste, waste from the automotive industry, waste from construction and demolition, and agricultural waste.

Packaging generated by the distribution and retail sector represents more than 80 % of the collectable waste plastics (potential). Collecting and processing waste plastics from mixed household waste appears to be one of the most difficult waste fractions to manage. Most of the plastics used in construction are for long-term applications. Consequently, estimating the potential waste stock of this waste fraction is difficult.

Information about the composition of waste plastic differs among several sources.33

[33] ACRR Association of Cities and Regions for Recycling, Good practices guide on waste plastics recycling a guide by and for local and regional authorities (2004).

Figure 27: Composition examples for waste plastic (rounded) 34 35 36

Plastic fraction	Source 1 (Europe)	Source 2 (Germany)	Source 3 (Slovakia)
LDPE	19%		
PP	15%		
HDPE	13%		
PE, PP		46%	74%
PET		5%	10%
PVC	14%	12%	1%
PU, PS	16%	13%	9%
Other	23 %	24%	6%

Waste recycling

Collection and sorting
Household

Collection schemes serving households include kerbside collection, neighbourhood containers and container parks. Kerbside collection and neighbourhood containers are aimed towards the collection of smaller plastic products - typically the packaging fraction, plastic bottles and, to a lesser extent, films. Container parks however, enable larger plastic products to be collected, including plastic furniture, pipes, window frames etc., which not only arise in household waste, but also in commercial and industrial waste streams.

Industry:

Waste generated by industrial sectors as well as agricultural and construction sector is generally collected by private services.[37]

Pre-treatment and recyclingtechnologies
Sorting and separation of mixed plastics:

As the quality of the products obtained by both mechanical and feedstock recycling depends on the ‘purity’ of the raw plastic wastes, the removal of contaminants and separation of plastics by types of resin is required before the plastic recycling can be carried out. Methods for the separation of plastics are: manual, flotation, dissolution, spectroscopic identification, etc.

[34] Source 1 (Europe): ACRR Association of Cities and Regions for Recycling, Good practices guide on waste plastics recycling a guide by and for local and regional authorities (2004).

[35] Source 2 (Germany): Plastics Europe, „Produktions- und Verbrauchsdaten für Kunststoffe in Deutschland unter Einbeziehung der Verwertung 2003“, prepared by CONSULTIC Marketing & Industrieberatung GmbH, August 2004.

[36] Source 3: Informačný súhrn Slovenskej republiky.

[37] ACRR Association of Cities and Regions for Recycling, Good practices guide on waste plastics recycling a guide by and for local and regional authorities (2004).

Mechanical and monomer recycling:

This recycling of plastics involves a number of treatments and operations: separation of plastics by types of resin, washing to remove dirt and contaminants, grinding and crushing to reduce the plastic particle size, extrusion by heat and reprocessing into new plastic. This type of recycling is mainly restricted to thermoplastics (e.g. PMMA, HDPE, LDPE, PP, PS, PET).

Feedstock recycling

Polymers are decomposed by means of heat, chemical agents and catalysts to yield a variety of products ranging from the starting monomers to mixtures of compounds, mainly hydrocarbons, with possible applications as a source of (basic) chemicals or fuels. It's suitable for almost every kind of plastic and rubber waste. Methods are classified into

- Chemical depolymerisation,
- Gasification,
- Thermal decomposition,
- Catalytic cracking and reforming, and Hydrogenation[38]

Preconditions and technical limitations
Mechanical and monomer recycling

- Limited by the restricted compatibility between the different types of polymers when mixed.
- Small amounts of dispersed polymer in a matrix of a second polymer may dramatically change the properties (PVC, PET).
- Different colours impart an undesirable grey colour to the recycled plastic.
- Degradation during their use leads to a progressive reduction in length and to partial oxidation of the polymer chains. Recycled polymers always have lower quality than the virgin material.

Feedstock recycling

The main problem is the presence of undesired elements and compounds (Cl, N, metals, etc.) in the plastic wastes that would be introduced into the refinery.[38]

Alternative management
Oher management options are incineration with energy recovery and landfilling.[39]

Environmental and health issues related to waste management

Key issues

[38] Jose Aguado, David P Serrano, Feedstock Recycling of Plastic Wastes, RSC Clean Technology Monographs, 1999.

[39] ACRR Association of Cities and Regions for Recycling, Good practices guide on waste plastics recycling a guide by and for local and regional authorities (2004).

Because of the property loss during their lifetime, recycled polymers can not completely substitute for virgin material. Recycled chemicals from the feedstock recycling (see above) can replace virgin basic chemicals (e.g. monomers, ethylene).

Plastic can be contaminated with hazardous substances. Plastics usually contain a variety of additives such as fillers, stabilizers, plasticizers, reinforcing agents, colorants, etc. Both organic and inorganic compounds in many cases contain heavy metals (cadmium, lead).

Because of their resistance to degradation, the decomposition process of plastic materials takes a long time after disposition in landfills. The slow degradation of plastics is responsible for the progressive reduction of landfill capacity. Plastic wastes account for about 25 % of all solid wastes accumulated in landfills.

The burning of plastic with energy recovery, due to the high level of hazardous emission, need to be controlled in proper facilities.

Waste recycling process
Material recycling requires a lot of energy, but making granulate from used plastics still needs less energy and generates less emission than the production of new plastic. Reuse of plastic is preferable to recycling as it uses less energy and fewer resources. Collecting and transporting plastic waste is generally associated with high costs.

Market

Plastic market
Continuous innovation helps to explain that since 1950 plastics production has increased by an average of almost 10% every year on a global basis. The total global production of plastics has grown from around 1.3 Mt in 1950 to 230 Mt in 2005. In 2005, EU 25+Norway/Switzerland generated 25% of global production, at a similar level to that of North America, at 24%.

The world plastic market is mature and consolidated, and in recent years the market has become stable with modest growth. The market demand has been growing considerably and more strongly in Central and Eastern European countries than in Western Europe. The main drivers are the packaging and the construction industry, where more than 50% of plastic products are used. But also the automotive and electronic industries use plastic components.

Recycling market
Plastic waste is dominated by post-consumer plastic waste, consisting mainly of packaging waste (short life span). Nearly 50% were recycled in 2005. The recycling of plastics is increasing year after year driven by waste legislation and EU recycling targets like ,

- the EU Packaging Directive (producer responsibility), but also
- the Landfill Directive, as well as
- the EU document "Management of Construction and Demolition Waste" published in 2000.

In principle, all types of plastics can either be re-used, material recycled or energy recovered.

There is a wide range of products made from recycled plastic, like:

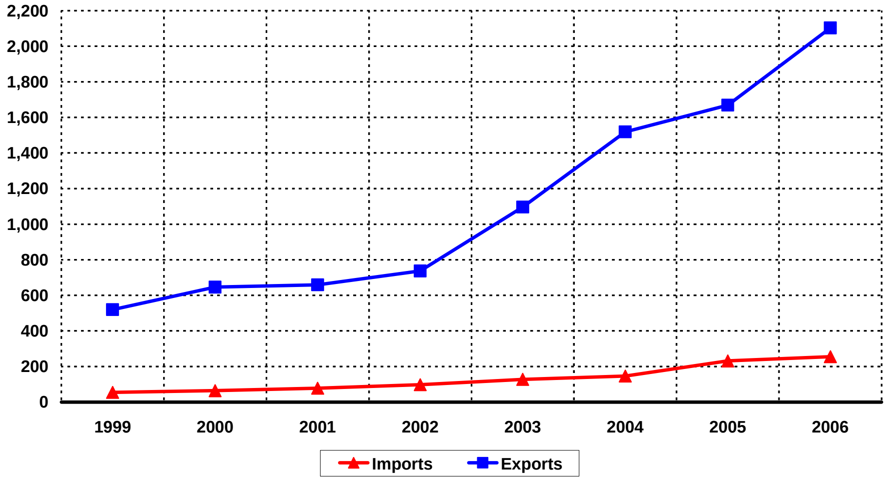
- bin liners,
- carrier bags,
- flooring and window frames,
- fencing, garden furniture, garden sheds and composters
- building insulation board
- and a lot of other products.

Within Europe, Germany has the largest number of plastics recycling plants in Europe. About 21.4% of the plastics recycling plants in the EU are situated in Germany. Another 14.3% are located in the UK, 13% in Italy, 8.9% in France and 7.6 % in Spain.[40]

Parts of the plastic waste are not appropriate for recycling, e.g. food packaging or plastics mixed with other materials, because, in this case, the cleaning of the contaminated plastic would be more costly due to the consumption of large amount of energy than the value of the products. However they can be used for energy recovery.

The EU 27 is a net exporter of waste, parings and scrap of plastics. Since 1999, the gap between imports and exports has constantly increased. After a slight rise between 1999 and 2002, exports have experienced an impressive acceleration of 405 % between 2002 and 2006 up to 2.1 Mt. From 1999 to 2006 imports increased from 55,000 tonnes to 256,000 tonnes, representing a catch-up of 466 %.

Figure 28: EU 27 waste, parings and scrap of plastics trade 1999-2006 (in '000 tonnes)



Source: COMEXT

Since 1999, the two main suppliers of waste, parings and scrap of plastics to the EU 27 have been Switzerland and Norway. Since 2002, Norway has increased its exports to the EU by 26 % and accounted for 50 % of total EU 27 imports with 126,000 tonnes in 2006. Switzerland and Norway have increased their exports to the EU 27 with a combined share of 73 % in 1999 to 85 % representing 217,000 tonnes in 2006.

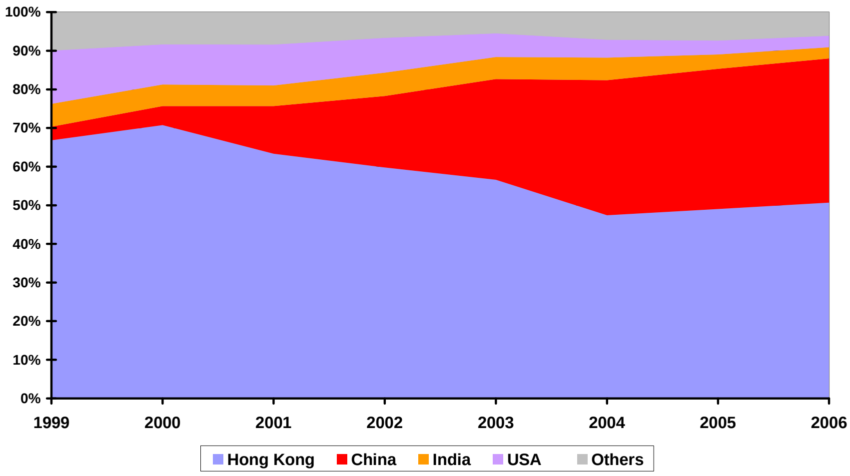
40 http://www.packwire.com/news/ng.asp?id=69515.

Figure 29: **Share of EU 27 waste, parings and scrap of plastic imports 1999 – 2006 by origin**

Source: COMEXT

As regard exports, Asian countries are the main destination for EU 27 waste, parings and scrap of plastic exports. Since 1999 exports to Hong Kong increased from 347,000 tonnes to 1.1 Mt in 2006, while the share of the total EU 27 exports decreased by 16 % to 51 % in 2006. In the meantime exports to China increased from 18,000 tonnes in 1999 to 786,000 tonnes in 2006. The share of the total export also increased from4 % to 37 %. In 2006, China and Hong Kong accounted for 88 % of total EU waste, parings and scrap of plastic exports representing 1.85 Mt.

Figure 30: **Share of EU 27 waste, parings and scrap of plastic exports 1999 – 2006 by destination**

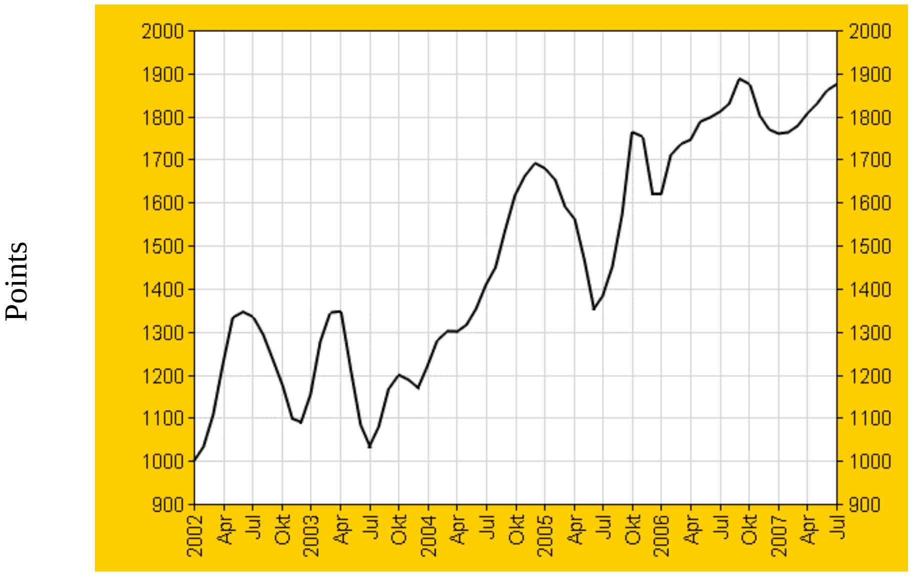


Source: COMEXT

Market prices

To indicate the price trend of primary plastics the "Plastixx" price index of the Kunststoff Information (KI) is used. This index illustrates the price trend of plastics (PE-LD/LLD, PE-HD, PP, PVC, HP, PET as well as ABS, PA, PC, PMMA, POM and PBT) in Western Europe. The calculation occurs monthly on the basis of the published market prices ascertained by KI of standard thermoplastic and technical thermoplastic. 2002 is the basis year set as 1,000 points.

Figure 31: Development of the price index for polymers in Western Europe

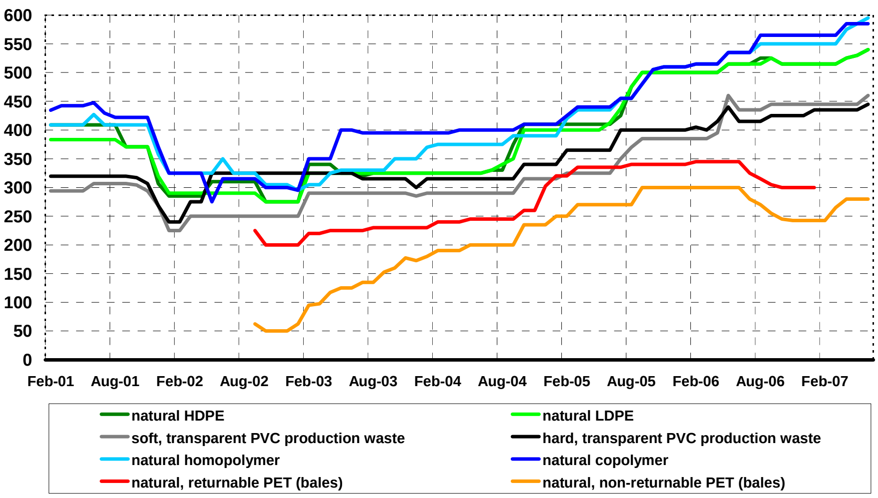


Source: Kunststoff Information, Bad Homburg 2007; www.kiweb.de

The price index has almost doubled during the last 5 years and due to the rising prices for crude oil anticipated in the coming years, another strong increase in prices for plastics is to be expected. For primary plastics, the average price is currently about 1.240 €/t, and for recycling plastics it is about 200 €/t to 650 €/t depending on the kind of plastic.

Example:
According to the price information for recycled plastic materials published for Germany by EUWID different price development trends for single plastic fractions can be observed:

Figure 32: Average prices for selected plastic waste (grinding stock) in Germany 2001-2007 in €/t.



Source: EUWID Recycling und Entsorgung, Märkte

After a drop of prices in 2001/2002 and a relatively stable price level between 2002 and 2004, prices for all plastic wastes have increased in Germany in the last three years. For example prices for natural HDPE and LDPE have nearly doubled between 2002 and 2007 to today's

540 EUR/t. Prices for natural, non-returnable PET in bales have also dramatically increased. Prices for this plastic waste are now almost five times higher than in 2002 (280 EUR/t). In June 2007 the highest prices were achieved for polypropylene (PP) waste (grinding stock): 585 EUR/t were paid for natural copolymer and 595 EUR/t for natural homopolymer.

7.3.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream plastics. As different statistical data sources were used, the equivalent waste groups on the EWC-STAT base were identified according to the official equivalence table.

Table 17: Waste sources for the waste stream plastics

*Grouping****	EWC	Waste Description	Hazardous	EWC-STAT**	Waste Description	Hazardous
III	070216	wastes containing dangerous silicones		02.1 ****	Off-specification chemical wastes	
	070217	waste containing silicones other than those mentioned in 07 02 16				
II	150102	plastic packaging		07.4	Plastic packaging and other plastic waste	
	020104	waste plastics (except packaging)				
	070213	waste plastic				
	120105	plastics shavings and turnings				
	160119	Plastic				
	170203	Plastic				
	191204	plastic and rubber				
	200139	Plastics				
V	160104*	end-of-life vehicles	☠	08.1	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
I	200301*	mixed municipal waste		10.1	Household and similar wastes	
	200307*	bulky waste				
IV	150105*	composite packaging		10.2	Mixed and undifferentiated materials	
	150106*	mixed packaging				
II	191003*	fluff-light fraction and dust containing dangerous substances	☠	10.3	Sorting residues	☠/⚐
	191004*	luff-light fraction and dust other than those mentioned in 19 10 03				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		12.1 *****	Construction and demolition wastes	

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered plastic waste amounts where estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of plastic waste is necessary. The considered plastic waste amounts where estimated as described in the Introduction.
*** Allocation of waste stream sources to the sources group in the flow sheet
**** Data available only for the aggregated group 02

I Municipal solid waste (MSW) and bulky waste

II Plastic packaging and other plastic waste (including separate collected fractions from MSW and separate recorded plastic waste from industry, construction & demolition as well as treatment processes (as described in the table “waste sources”) for member states with EWC-STAT data base. For member states with EWC-6-digit-level data base are considered only separate selected fractions from MSW, code 200139 and waste from treatment processes, codes 191003 and 191004)

III Demolition and construction waste (including code 170203 for member states with EWC-6-digit-level data base)

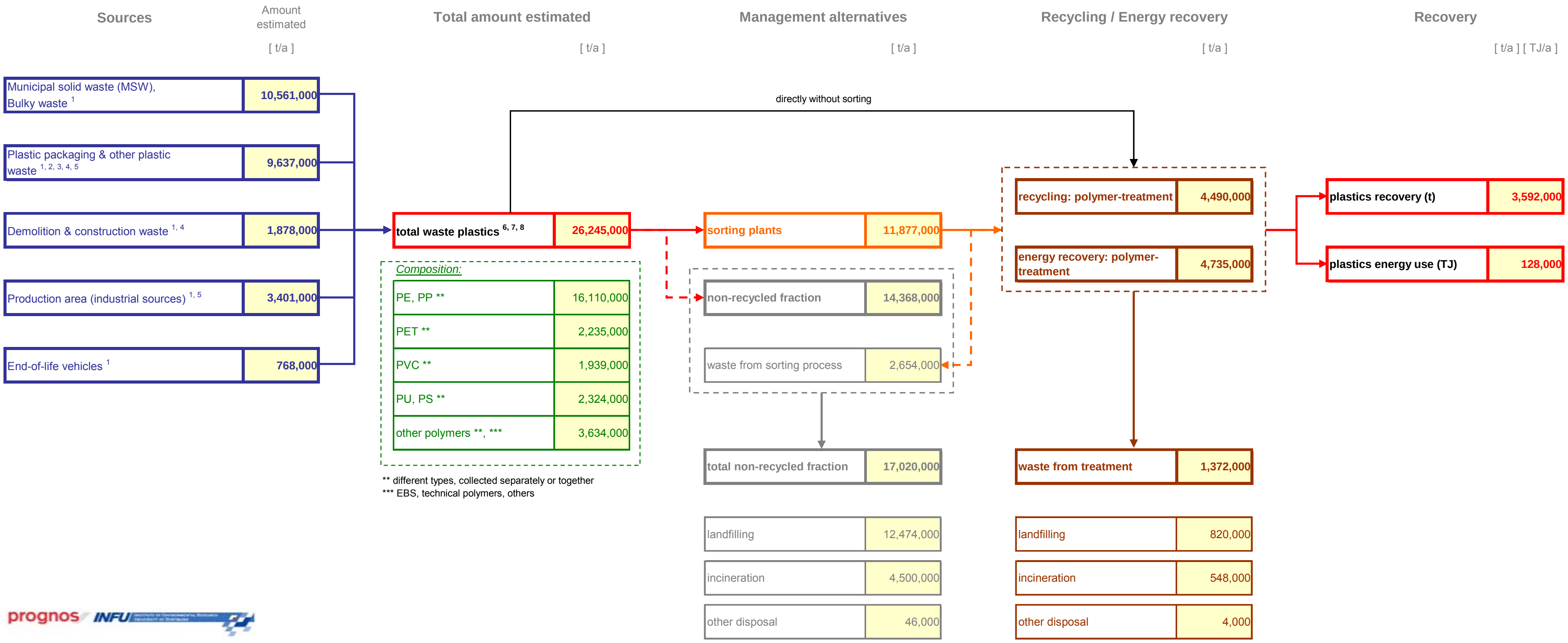
IV Production and industrial sources (including codes 020104, 070213,120105 and 150102 for member states with EWC-6-digit-level data base)

V End-of-life-vehicles (including code 160119 for member states with EWC-6-digit-level data base)
***** Data available only for the aggregated group “12.1 to 12.5 not 124”

7.3.3 Key figures

As a result of adjusting the available data basis the following flow sheet for the waste stream plastics could be compiled.

Figure 33: Estimation of waste plastics flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group “plastic packaging and other plastic waste”. Separate data available only for the member states with data base on the EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 704,000 tonnes.
3. Includes also plastic waste from treatment processes, which are part of the aggregated group “plastic packaging and other plastic waste”. Separate data available only for the member states with data base on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). There share amounts approx. 1.16 Mt.
4. Plastics separately collected from construction & demolition waste (170203) are included in the group “plastic packaging and other plastic waste” for member states with EWC-STAT base, for member states with EWC-6-digit-level data base allocated to the group “construction & demolition waste”.
5. Plastics separately collected from industry (150102, 020104, 070213, 120105) are included in the group “plastic packaging and other plastic waste” for member states with EWC-STAT data base, for member states with EWC-6-digit-level data base allocated to the group “production area (industrial sources)”.
6. Data for Latvia refers only to municipal and commercial waste, no information was available for other economic sectors.
7. Data for Poland, Slovakia and Czech Republic was compiled from several other sources due to missing or fragmentary EWC-6-digit-level data for MSW or C&D.
8. Data for Portugal is based on several estimations due to missing data for the EWC-STAT groups 02.1, 08.1 and 10.2, 10.3, 12.1

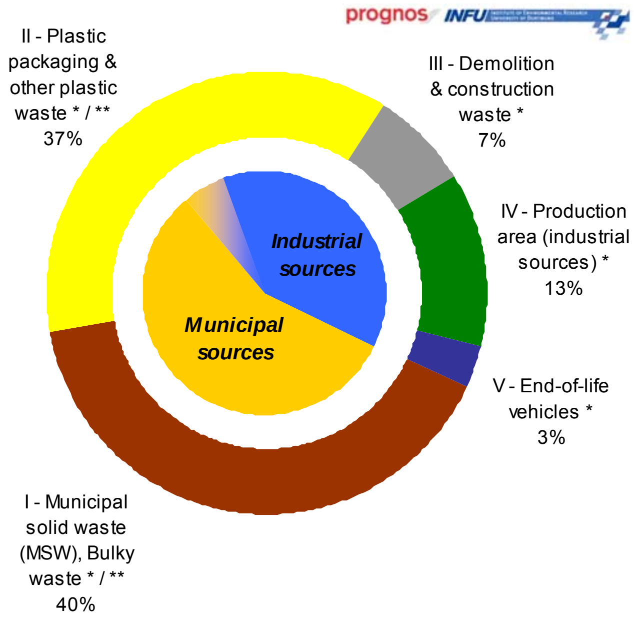
The main sources for waste plastics as the starting point of the waste flow sheet is displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows:
Due to the use of at least two different data sources (EWC and EWC-STAT)

- Plastic waste collected separately from municipal solid waste is not reported separately, but included in the group “plastic packaging and other plastic waste”, as separate data is only available for member states with the EWC data base.
- Plastics from waste treatment processes are not reported separately, but also included in the group “plastic packaging and other plastic waste”, as separate data is only available for member states with the EWC data base.
- Plastics from construction and demolition sources cover potentials from mixed C&D fractions. Separate collected fractions (170203) are only included for member states with the EWC data base. For all member states with the EWC-STAT data base these amounts are included in the group “plastic packaging and other plastic waste”, because disaggregating the data is not possible due to the lack of information.
- Plastics from industry cover several potentials. Separate recorded fractions (150102, 020104, 070213 and 120105) are only included for member states with the EWC data base. For all member states with the EWC-STAT data base these amounts are included in the group “plastic packaging and other plastic waste”, because disaggregating the data is not possible due to the lack of information.

In total, the amount of plastic waste generated in the EU 27 was 26.2 Mt in 2004, of which 57 % to 62 % is originated from MSW[41].

[41] No better estimates can be provided because the aggregated group “plastic packaging & other plastic waste” includes plastic fractions from both MSW and from production and commercial sources.

Figure 34: Estimated plastic waste generation by sources



* please take into consideration also notes referring to Table 16 and Figure 33
** includes waste fractions from MSW

The amount of plastic waste fraction collected separately or collected and then separated in sorting plants with the objective of recovery / recycling[42] was estimated at 11.9 Mt in 2004. Taking into account several losses during the sorting process about 4.5 Mt of plastic waste were returned to plastic manufacturing industry for recycling and similar amount for energy recovery. With the consideration of any further losses during the plastic recycling processes the total material recycling of secondary plastic amounted to about 3.6 Mt in 2004; the energy generated amounted to approx. 128,000 TJ.

Therefore, the estimated share of the plastic waste for recovery/recycling of the total estimated plastic waste generation (rate of utilisation) reached about 35 % at the level of the EU 27 and when excluding the part of energy recovery, rate of recycling about 17%, also shown in Figure 37.

At country level the generation and total utilisation of plastic waste differ from country to country, as shown in

[42] Total generated plastic waste less direct disposed plastic waste fractions.

Figure 35. The Netherlands, Denmark, Luxembourg and Sweden record the highest waste plastic rate of utilisation at more than 55 %.

Figure 35: Recycling potentials in kg per capita. (2004)

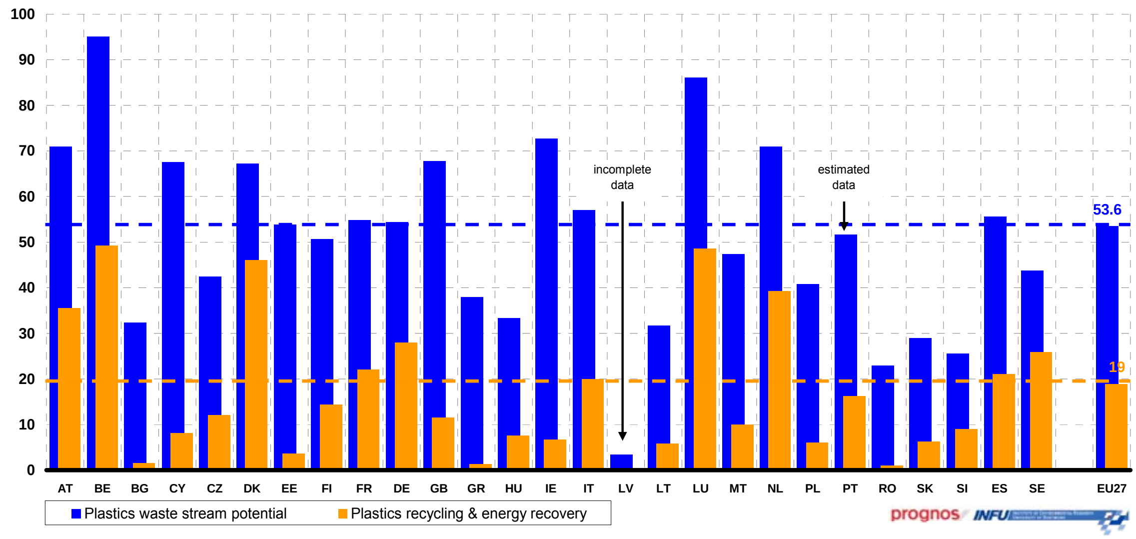


Figure 36 shows the estimated total amount of plastic waste by different waste management alternatives and the Figure 37 presents the same data but in percentage. While three member countries have managed to reduce the amount to landfill to less than 10%, nearly half of the plastic waste still is landfilled in the EU.

Figure 36: Management alternatives for plastic waste (in '000 tonnes)

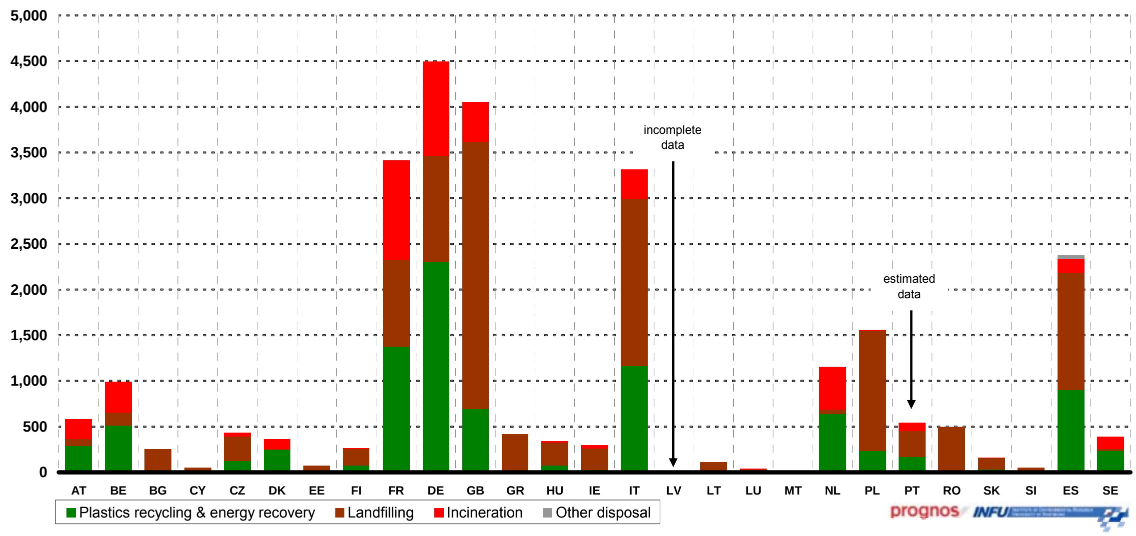
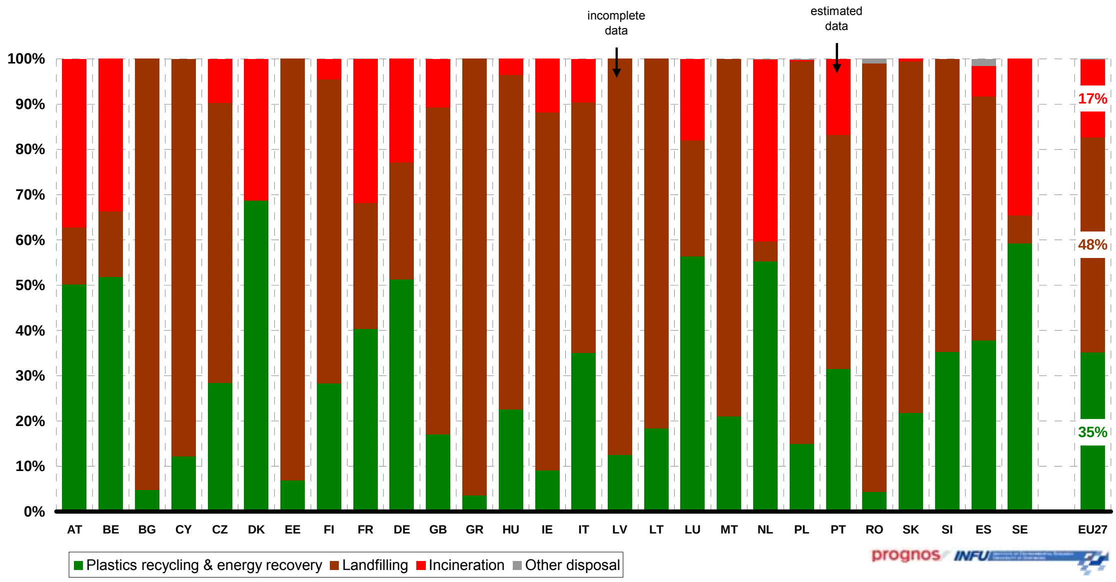


Figure 37: Estimated share of alternatives in plastics waste (2004)



7.4 Wood

Main findings:

- The amount of waste wood generated in the EU 27 can be estimated at 70.5 Mt in 2004.
- Of these, an estimated 45.7 Mt were recycled directly or in energy recovery processes (approx. 65%).
- The implementation of several EU Directives leads to an increasing demand for waste wood and better separation of waste wood fractions from bulky waste as well as construction and demolition waste.
- The wste wood market is more and more internationalized. A growing competition between wood recycling as material and recovery as energy is leading to increasing market prices. Furthermore, seasonal and quality variations are also factors affecting the price.

7.4.1 Characterisation of the waste stream

Overview

General characteristics
Sources of wood scrap mainly are the wood working industries, construction and demolition, packaging and bulky waste. They are often being transported directly from source to the sorting and processing facilities.

The type of wood scrap ranges from bark and sawdust over old furniture to construction wood and railway sleepers. The classification of waste scrap is often done according to the level of contamination (as further discussed in the following section).

Waste recycling

Collection and sorting
Collection of used wood is not very well developed as there is no trade body of wood recyclers who would buy small amounts and accumulate the scrap until they have a sufficient quantity to sell to the recycling company.

Therefore only large producers of waste undertake some sort of re-use or recycling since they can gather enough wood scrap. This situation is expected to change in the next years. (see the Section on Recycling market).

Pre-treatment and recovery/recycling technologies
The treatment of wood waste depends on the designation of the waste - incineration or recycling. In state-of-art wood treatment plants, loads of scraps are pre-screened into the following categories:

- Untreated lumbers,
- Coated lumbers with surface coating not containing organohalogen compounds,

- Coated lumbers with surface coating containing organohalogen compounds,
- Lumbers treated with timber preservative.

Both the untreated lumbers and the coated lumbers without organohalogen compounds can be recycled using the following treatments. The other two types of treated woods are not suitable for this due to their level of contamination.

- Selection of contaminants by hand (manual sorting),
- Single-stage, two-stage or three-stage crushing,
- Segregation of ferrous and non-ferrous materials (by magnets or cyclones),
- Segregation of minerals like concrete through sieving,
- Segregation of light-weight contraries like plastic through single-stage or multi-stage air sieving,
- Sieving of wood pieces according number and size for different purposes,

Coated lumbers with organohalogen compounds and wood treated with preservatives can only be used for energy recovery via incineration.

Ways to gain energy from wood scrap can be:

- In small heating systems,
- In heating systems requiring authorisation,
- In facilities for gasification,
- In facilities for the production of cement and cement clinker.

Currently, the major ways of using recycled wood scrap are:

- Production of derived timber products,
- Structure for compost facilities,
- Sawdust for stables, etc.

Preconditions and technical limitations
Before treatment the wood waste has to be sorted according to its state of composition of wood products (coated lumbers, coated lumbers with organohalogen compounds, lumbers treated with timber preservatives) and quality as well as its designation.

Combustion of wood wastes that contains chemical components such as paints, glues or antidegradants (materials applied to wood in order to stop or slow down the decomposing process), toxic fumes form due to the redundant heat that decomposes these chemical components.

Municipal waste incinerating plants as well as most others are commonly not equipped to deal with these toxic elements. This means that only specialised plants can burn these types of wood scrap and only if it has been separated by its different states of treatment.

Alternative management
Used wood is increasingly accepted as a source for energy. This utilisation requires facilities that meet high standards for emission control, thus implies high investments.

Wood pellets for energy recovery have been produced in a growing market for a few years now. For this, only untreated wood scrap is allowed (e.g. waste from sawmills) in order to keep the emission levels low. Treated wood scraps can only be incinerated in facilities that possess adequate off gas cleaning technologies.

Small companies preferably dump their waste into landfills, because they are deterred by the costs of separation and storage of the wood.[43]

Environmental and health issues related to waste management

Key issues
Landfilling of organic materials such as wood leads to emissions of methane.
Recycling wood helps to decrease the deforestation which has major positive effects on the environment.

Waste recovery process
Inefficient burning of wood causes incomplete combustion that results in increased production of particulates, carbon monoxide and various volatile organic compounds, e.g. PAHs, while at the same time it also results in less efficient use of wood fuel. Pollutants from incomplete combustion reduce visibility and produce odours. In addition, some of the organic compounds are proven to be health hazardous.

Market

Wood market
More than 50% of the worldwide supply of wood is used as firewood or for the production of charcoal (energy use). Only less than 50% is available for industrial use.
The main products from wood industries are:

- Paper (Printing paper, Packaging paper and cardboard and newspaper)
- Sawn wood
- Panels and fibreboards
- Sawdust

This leads to a lack of wood and increasing prices. For a long time, the wood market has developed from a regional to a global market.

Recycling market
Under the European strategy of security and sustainable energy, renewable energy becomes more important (Directive 2001/77/EC on the production of electricity from renewable energy sources; Biomass Action Plan from December 2005).

With the measures that have been put in place the Commission estimates that the share of renewable energy sources in EU 15 reaches 10% in 2010. In order to achieve this target, the

[43] Magin, G.(2001) An introduction to wood waste in the UK. Fauna & Flora International, Cambridge, UK.

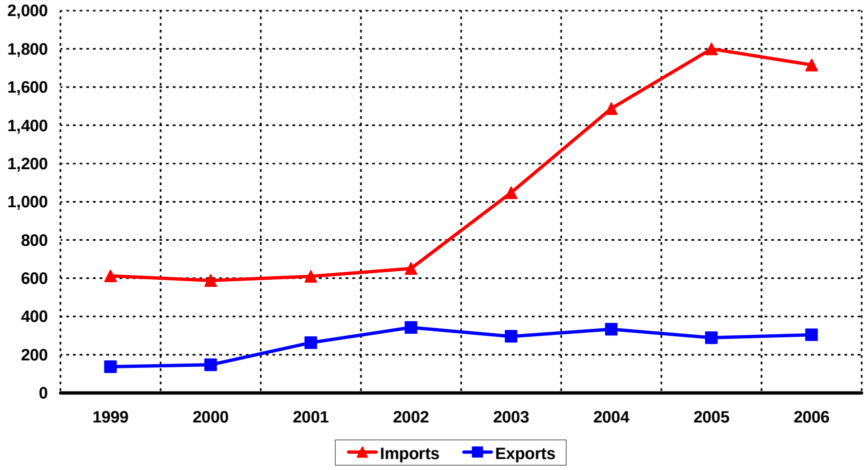
Member States of the EU are required to promote the use of renewable energy in heating systems.

Apart from this energy policy, the Landfill Directive also impacts on the development of the wood recycling market. As wood is biodegradable, it cannot be landfilled in the future. This, in turn, is leading to better separation of the waste wood fraction from bulky, construction and demolition waste.

Both influences, the push for recycling as renewable energy and the Landfill Directive, favour the recycling market of waste wood, especially the trading of high quality of wood wastes since they can be used for either material or energy recycling. It is anticipated that these policies and measures will be continuously play a dominant role on the waste wood market and stimulate the competition between material recycling and energy recovery. It is also expected that former exporting countries of waste wood like the Netherlands or Denmark will use their own waste wood more intensively in the future.

Since 1999, the EU 27 sawdust and wood waste and scrap trade balance is negative as the volume of imports is much higher than the volume of exports. Since 2002, the gap between imports and exports has constantly increased. Imports have increased sharply by 276 % between 2002 and 2005 (from 65,000 tonnes to 180,000 tonnes). Since 1999, exports have more than doubled with a catch-up in 2002, a drop in 2003, and yet another catch-up in 2004. In 2006, exports reached a level of 304,000 tonnes.

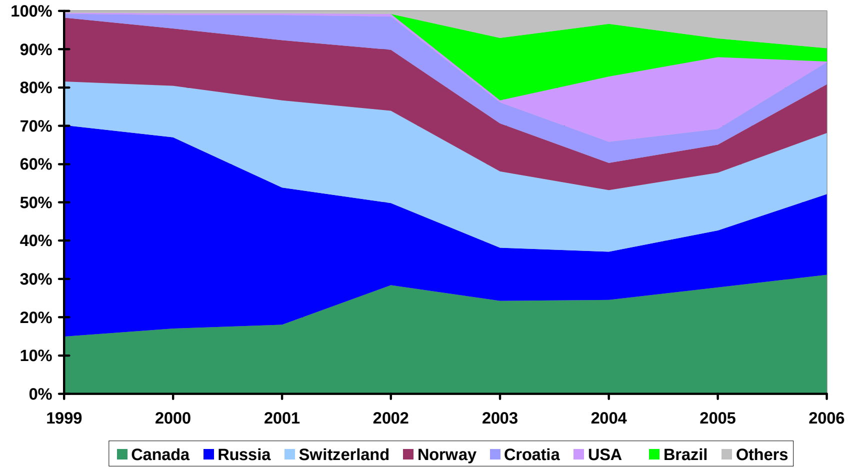
Figure 38: EU 27 sawdust and wood waste and scrap trade 1999 - 2006 (in '000 tonnes)



Source: COMEXT

With regard to increasing imports, it is notable that the influence of imports from Russia decreased from 55 % in 1999 to 21 % in 2006 representing 362,000 tonnes. In the meantime, Canada has doubled its share of the total EU 27 imports to up to 31 % (533,000 tonnes). Other important wood waste import countries are Switzerland and Norway with a share of 16 % and 13 % of the total amount in 2006.

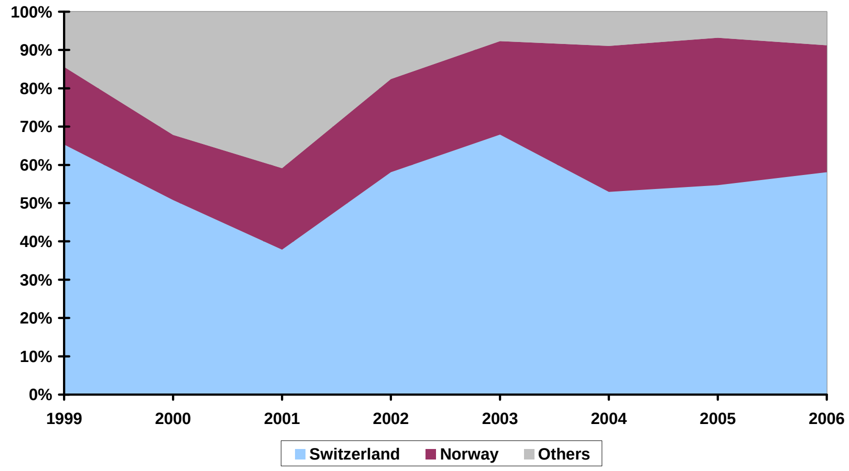
Figure 39: Share of EU 27 sawdust and wood waste and scrap imports 1999-2006 by origin



Source: COMEXT

Since 1999, Switzerland and Norway are the principal destinations of EU 27 sawdust, wood waste and scrap exports. About 91 % of all EU exports went to these two countries. From 1999 to 2006 EU 27 exports to Switzerland nearly doubled (2006: 176,000 tonnes) with its share of the total EU27 exports slightly decreasing from 65 % to 58 %. In the same period, exports to Norway increased by 362 % to 100,000 tonnes in 2006; its share also increased from 20 % in 1999 to 33 % of total EU 27 exports in 2006.

Figure 40: Share of EU 27 sawdust and wood waste and scrap exports 1999-2006 by destination



Source: COMEXT

In the material recycling market, wood-based panel manufacturers are one of the major consumers of recycled woodchips, while the pellet industry competes for non-contaminated waste woods to produce pellet mainly residential heating. Traditionally, waste wood is also used in industrial heating. Due to growing demands for non-contaminated waste wood, the industrial biomass heating plants are increasingly using waste wood with contamination. But electricity can also be generated from waste wood (CHP (combined heat and power)-plants).

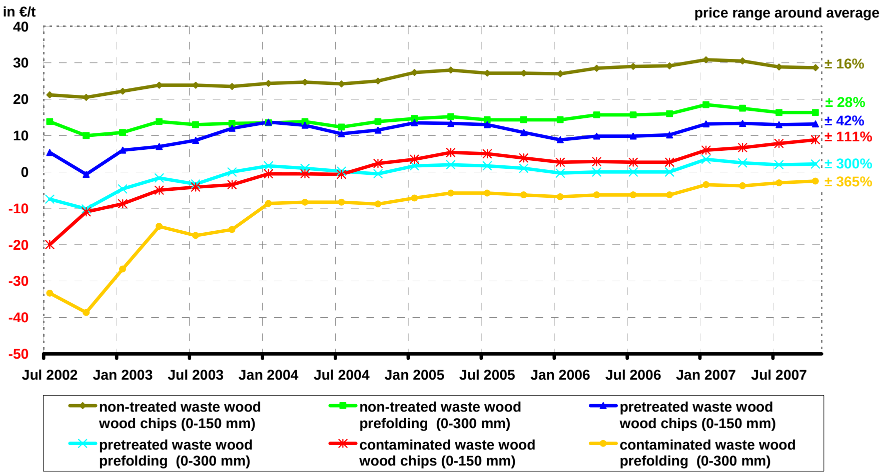
Market prices

Due to the described competition of utilization and the limited supplies, the market price is going up. The margin of the market price is influenced by:

- the regional available amount of waste wood
- the intensity of competition between material and energy recovery
- seasonal variations (winter stock etc.).

Example:
In Germany, prices for waste wood differ not only depending on the type of wood, but also between regions. Average prices can therefore only give some orientation, as prices deviate up to more than 100% over or under the average price (see Figure 41). For highly contaminated waste wood, the distributor even faces additional costs rather than revenue, as the contaminations make the wood unmarketable and cause costs for proper disposal/special treatment.

Figure 41: Development of average prices (in €/t) for selected waste wood fractions in Germany



Source: EUWID Recycling und Entsorgung, Märkte

7.4.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream wood. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 18: Waste sources for the waste stream wood

*Grouping****	EWC	Waste Description	Hazardous	EWC-STAT**	Waste Description	Hazardous
IV	030199	wastes not otherwise specified		02.1****	Off-specification chemical wastes	☠ / ⚐
	030201	non-halogenated organic wood preservatives	☠			
II	150103	wooden packaging		07.5	Wood packaging, sawdust and shavings and other wood wastes	☠ / ⚐
	030104	sawdust, shavings, cuttings, wood, particle board and veneer containing dangerous substances	☠			
	030105	sawdust, shavings, cuttings, wood, particle board and veneer other than those mentioned in 03 01 04				
	030101	waste bark and cork				
	030301	waste bark and wood				

*Group-ing***	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
	170201	wood				
	191206	wood containing dangerous substances	☠			
	191207	wood other than that mentioned in 19 12 06				
	200137	wood containing dangerous substances	☠			
	200138	wood other than that mentioned in 20 01 37				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠ / ⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
IV	020107	wastes from forestry		**09.2 *******	Green wastes	
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1 ********	Construction and demolition wastes	

☠ Hazardous waste fraction

☠/⚐ As well as hazardous and non-hazardous fractions

* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered wood waste amounts where estimated as described in Sources of data collection.

** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of waste wood is necessary. The considered wood waste amounts where estimated as described in the Introduction.

*** Allocation of waste stream sources to the sources group in the flow sheet

- I Municipal solid waste (MSW) and bulky waste
- II Wood packaging, sawdust and shavings and other wood wastes (including separate collected fractions from MSW and separate recorded wood waste from industry, construction & demolition such as treatment processes (as described in the table "waste sources"). For member states with EWC-6-digit-level data basis are considered only separate selected fractions (200138, 200138) and waste from treatment (191206 and 191207).
- III Demolition and construction waste (including code 170201 for member states with EWC-6-digit-level data basis)
- IV Production and industrial sources (including codes 150103, 030104, 030105, 030101, 030301 for member states with EWC-6-digit-level data basis)
- V End-of-life-vehicles

**** Data available only for the aggregated group "02"

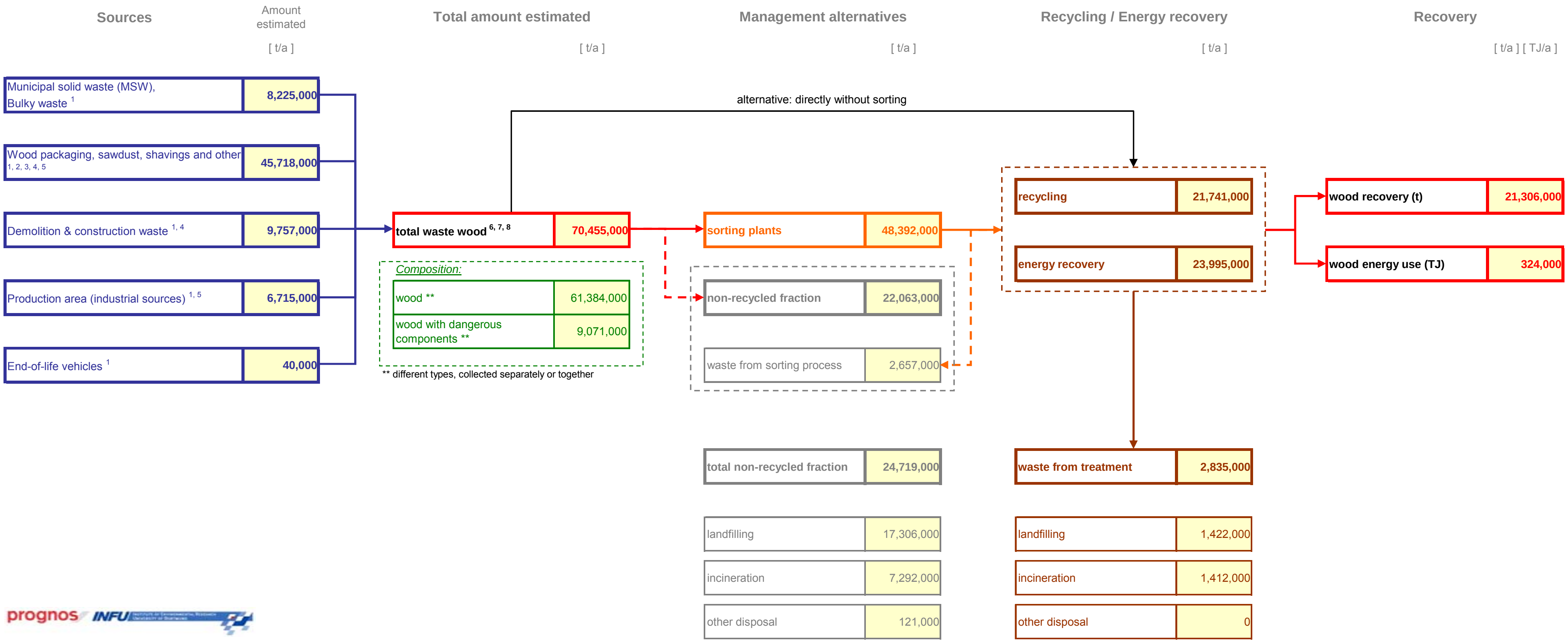
***** Data available only for the aggregated group "09 not 0911 and 093"

****** Data available only for the aggregated group "12.1 to 12.5 not 12.4"

7.4.3 Key figures

As a result of adjusting the available data basis the following flow sheet for the waste stream wood could be compiled.

Figure 42: Estimation of waste wood flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "wood packaging, sawdust and shavings and other wood wastes". Separate data available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 489,000 tonnes.
3. Includes also wood waste from treatment processes, which are part of the aggregated group "wood packaging, sawdust and shavings and other wood wastes". Separate data available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 31,000 tonnes.
4. Wood separate collected from construction & demolition waste (170201) is included in the group "wood packaging, sawdust and shavings and other wood wastes" for member states on EWC-STAT basis, for member states with EWC-6-digit-level data base allocated to the group "construction & demolition waste".
5. Wood separate collected from industry (150103, 030104, 030105, 030101, 030301) is included in the group "wood packaging, sawdust and shavings and other wood wastes" for member states on EWC-STAT basis, for member states with EWC-6-digit-level data base allocated to the group "production area (industrial sources)".
6. Data for Latvia pertains only to municipal and commercial waste, no information was available for other economic sectors.
7. Data for Poland, Slovakia and Czech Republic was compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.
8. Data for Portugal is only fragmentary due to missing data for the EWC-STAT groups 02.1, 08.1 and 09.2.

The main sources for waste wood as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.
Due to at least two different data sources (EWC and EWC-STAT)

- Wood waste collected separately from municipal solid waste is not reported separately, but included in the group "wood packaging, sawdust and shavings, and other wood wastes", as separate data is only available for member states with EWC data basis.

- Wood from construction and demolition sources covers potentials from mixed C&D fractions and C&D fractions with dangerous substances. Separately collected fractions (170201) are only included for member states with an EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "wood packaging, sawdust and shavings, and other wood wastes", because an allocation is not possible due to the aggregated data basis.

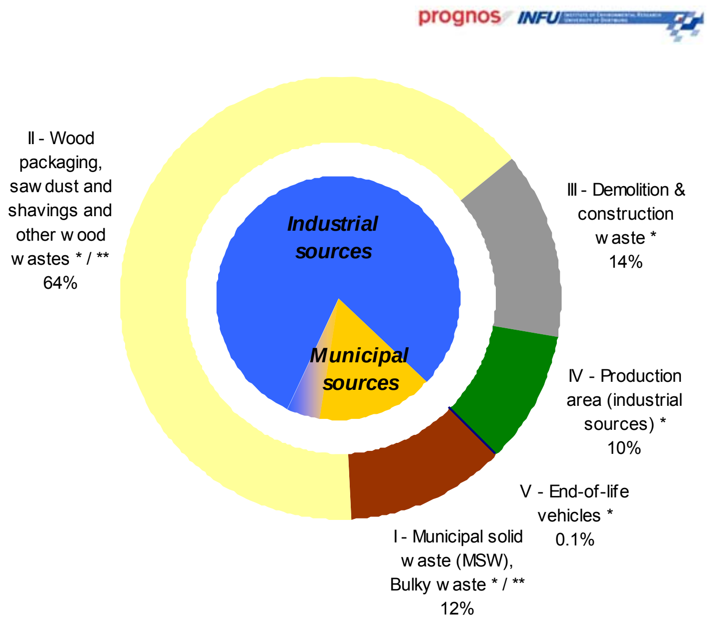
- Wood from industry covers several potentials. Separately recorded fractions (150103, 030104, 030105, 030101, and 030301) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "wood packaging, sawdust and shavings, and other wood wastes", because an allocation is not possible due to the aggregated data basis.

- Wood from waste treatment processes is not reported separately, but also included in the group "wood packaging, sawdust and shavings, and other wood wastes", as separate data is only available for member states with an EWC data basis.

In total, the amount of waste wood generated in the EU 27 was 70.5 Mt in 2004, of which 16 % - 20 % is originated from MSW44.

[44] No better estimates can be provided because the aggregated group "wood packaging, saw dusts, shavings & other wood waste" includes wood fractions from both MSW and from production and commercial sources.

Figure 43: Estimated wood waste generation by sources



* please take into consideration also notes referring to Table 18 and Figure 42
** includes waste fractions from MSW

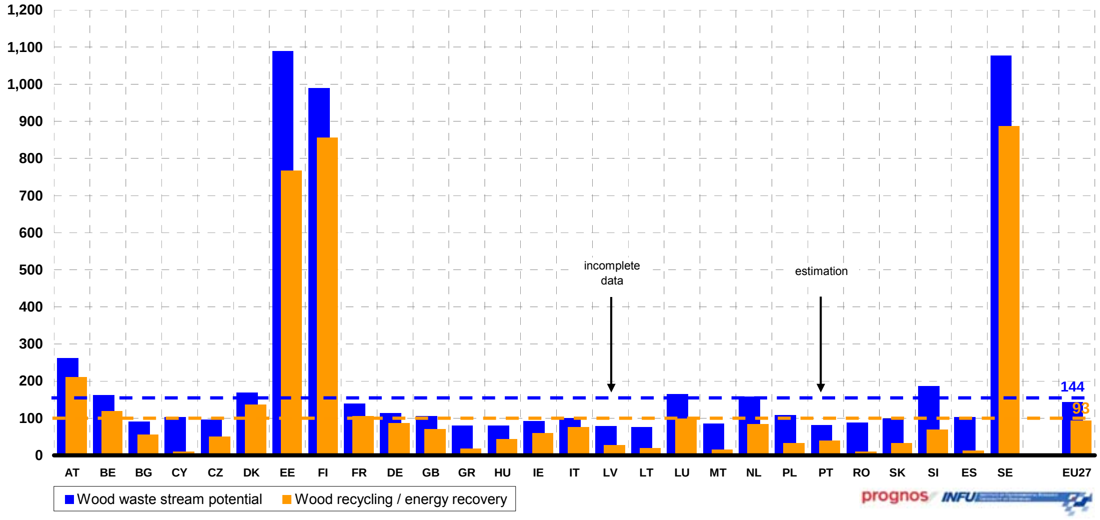
The amount of wood waste collected separately or collected and then separated in sorting plants with the objective of recovery / recycling[45] was estimated at 48.4 Mt in 2004. Taking into account various losses during the sorting process about 45.7 Mt of wood waste were returned to wood manufacturing industry for recycling or energy recovered. With the consideration of further losses during the recycling processes the total material recovery of wood amounted to about 21.3 Mt in 2004; the energy use amounted to approx. 324,000 TJ.

The estimated share of the waste wood for recycling or energy recovery of the total estimated waste wood generation (rate of recycling/energy recovery) reached about 65 % at the level of the EU 27, also shown in Figure 46.

At country level the generation and rate of recycling/energy recovery differ from country to country as shown in Figure 44.

[45] Total generated waste wood less direct disposed waste wood fractions.

Figure 44: Recycling potential in kg per capita (2004)



The significantly higher potential for the Nordic countries Finland, Sweden, and Estonia is very conspicuous. It has to be pointed out that the data for Estonia submitted to Eurostat is based on different sources, which mainly reflect expert opinions. Estonia owns large areas with dense a forestation, which is used exceedingly. It is therefore to be expected that the waste wood potential is mainly derived from manufacturing of wood and wood products. Additionally, double counts (e.g. high import of saw dust from Latvia) are possible.

Estonia mainly exports to the Scandinavian countries (especially Finland and Sweden). The data for these countries may need to be further clarified to distinguish domestic generation of waste and net imports and to avoid double counting.

Figure 45 shows the estimated total amount of waste wood by different waste management alternatives, and the Figure 46 presents the same data but in percentage.

Figure 45: Management alternatives for waste wood (in ‘000 tonnes)

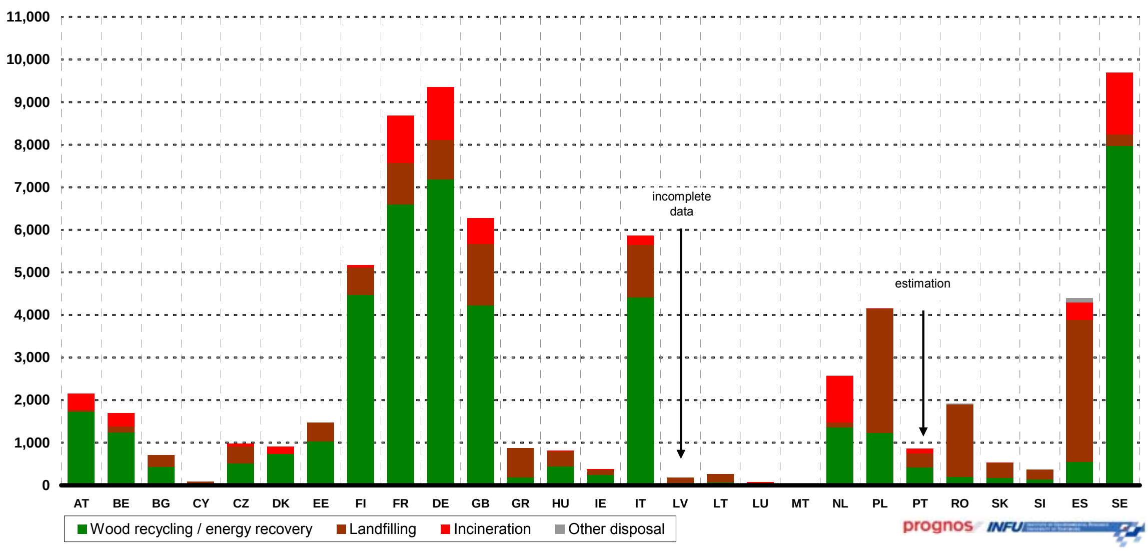
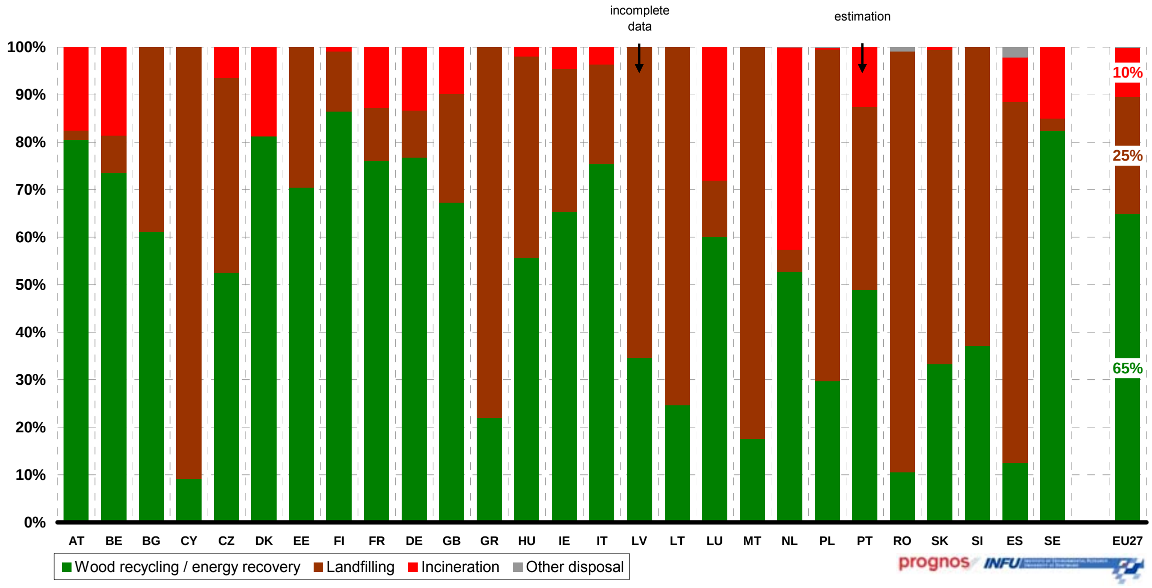


Figure 46: Estimated share of alternatives in waste wood management (2004)



7.5 Textiles

Main findings:

- The amount of waste textiles generated in the EU 27 can be estimated at nearly 12.2 Mt in 2004.
- Of these, an estimated 3.9 Mt were material recycled in the textile industry or for energy recovery (32 %).
- Data availability is unbalanced. Furthermore there is no guarantee for full data comparability due to different methodology of data collection and aggregation in all countries.
- Textiles can be contaminated with heavy metals, depending on the usage.
- The market for waste textiles and sorted textiles is an international market and an important source of raw material.
- The textile market has witnessed a down-turn in prices due to the growth of the market in Africa for clothes manufactured in the Far East and China.

7.5.1 Characterisation of the waste stream

Overview

General characteristics
The term textile covers all materials which are completely or mostly made from fibres or fur. Textiles can be divided into the categories of clothing, home (e.g. carpets, curtains), household (e.g. towels, bed linen) and technical textiles.

The material characteristics of used textiles are heterogeneous due to their different purpose.

- On average, clothing is made out of cotton (~ 67-68%) and chemical fibres (~27-28%). Only 6-7% is made out of wool. Impurities like buttons or zippers range from 5 to 10 %.
- Normally a high portion of household textiles consists of cotton.
- Home textiles are usually made out of chemical fibres. Quantitatively, textile floorings, which on average consist of ~ 60% chemical fibres and ~31% chalk, are particular relevant for waste management. Chemical fibres are usually made out of polypropylene (PP) and polyamide (PA), which can be recycled.
- Technical textiles mostly consist of chemical fibres. The material characteristics are heterogeneous due to the wide range of uses. The majority of technical textiles are merged with other materials. Hence, composite materials (materials composed of various other materials) are the result.[46]

Waste recovery

Collection and sorting

[46] Website LUA NRW: http://www.lanuv.nrw.de/abfall/bewertung/textilien.html (last access date: 20.06.2007).

The collection of waste textiles can be carried out by either commercial companies (state-owned or private-sector companies) or charitable organisations.

In general, collection systems differ depending on whether the textiles are collected from the households by the collection companies or waste disposal companies, or whether the waste is brought to special areas or premises. The first is known as "collection" system, e.g. collection of household waste, bulky refuse and the traditional street collection of textiles. The second is known as "bring-in" system, e.g. containers for used textiles, made available for public use.

The collection systems can be further divided into:

- Collection systems for waste which has not been separated:
    - Collection of household refuse
    - Bulky refuse collection
- and separate collection systems:[47]
    - Street collection
    - Collection from containers
    - Collection from recycling yard.

Pre-treatment and recovery technologies

Clothing and home textiles

Used textiles are normally separated by hand in waste treatment companies, depending on their quality and characteristics. At these companies, the collected waste textiles typically contain, on average, 40–50% wearable textiles for possible second hand re-uses, 25-30% suitable for cleaning cloths, 20-30% for utilisation as secondary raw material, and 12% contaminants.[48]

For recycling, used textiles have to be free of impurities (like buttons or zippers), which are manually removed. After the removal of impurities, the waste textiles are sent for recycling mainly in two industries:

- For the ravelling and fleece industry, used textiles are mechanically lacerated and frayed out. As a final step the fibres are enhanced to be suitable for the use in weaving mills.
- In the paper and board industry inferior textiles are frayed out and mixed with other substitutes to produce paper and board.

Textile floorings

Only a low percentage of textile floorings are recycled even though the technical potential exists.

Basically the floorings are sorted by hand into re-usable and non-re-usable fractions, chopped and treated in physical and chemical processes.[49]

Preconditions and technical limitations

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[47] Morana, R. (2000): Redistribution of textiles. Organization and strategies. Carl von Ossietzky University of Oldenburg.

[48] bvse Bundesverband Sekundärrohstoffe und Entsorgung e.V. (Hrsg.): Textilrecycling – Zahlen, Daten, Fakten, Bonn, S. 15 (2001).

[49] Website LUA NRW: http://www.lanuv.nrw.de/abfall/bewertung/textilien.html (last access date: 20.06.2007).

To be recyclable, textile waste should be made of only one type of fibre, or it should be produced in such a way that the different types of fibre can easily be disentangled.[50]

Alternative management
Textiles can be used as a fuel for energy recovery; they have a sufficiently high calorific value to be an effective source.

Textiles present a problem in landfill, since synthetic fibres will not decompose and woollen fibres emit methane when decomposing.

Environmental and health issues related to waste management

Key issues
Textiles can be used for a wide range of purposes. Hence, the contamination with hazardous substances varies depending on the usage. Wastes from the textile industry as well as used clothing, home- and household textiles generally have a low level of contamination. However, textiles from other industries where they have been used as cleaning or filter cloths are highly contaminated. They have to undergo special treatment. Depending on the use, they can be contaminated with petroleum-derived hydrocarbons, PAHs, solvents etc.

Waste recovery process
Textiles can be contaminated with heavy metals (e.g. from colours), which can be set free in incineration processes, or cause toxic reactions by re-use and recycling. Heavy metals can include chrome, which is carcinogenic, mercury or nickel.

Textile products with their wide range of applications and complex chemistry could be a significant source of dioxins and/or precursor compounds for the formation of dioxins and other POPs (persistent organic pollutants). These form during the incineration process.[51]

Market

Textile industry
Production of textile increases each year and an increasing amount of waste textile is generated each year. For economic and environmental reasons, it is preferable to maximise the recovery of textile waste instead of disposing them in landfills. The legal environment (e.g. Landfill Directive, Hazardous waste Directive etc.) is given by the EU Directives and regulations.

The main markets for re-use and recycled textiles are:

- Wearable clothes are re-sold nationally or abroad.

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[50] Morana, R. (2000): Redistribution of textiles. Organization and strategies. Carl von Ossietzky University of Oldenburg.

[51] Dioxin and Dioxin-like Persistent Organic Pollutants in Textiles and Chemicals in the Textile Sector
Bostjan Krizanec and Alenka Majcen Le Marechal, Faculty of Mechanical Engineering, Smetanova 17, SI-2000 Maribor, Slovenia.

- Non-wearable textiles are sold to the flocking industry. Items here are shredded for fillers in car insulation, roofing felts, loudspeaker cones, etc.
- Woollen garments are sold to specialised firms for fibre reclamation and turned into yarn or fabric and cotton
- Silk is sorted into different grades to become cleaning cloths for a range of industries from automotive to mining and to be used in paper manufacture.

Example

The composition of the collected textiles varies depending on their origin. The German Fachverband Textilrecycling e.V. estimates that 100 kg collected textile waste can be processed in to the following marketable fractions:

- *1 – 3 kg wearable textiles for second-hand trading*
- *– 20 kg wearable textiles for resale to Eastern Europe*
- *– 30 kg wearable textiles for resale to Africa*
- *25 kg non-wearable textiles for fibre reclamation*
- *25 kg non-wearable textiles for energy recovery.*

The recycling of used clothing, linens and textile by-products provides an important source of raw materials and creates jobs.

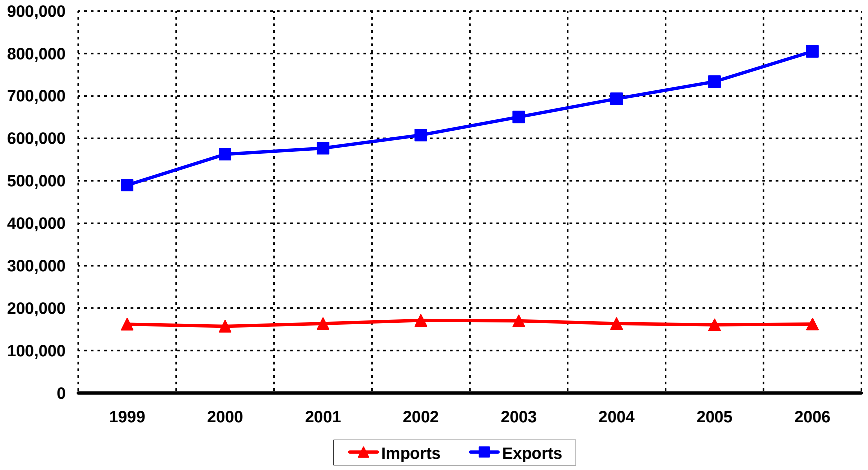
The European textile recycling sector employs about 100,000 workers.

The textile recycling market is an international market.

Recycling market

The EU 27 is a net exporter of worn clothing and other worn textile articles. Since 1999 exports have constantly increased by 164 % from 490,000 tonnes in 1999 to 805,000 tonnes in 2006. On the other hand, over the last 8 years imports of worn textile articles have been quite stable with an account of around 162,000 tonnes.

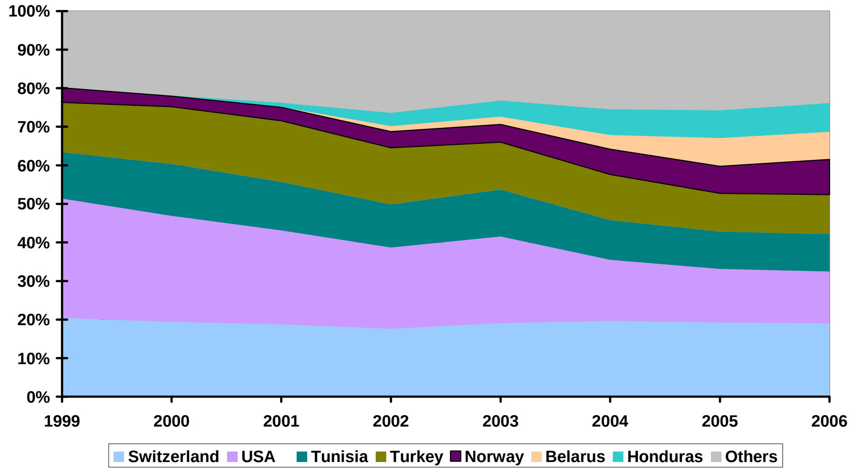
Figure 47: EU 27 worn clothing and other worn textiles articles trade 1999-2006 (in '000 tonnes)



Source: COMEXT

In 1999, 51 % of worn clothing and other worn textile articles imports came from Switzerland and the USA. While Switzerland's share of the total imports over the last 8 years has been reasonably stable at around 20 %, imports from the USA decreased from 31 % to 13 % of the total amount. Other main exports to the European market came from Tunisia, Turkey and Norway.

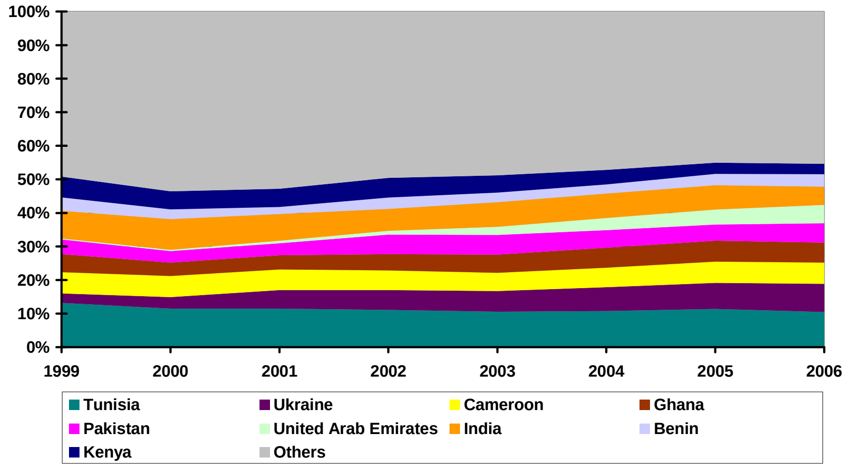
Figure 48: Share of EU 27 worn clothing and other worn textile articles imports 1999-2006 by origin



Source: COMEXT

There is no principal destination for EU exports. These go to a large number of countries especially in African countries and countries in the Near East. Exports to Tunisia have been quite stable over the years (10 % of the total amount).

Figure 49: Share of EU 27 worn clothing and other worn textile articles exports 1999-2006 by destination



Source: COMEXT

Market prices

Demand for all grades of recycled textiles (mainly second hand clothes) proves to be stable at low price levels. Prices have fallen during recent years mainly driven by competition advantages of low-wage countries in Eastern Europe and North Africa and a lower overall supply due to poor quality of new clothes from Asia and Far East, making them unsuitable for recycling.

The financial viability of textile recycling and energy recovery is strongly influenced by the sale of the wearable fractions as second-hand clothes.

Despite the downturn in prices, a market for second hand clothing continues to play an important role in diverting unwanted textile material from landfill.

Example
Actual prices for container ware (bring-in system) in Germany are between 22 to 28 cents per kg, for collected textiles around 30 cents, for high quality material the prices are up to 35 cents.[52]

7.5.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream textiles. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 19: Waste sources for the waste stream textiles

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
IV	150202	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	☠	**03.1**	Chemical deposits and residues	☠/⚐
	150203	absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02				
II (IV)	200110	clothes		**07.6**	Worn clothing & miscellaneous textiles wastes	
	040209	wastes from composite materials (impregnated textile, elastomer, plastomer)				
	040210	organic matter from natural products (e.g. grease, wax)				
	040221	wastes from unprocessed textile fibres				
	040222	wastes from processed textile fibres				
	150109	textile packaging				
	191208	textiles				
	200111	textiles				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1******	Construction and demolition wastes	

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered textile waste amounts where estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of textile waste is necessary. The considered textile waste amounts where estimated as described in the Introduction.
*** Allocation of waste stream sources to the sources group in the flow sheet
I Municipal solid waste (MSW) and bulky waste

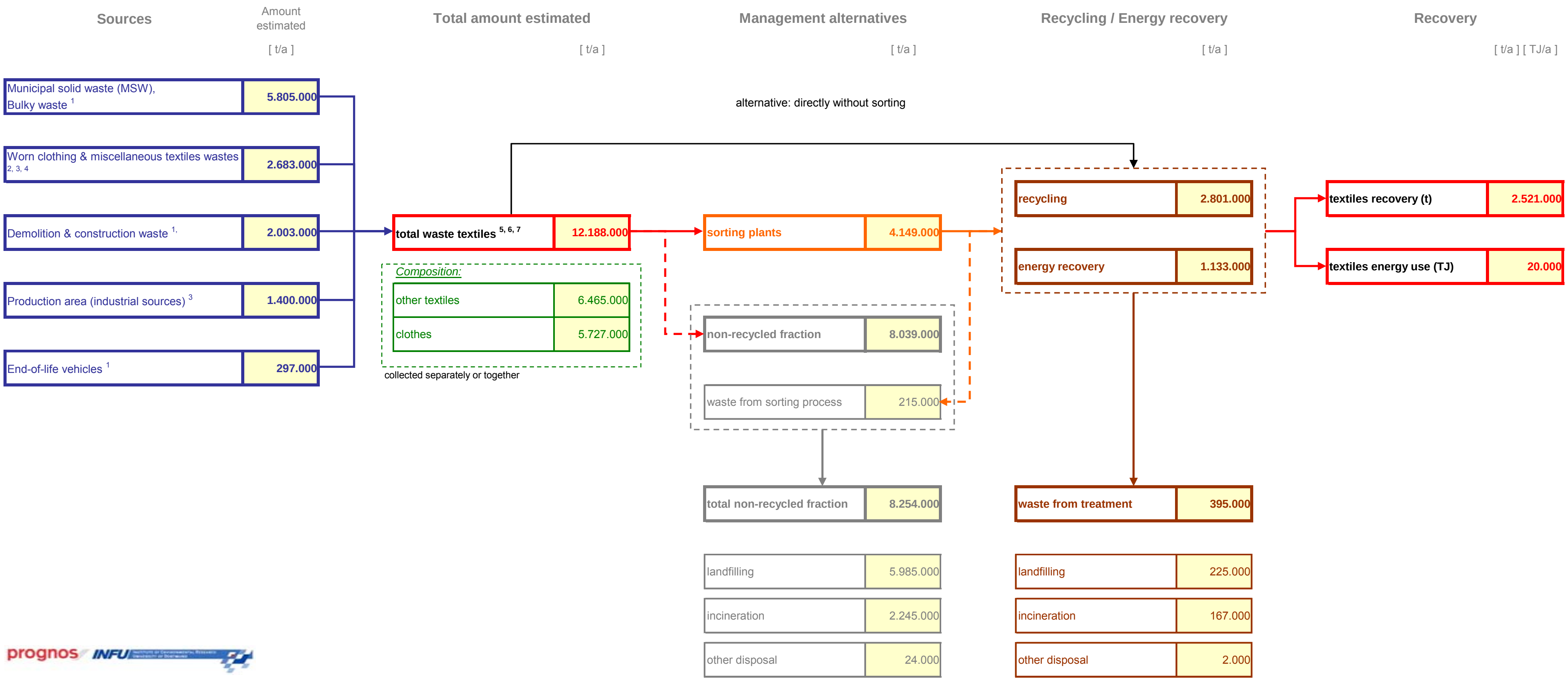
[52] Euwid, Marktbericht Alttextilien Juli 2007.

II Worn clothing & miscellaneous textiles wastes (including separate collected fractions from MSW and separate recorded textiles waste from industry and treatment processes (as described in the table "waste sources"). For member states with EWC-6-digit-level data basis are considered only separate selected fractions 200110, 200111 and waste from treatment 191208.
III Demolition and construction waste
IV Production and industrial sources (including codes 040209, 040210, 040221, 040222 and 150109 for member states with EWC-6-digit-level data basis)
V End-of-life-vehicles
**** Data available only for the aggregated group "12.1 to 12.5 not 12.4"

7.5.3 Key figures

As a result of adjusting the available data basis the following flow sheet for the waste stream textiles could be compiled.

Figure 50: Estimation of waste textiles flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "Worn clothing & miscellaneous textiles wastes". Separate data available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 18,000 tonnes.
3. Textiles recorded separately from production and industry (040209, 040210, 040221, 040222 and 150109) is included in the group "Worn clothing & miscellaneous textiles wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "production and industrial sources".
4. Includes also textiles waste from treatment processes, which are part of the aggregated group "Worn clothing & miscellaneous textiles wastes". Separate data available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 17,000 tonnes.
5. Data for Latvia pertains only to for municipal and commercial waste; no information is available for other economic sectors.
6. Data for Poland, Slovakia and Czech Republic was compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.
7. Data for Portugal is available only for MSW, all other figures roughly estimated.

The main sources for waste textiles as the starting point of the waste flowsheet is displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.

Due to the use of at least two different data sources (EWC and EWC-STAT)

- Textiles waste collected separately from municipal solid waste is not reported separately, but included in the group "worn clothing & miscellaneous textiles wastes", as separate data is only available for member states with EWC data basis.

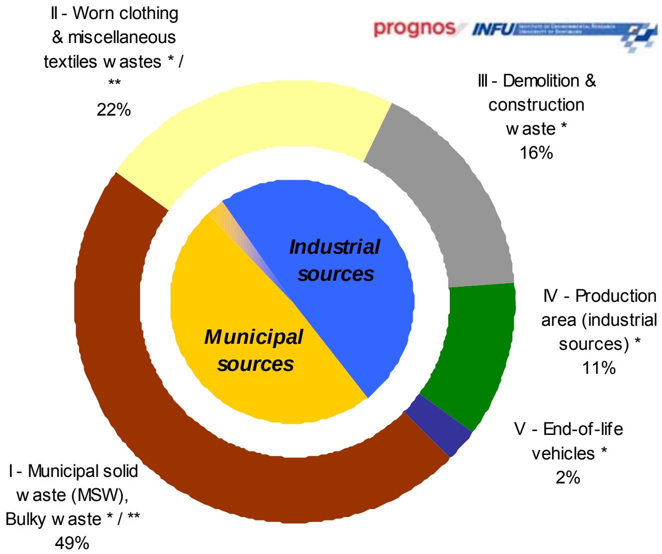
- Textiles from production and industry sources cover several potentials. Separately recorded fractions (040209, 040210, 040221, 040222 and 150109) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "worn clothing & miscellaneous textiles wastes", because an allocation is not possible due to the aggregated data basis.

- Textiles from waste treatment processes are not reported separately, but also included in the group "worn clothing & miscellaneous textiles wastes", as separate data is only available for member states with an EWC data basis.

In total, the amount of waste textiles generated in the EU 27 was 12.2 Mt in 2004, of which 9 % - 51 % is originated from MSW[53].

[53] No better estimates can be provided because the aggregated group "Worn clothing & miscellaneous textile waste" includes textile fractions from both MSW and from production and commercial sources.

Figure 51: Estimated textiles waste generation by sources



* please refer also to notes referring to Table 19 and Figure 50
** includes waste fractions from MSW

The amount of textiles waste fraction collected separately or collected and then separated in sorting plants with the objective of recycling / energy recovery[54] was estimated at 4.15 Mt in 2004. Taking into account various losses during the sorting process, about 3.9 Mt of textiles waste were returned to the textiles manufacturing industry for recycling or to energy recovery. Considering further losses during the textiles recycling processes, the total material recovery of textiles waste amounted to about 2.5 Mt in 2004; energy use was estimated to approx. 20,400 TJ.

The estimated share of the waste textiles for recycling or energy recovery of the total estimated waste textiles generation (rate of recycling/energy recovery) was about 32 % at the level of the EU 27, also shown in

[54] Total generated textiles waste less directly disposed textiles waste fractions.

Figure 54.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 52.

France, Germany, Luxembourg, Denmark, Austria and Belgium record the highest textiles waste recycling rate of more than 40 %.

Figure 52: Recycling potential in kg per capita (2004)

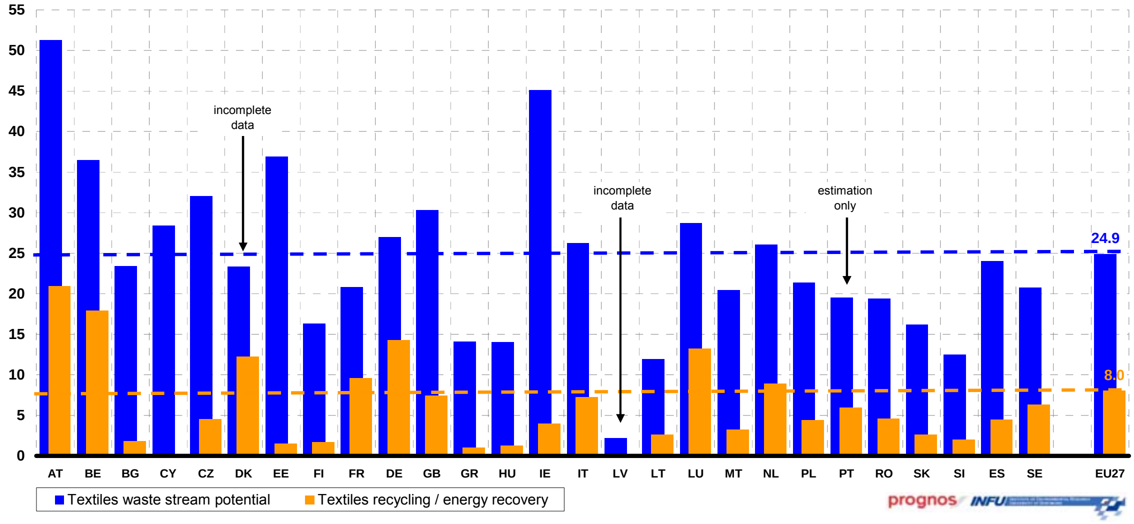


Figure 53 shows the estimated total amount of textiles waste by different waste management alternatives, and

Figure 54 presents the same data but in percentage.

Figure 53: Management alternatives for waste textiles (in '000 tonnes)

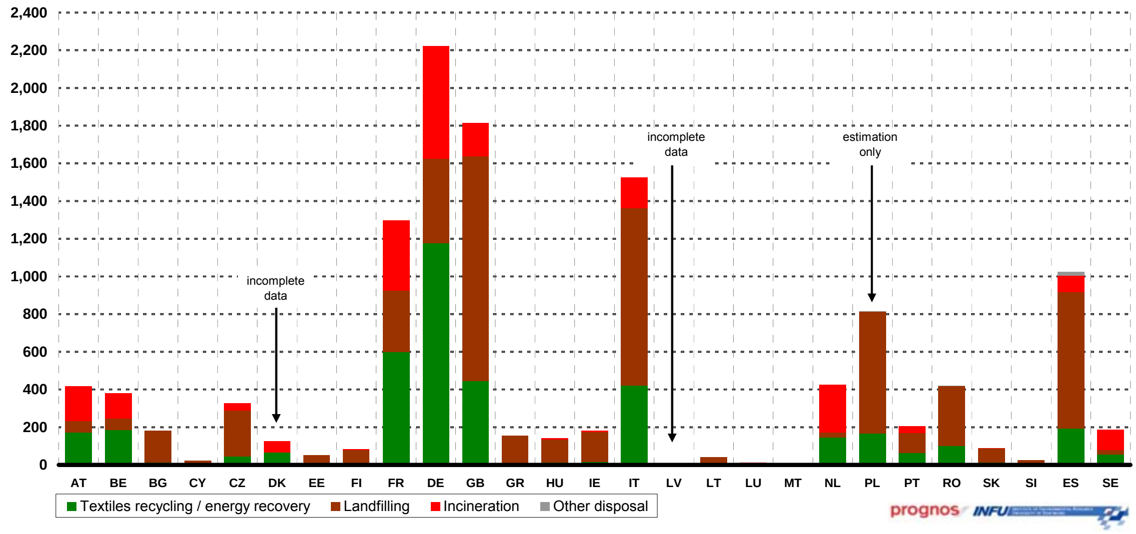
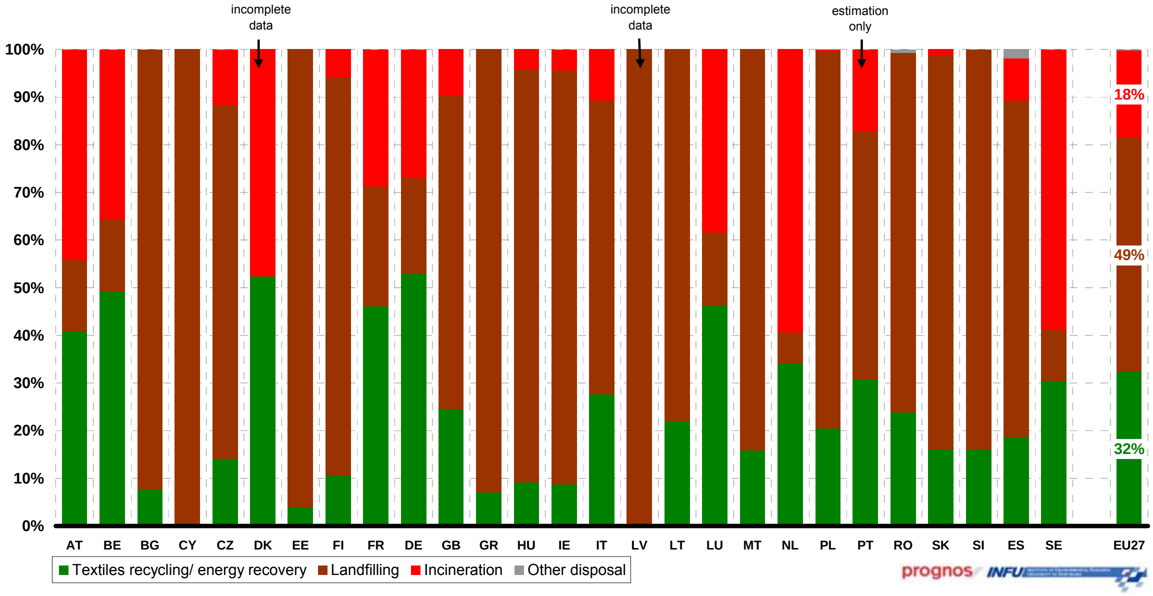


Figure 54: Estimated share of alternatives in waste textiles management (2004)



7.6 Iron & steel

Main findings:

- The amount of iron & steel generated in the EU 27 can be estimated at 102.6 Mt in 2004. In addition, approx. 20 % can be added in the form of scraps as a result of the production processes of steel, which are not recorded in waste statistics.
- Of these, an estimated 77.7 Mt were recycled in furnace (nearly 76 %).
- Iron and steel can be recycled any number of times without loss of quality.
- The iron and steel scrap industry rely exclusively on the steel industry. The demand is expected to grow in the next years. The market is an international market. The prices remain at a high level.

7.6.1 Characterisation of the waste stream

Overview

General characteristics
Steel is an alloy that consists mostly of iron, with the carbon content between 0.02 % and 2.04 % by weight, depending on grade. Carbon is the most cost-effective alloying material for iron, but various other alloying elements are used such as manganese and tungsten.

Steel can be used in a wide range of applications from container ships to ballpoint pens. Steel can also be used in a wide variety of environments, including extremes of cold and heat, and in both arid and wet climates due to its strength.

The main sources of iron and steel scrap are the construction and transportation sectors, which together account for 42 % of the total steel consumption in 2006. Mechanical engineering, tube and metal ware account for another 40 % and are also the main sources of old scrap.[55]

Waste recovery

Collection and sorting
Steel is one of the easiest materials to recover from waste streams. It can be recovered by magnet sorting.

All steel can potentially be recycled, although it may take very long for some steel products to become scrap. This is true for steel used in permanent public works and buildings. Also, in some applications, steel will gradually wear away, which makes it impossible to recover. Examples are grinding balls and liners for crushing.

However, the great majority of steel scrap is available for recycling. It comes from a variety of sources, including scrap generated in steel plants (known as home scrap), off-cuts generated by manufacturers (prompt industrial scrap), both known as new scrap, and steel

[55] End-of-waste – Scrap Metal Case Study, working document, 20 March 07, European Commission Institute for Prospective Technological Studies.

locked up in items that have come to the end of their lives, old scrap. The highest amount of scrap steel comes from end-of-life vehicles (about 25 %)[56]

Life spans of steel products vary significantly from 20 to 60 years in buildings to just a few days for steel cans. As consequence, the yearly availability of iron steel scrap is affected.

Steel mills and foundries acquire ferrous scrap provided by brokers, scrap collectors, and processors. Brokers bring scrap buyers and sellers together for making a scrap transaction, and they receive a fee for this service.

Pre-treatment and recovery technologies

Using a variety of technologies, scrap dealers collect and process scrap into a physical form and chemical composition that steel mill furnaces can handle.

The largest and most expensive form of equipment used for scrap treatment is the shredder, which fragments vehicles and other steel-containing objects into fist-size pieces of various materials. These are further segregated by using magnets, fans, air ducts, hand pickers, and flotation equipment.

At the end of this process, steel components can be:

- recycled in the Electric Arc Furnace (EAF) and Basic Oxygen Furnace (BOF) steelmaking processes to make new steel for a different application, or foundry industries.
- re-used, e.g. by dismantling components from scrap vehicles and fitting them to another car, or by removing the cladding on a building and using for another structure, and
- re-use, e.g. by taking a beam or column from a building and cutting or shaping it for another building or use.

The recycling of metal alloy is more complicated, because the metal needs to be sorted and recycled by type of alloy using complex and expensive technologies.

Preconditions and technical limitations

Iron and steel can be recycled any number of times without loss of quality.

However, the contamination of copper can affect the recyclability of the steel scrap. Mixed scrap often has high level of copper, which can not be totally eliminated during the pre-treatment process. This may, particularly in the long term, result in the accumulation of copper in steel recycling circle, exceeding the tolerance of the furnaces.
There are several limitations in collecting iron and steel waste for recycling if there is no magnetic equipment available. In these cases the losses are high, especially in the case of mixed MSW due to the difficulties in hand sorting.

Alternative management

Iron-containing waste that cannot be recovered is disposed of in landfills, losing potential valuable resources as well as creating potential problems with emissions.

[56] http://www.recycle-steel.org/cars.html (2007).

Environmental and health issues related to waste management

Key issues

The recycling of scrap steel is vital to the production of new steel products. Recycling enables steel makers to save energy in the production of steel as well as to preserve the earth's resources.

It is estimated that over 99 % of the steel in a car is usually recycled. Typically, 84 % of the steel in a demolished building is recycled, and 10% is re-used.

It is further estimated that over 60 % of steel cans are recycled. Recycling 7 steel cans thereby saves enough energy to power a 60 watt light-bulb for 26 hours[57].

An integrated steel plant generates by-products, mainly consisting of iron scale from the rolling mills and a wide variety of gases and sludges from waste gas treatment devices, which are then transported to sinter plants.

Whenever these dust, sludges, and mill scales have a sufficiently high iron content (over 50 %) they can be used as raw materials for sinter plants. In most plants these account for 10 to 20 % of the plant's feed.

Although a great part of the emitted gases and sludges are filtered out or re-used, emissions (dioxins and furans) still find their way into the environment. The maximum emission which can be tolerated is often set by state governments or the EU[58]

.

Heavy metals can pose a serious, sometimes fatal health threat to living organisms exposured to high concentrations.

Dioxins and furans are known to be toxic as well with health risks even when exposed to small amounts over a limited amount of time.

Waste recovery process

<u>Emissions from Basic Oxygen Furnace (BOF):</u>

By far the largest mass of fumes is generated during the main blow, consisting of:

- Hot gases emitted into the air. About 80 Nm³ per tonne of steel consisting of 80-95 % CO and the rest CO_2 are emitted to air. Additionally, oxide dust is produced, about 12 kg iron oxide per tonne of steel which also contains heavy metal oxides, e.g. zinc, lead, and others, depending on the scrap mix,
- Lime and slag particles, about 4 kg per tonne of steel.
- BOF slag is generated at a rate of 60 to 100 kg per tonne of steel. After steel tapping, it is poured in a slag pot by tilting the converter and it is dumped in the slag yard from which it can be reclaimed.

[57] http://www.steeluniversity.org/content/html/eng/default.asp?catid=144&pageid=2081271457.

[58] EUROFER EAF, 1997 or EUROFER BOF, 1997.

Currently, about half of this quantity is recycled locally, either in the sinter plant or else used directly in the blast furnace. The valuable elements recovered are Fe and CaO. Such in-plant slag recycling has been declining because of higher steel quality demands, e.g. with a lower content of phosphorus.

Other uses such as landfill, aggregate and agricultural purposes are being explored.

Emissions from Electric arc furnace (EAF):

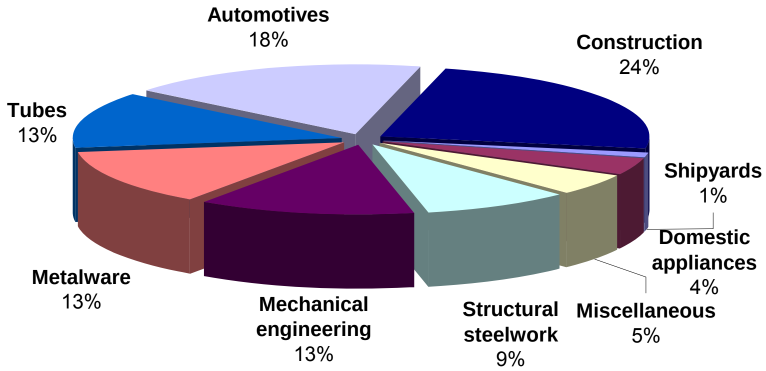
- Heavy metals such as mercury and cadmium which occur mostly as gases.
- The emission of dioxins and furans depends on the quality of steel supplied to the furnace.
- Sludges accrued in the process are often used for construction, e.g. for roadworks.

Market

Iron & steel Industry

With production of 198.4 Mt in 2006, about 16% of the world's total steel output, the EU is the second leading manufacturer in the world after China, ahead of Japan and the US. The steel market is fully globalised, including the prices. Nevertheless, due to increasing transport costs and the need for a close technical and service relationship with clients, regional markets are the core business for steel producers.

Figure 55: EU main uses of steel in 2005



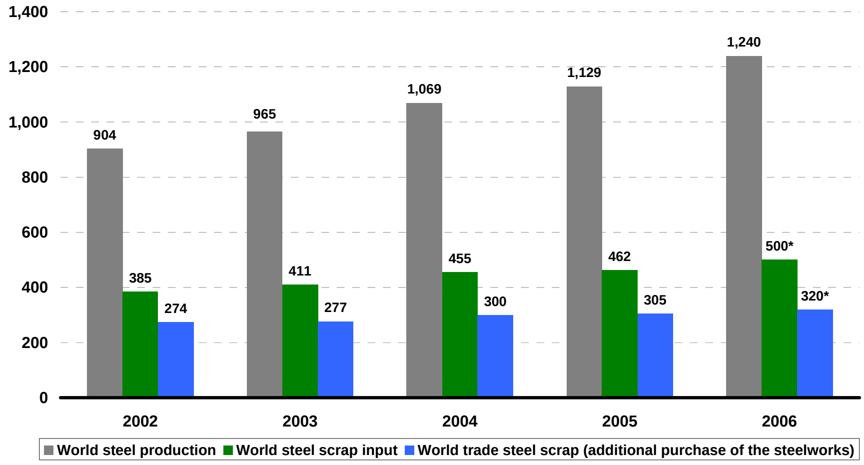
Source: EUROFER

All industrial sectors depend on steel to some extent. Those which are heavily dependent on steel are transport, construction, infra-structure, mechanical engineering, and household goods.

Recycling market The iron and steel scrap recycling industry relies exclusively on the steel industry. For 2006 the use of steel scrap for steel production worldwide is estimated at 500 Mt.[59]

Figure 56: Worldwide steel production, scrap use and scrap trade

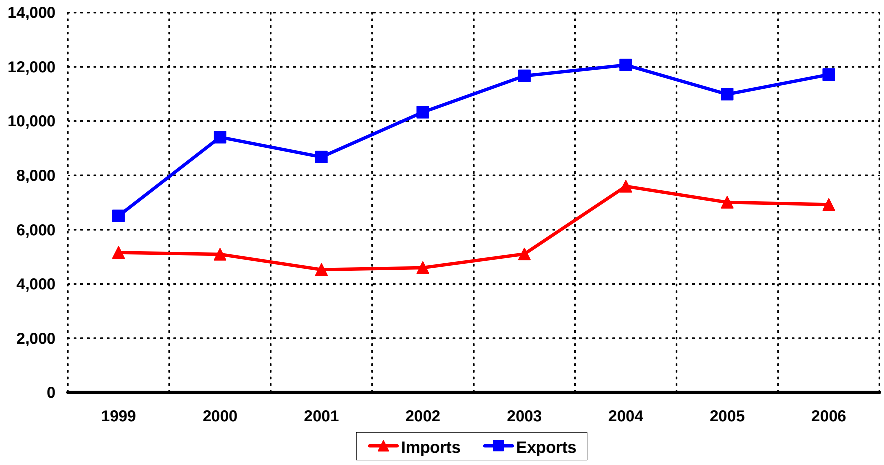
[59] Bundesvereinigung Deutscher Stahlrecycling- und Entsorgungsunternehmen (BDSV) on the basis of IISI-data; In: Stahlrecycling 1/2007, p. 8.



Source: Bundesvereinigung Deutscher Stahlrecycling- und Entsorgungsunternehmen

The International Iron and Steel Institute (IISI) expects a continuous growing demand for steel in 2007. The international trade of steel scrap is an important factor for the supply of steel mills.

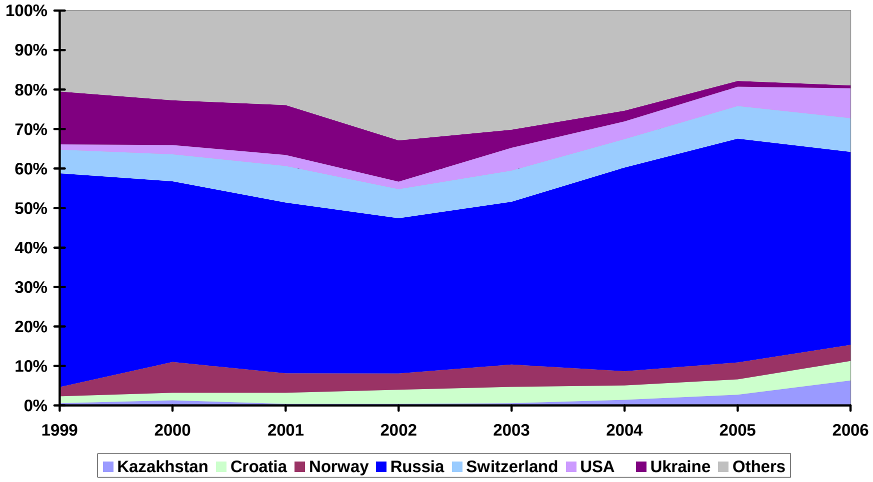
Figure 57: EU 27 ferrous waste and scrap trade 1999 – 2006 (in '000 tonnes)



Source: COMEXT

The ferrous scrap trading channels for the EU 25 have remained quite stable over the last 6 years. Russia has remained by far the most important ferrous scrap supplier to the EU with a share of 49 % of total imports in 2004, accounting for 4.2 Mt. The export volume of Russia decreased in the last year due to higher domestic demand (new capacities of electric arc furnaces).

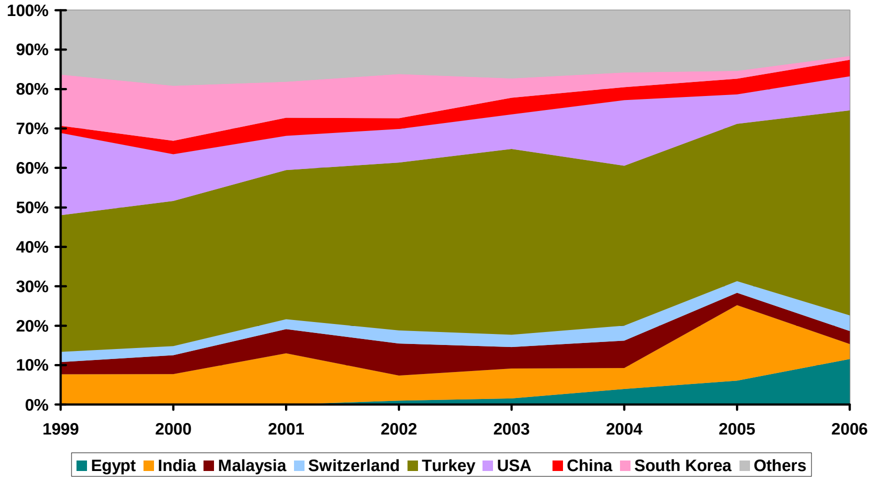
Figure 58: Share of EU 27 ferrous waste and scrap imports 1999 – 2006 by origin



Source: COMEXT

Europe is clearly a net exporter of scrap with a growing gap between imports and exports. The EU 25 exported about 10 Mt in 2006. More than 50 % of EU 25 ferrous scrap exports are still going to Turkey (4.83 Mt/2006) and the USA (0.92 Mt/2006).[60]

Figure 59: Share of EU 27 ferrous waste and scrap exports 1999 – 2006 by destination



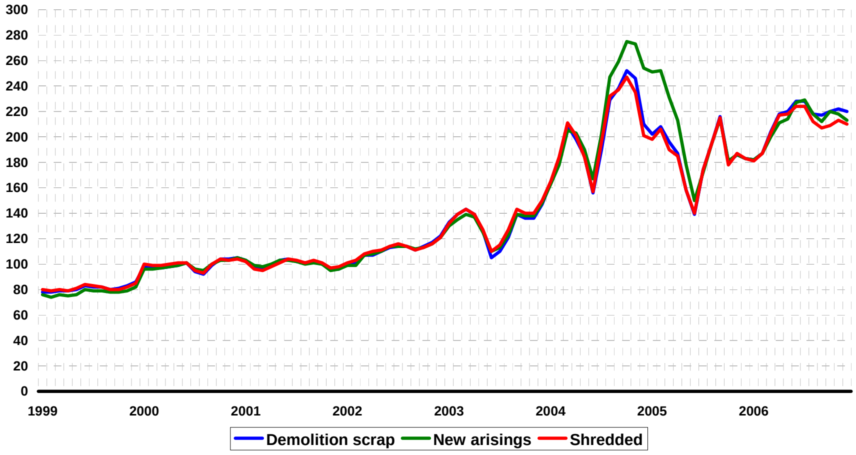
Source: COMEXT

Market prices According to information from the European Confederation of Iron and Steel Industries (EUROFER), the price index for demolition scrap in June 2007 was at 242 €/t (New arisings: 238 €/t, shredded: 236 €/t).[61] In comparison to 1999, the price for demolition scrap increased to three times on average. The European steel scrap prices now remain at a high level and after the relative high fluctuation between 2004 and 2005, the average prices in 2006 stabilised at the same level as in 2004.

60 Bundesvereinigung Deutscher Stahlrecycling- und Entsorgungsunternehmen (BDSV); In: Stahlrecycling 1/2007, p. 8.

61 Index (2001 = 100) calculated on the basis of the average price in € for the following countries: France, Germany, Italy, Spain, UK.

Figure 60: Scrap price index for demolition scrap, new arisings and shredded (€ per ton)



Index (2001= 100) calculated on the basis of the average price in € for the following countries: France, Germany, Italy, Spain, UK; Source: EUROFER

7.6.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream iron & steel. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 20: Waste sources for the waste stream iron & steel

*Grouping****	EWC	Waste Description	Hazardous	EWC-STAT**	Waste Description	Hazardous
II	100210	mill scales		06.1****	Ferrous metal waste and scrap	
	120101	ferrous metal filings and turnings				
	120102	ferrous metal dust and particles				
	160117	ferrous metal				
	170405	iron and steel				
	190102	ferrous materials removed from bottom ash				
	191001	iron and steel waste				
	191202	ferrous metal				
	150104*	metallic packaging		06.3****	Mixed metal wastes	
	020110*	waste metal				
	170407*	mixed metals				
	200140*	metals				
V	160104*	end-of-life vehicles	☠	08.1	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
	160211*	discarded equipment containing chlorofluorocarbons, HCFC, HFC	☠	08.2	Discarded electrical and electronic equipment	☠/⚐
	160213*	discarded equipment containing hazardous components other than those mentioned in 16 02 09 to 16 02 12	☠			

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
	160214*	discarded equipment other than those mentioned in 16 02 09 to 16 02 13				
	200135*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components	☠			
	200136*	discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35	☠			
	160107*	oil filters	☠	**08.4**	Discarded machines and equipment components	☠/⚐
	160215*	hazardous components removed from discarded equipment	☠			
	160216*	components removed from discarded equipment other than those mentioned in 16 02 15				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
IV	120113*	welding wastes		**10.2**	Mixed and undifferentiated materials	
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1** *****	Construction and demolition wastes	
IV	100909*	flue-gas dust containing dangerous substances	☠	**12.4**	Combustion wastes	☠/⚐
	100910*	flue-gas dust other than those mentioned in 10 09 09				
	100903*	furnace slag				

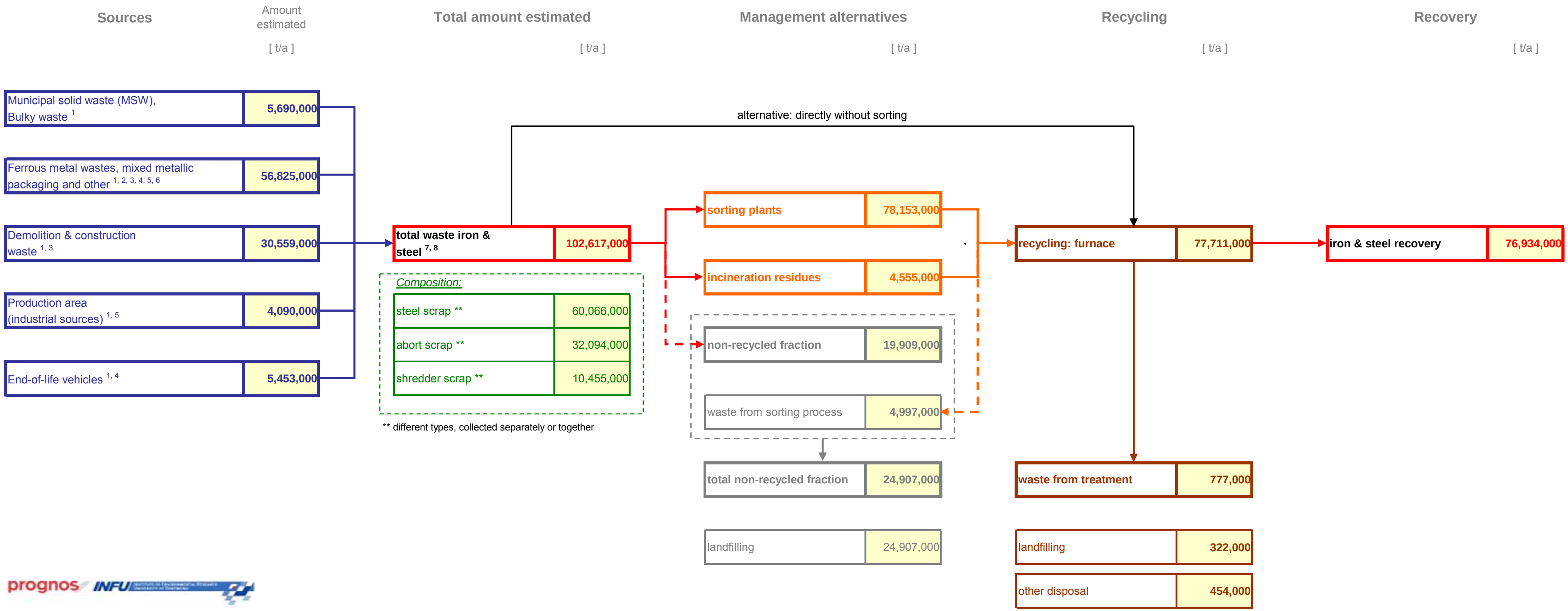
☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered iron/steel waste amounts where estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of waste iron/steel is necessary. The considered iron/steel waste amounts where estimated as described in the Introduction.
*** Allocation of waste stream sources to the sources group in the flow sheet
I Municipal solid waste (MSW) and bulky waste
II Ferrous metal waste, mixed metallic packaging and other mixed metallic wastes (including separate collected fractions from MSW and separate recorded iron/steel waste from industry, end-of-life vehicles and discarded electronic equipment and construction & demolition such as treatment processes (as described in the table “waste sources”). For member states with EWC-6-digit-level data basis are considered only separate selected fraction 200140 and waste from treatment 190102, 191001 and 191202).
III Demolition and construction waste (including code 170405 and 170407 for member states with EWC-6-digit-level data basis)
IV Production and industrial sources ((including code 100210, 120101, 120102 and 150104 for member states with EWC-6-digit-level data basis)
V End-of-life-vehicles and discarded electronic equipment (including code 160117 for member states with EWC-6-digit-level data basis)
**** Data available only for the aggregated group “06”
*****Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.6.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream iron & steel could be compiled.

In addition to old scrap collected for recycling from steel in society, the model includes only a share of recovered steel from manufacturing, which occurs within several processing stages in metallurgical plants, steel and rolling mills (cycle scrap) or within production of steel products. This recovered steel is returned directly to steel manufacturing without further processing and therefore not recorded completely.

Figure 61: Estimation of iron & steel waste flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "Ferrous metal waste, mixed metallic packaging and other mixed metallic wastes". Separate data available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 79,000 tonnes.
3. Iron/steel collected separately from construction & demolition waste (170405, 170407) is included in the group "Ferrous metal waste, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "construction & demolition waste".
4. Iron/steel recorded separately from end-of-life-vehicles (160117) is included in the group "Ferrous metal waste, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "end-of-life-vehicles".
5. Iron/steel recorded separately from production and industry (100210, 120101, 120102 and 150104) is included in the group "Ferrous metal waste, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "production and industrial sources". "Cycle scrap" within steel works ("own scrap") is not included.
6. Includes also iron/steel waste from treatment processes, which are part of the aggregated group "Ferrous metal waste, mixed metallic packaging and other mixed metallic wastes". Separate data available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 3.7 Mt.
7. Data for Latvia and Portugal reflects only municipal and commercial waste; no information is available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic is compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.

The main sources for waste iron & steel as the starting point of the waste flow sheet is displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.

Based on the use of at least two different data sources (EWC and EWC-STAT)

- Iron & steel waste collected separately from municipal solid waste is not reported separately, but included in the group "ferrous metal waste, mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with EWC data basis.

- Iron & steel from construction and demolition sources covers several potentials. Separately collected fractions (170405 and 170407) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "ferrous metal waste, mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

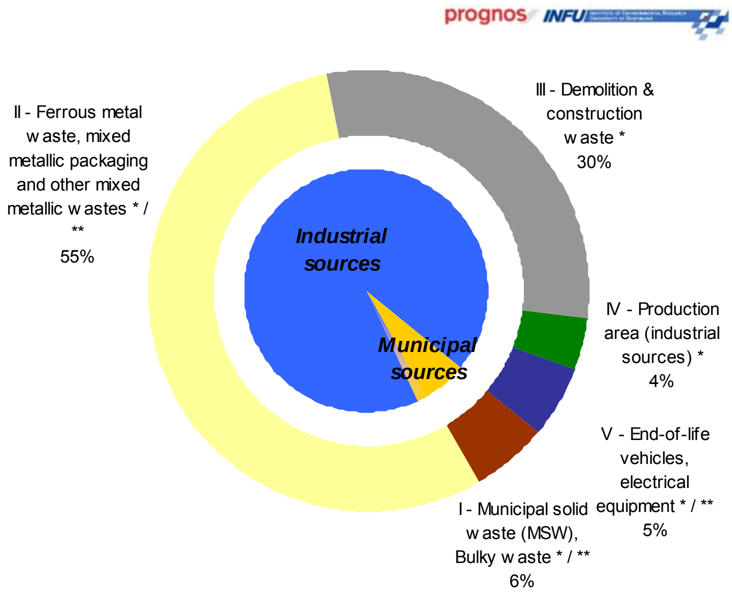
- Iron & steel from production and industry sources covers several potentials. Separately recorded fractions (100210, 120101, 120102 and 150104) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "ferrous metal waste, mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis. "Cycle scrap" within steel works ("own scrap") is not included.

- Iron & steel from end-of-life-vehicles covers potentials from mixed end-of-life-vehicle fractions and end-of-life-vehicle fractions with dangerous substances. Separately collected fractions (160117) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "ferrous metal waste, mixed metallic packaging and other mixed metallic wastes", as an allocation is not possible due to the aggregated data basis.

- Iron & steel from waste treatment processes is not reported separately, but also included in the group "ferrous metal waste, mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with an EWC data basis.

In total, the amount of iron & steel waste generated in the EU 27 was 102.6 Mt in 2004, of which 6 % - 7 % is originated from MSW[62].

Figure 62: Estimated iron & steel waste generation by sources



* please also refer to notes on Table 20 and Figure 61
** includes waste fractions from MSW

The estimated amount of iron/steel waste fraction collected separately or collected and then separated in sorting plants with the objective of recycling [63] was estimated at 82.7 Mt in 2004. Taking into account various losses during the sorting process, about 77.7 Mt of iron/steel waste were returned to recycling processes (furnace). Considering further losses during iron & steel furnace processes, the total recovery of iron & steel waste amounted to about 76.9 Mt in 2004.

The estimated share of the iron & steel waste for recycling of the total estimated iron & steel waste generation (rate of recycling) was about 76 % at the level of the EU 27, also shown in

[62] No better estimates can be provided because the aggregated group "Ferrous metal, mixed metallic packaging and other mixed metallic wastes" includes iron/steel fractions from both MSW and from production and commercial sources.

[63] Total iron/steel waste generated less directly disposed iron/steel waste fractions.

Figure 65.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 63. The Netherlands, Sweden, Germany and Denmark record the highest iron & steel waste recycling rate of more than 80%.

Figure 63: Recycling potential in kg per capita (2004)

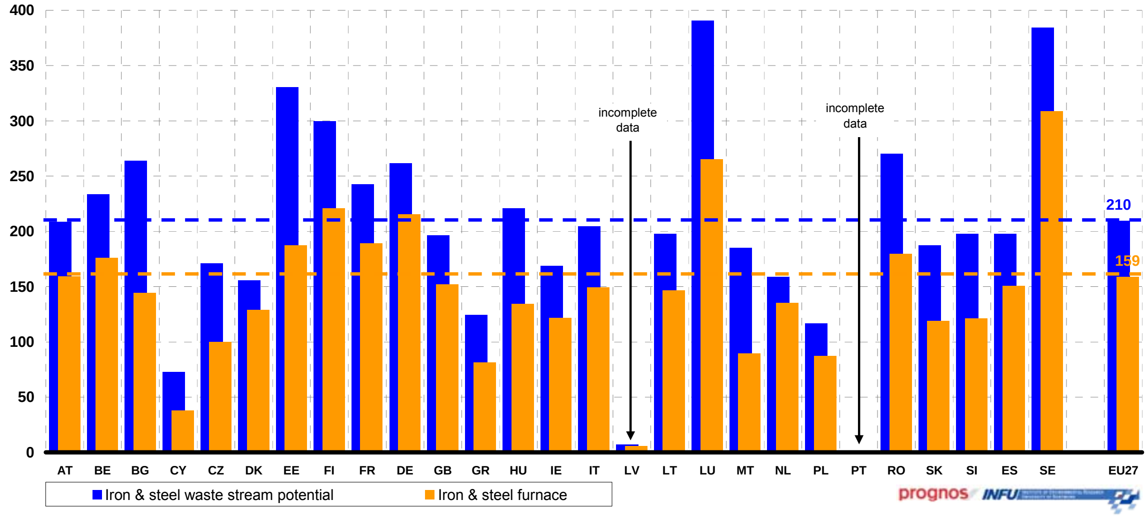


Figure 64 shows the estimated total amount of iron & steel waste by different waste management alternatives, and

Figure 65 presents the same data but in percentage.

Figure 64: Management alternatives for iron & steel waste (in '000 tonnes)

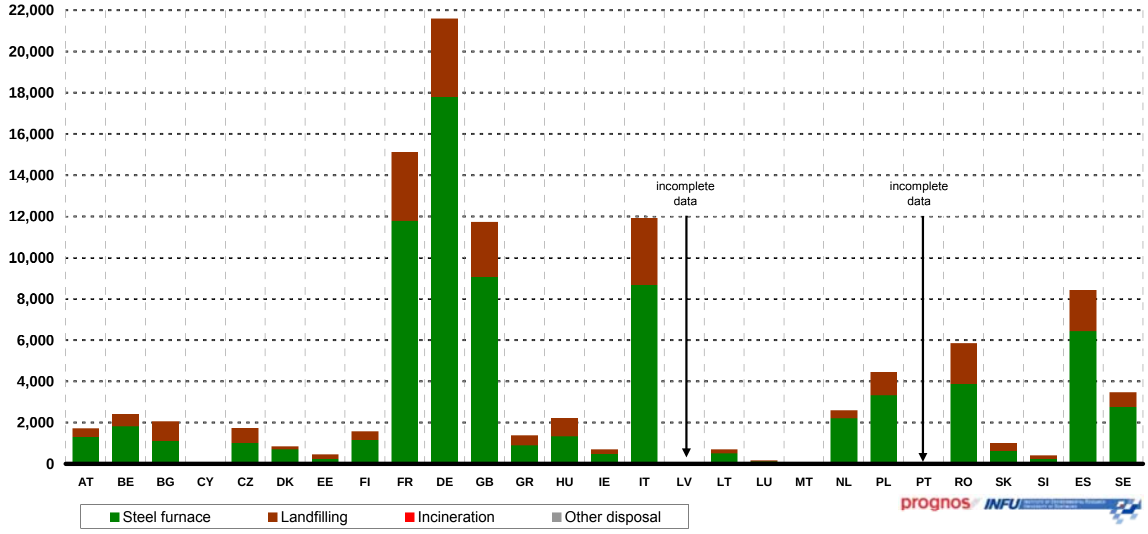
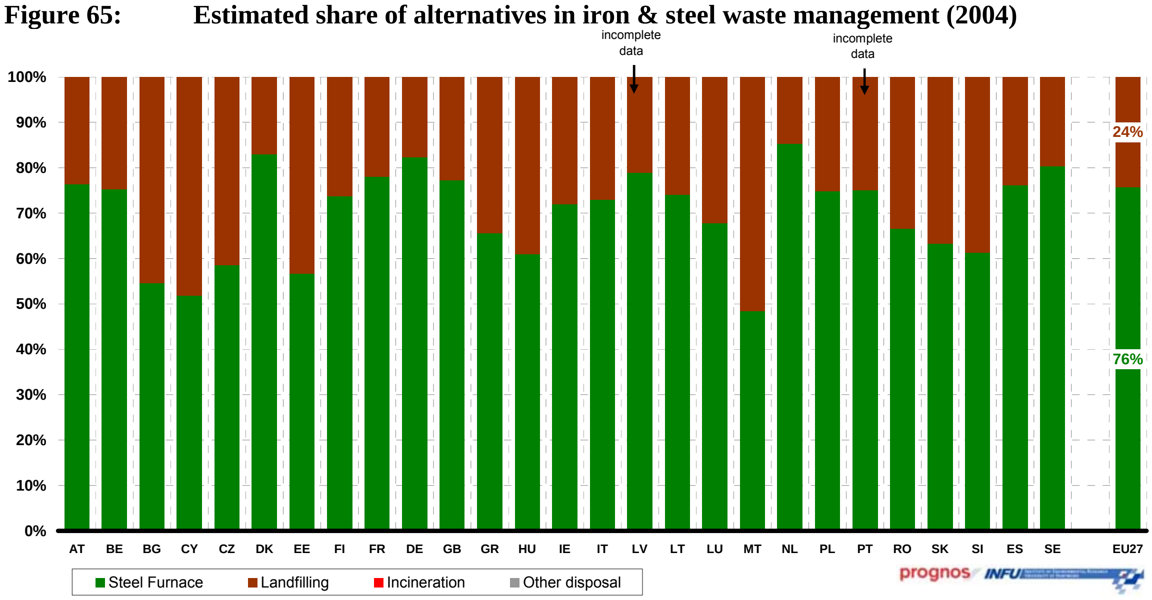


Figure 65: Estimated share of alternatives in iron & steel waste management (2004)



7.7 Aluminium

Main findings:

- The amount of aluminium waste generated in the EU 27 can be estimated at 4.6 Mt in 2004. Additional amount is added from scraps within the production of aluminium products, which are not recorded in waste statistics
- Of these, an estimated nearly 3.1 Mt were recycled in the secondary-aluminium-process (nearly 66 %).
- Aluminium-containing scraps are recycled when relevant from both an economic and environmental perspective. In total, it is assumed that 70 % of yearly aluminium production can be recycled either in the same year or when reaching their end of life.
- Due to an increasing demand, aluminium scrap has a significant market price. The market is an international market.

7.7.1 Characterisation of the waste stream

Overview

General characteristics
In Europe, aluminium enjoys high recycling rates, ranging from 41 % for beverage cans to 85 % for building and construction and 95 % for transportation vehicles.

The re-melting and refining process using aluminium scrap saves up to 95 % of the energy needed to produce the primary metal.

Aluminium scrap generation has doubled since 1990 and is expected to increase further, mainly due to the continuous increase of aluminium content in products such as vehicles in the last 15 years.

The automotive industry is by far the largest source for aluminium scrap, followed by the construction and building industries and packaging.[64]

Aluminium is a light metal which can be given tremendous strength by alloying. It conducts heat and electricity, reflects light and radiant energy and resists corrosion. It is also non-magnetic, non-toxic, and can be formed by all known metal working processes. Because of these advantages, it is widely applied.

The density of Aluminium is 2.7 kg/dm³ or approximately one third the density of steel.

Waste recovery

Collection and sorting

[64] End-of-waste – Scrap Metal Case Study, working document, 20 March 07, European Commission Institute for Prospective Technological Studies.

Aluminium destined for recycling can be divided into two categories: new and old scrap. New scrap is the surplus material that is discarded during the fabrication and manufacturing of aluminium alloys (e.g. the splinters of sheet edge trimmings).

Most new scrap that reaches the recycling industry comes directly from the foundries and fabrication plants. It is usually of known quality and composition and often uncoated. It can therefore be melted down with little preparation.

Old scrap is generated and collected after an aluminium-containing product has reached the end of its life. Such scrap could be, e.g., used beverage cans, car cylinder heads, window frames from a demolished building, or old electrical conductors.

Old scrap comes to the recyclers via a very efficient network of metal merchants, collectors, dismantlers and scrap processors who have the technology to separate aluminium from other metals and wastes that are also part of the motor vehicles, household appliances, etc. This is often done using heavy equipment like shredders, normally used together with magnetic separators to remove iron, eddy current technique to remove non-metal elements, and / or sink-and-float installations to separate the aluminium from other non-ferrous metal and materials by density.

The collection rate of aluminium beverage cans in Western Europe has more than doubled from 21% (1991) to 52 % (2005).

Pre-treatment and recovery technologies

If the scrap is of unknown quality the aluminium will first be passed through large magnets to remove any ferrous metal. Depending upon the type of contamination present, some scrap must be processed further; beverage cans for example must have their lacquer removed prior to re-melting.

The scrap aluminium is loaded into a furnace, which melts the aluminium completely. This molten metal is then cast or processed - using the same techniques as during primary processing.[65]

Aluminium can be alloyed with other materials to make an array of metals with different properties. The main alloying ingredients are iron, silicon, zinc, copper, and magnesium. Other materials are also used.

Aluminium can be rolled into plate, sheets, or wafer thin foils the thickness of a human hair. The rolling process changes the characteristics of the metal, making it less brittle and more ductile[66].

Preconditions and technical limitations

The quality of aluminium is not impaired by recycling; it can be repeatedly recycled. However, in a similar way as ferrous scrap, the accumulation of magnesium in the aluminium scrap in the long term is not desirable.

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[65] http://www.world-aluminum.org/production/recycling/process.html.

[66] http://www.world-aluminum.org/production/recycling/process.html.

Alternative management

Aluminium that is not recycled is disposed of in landfills.

Environmental and health issues related to waste management

Key issues
While aluminium is an abundant element in the environment, the naturally occurring forms are usually stable and do not interact with living organisms. Yet, under acidic conditions, aluminium may be released in a soluble form which can be absorbed by plants and animals.

This, however, does not seem to have any effect on living organisms.

Animal studies have shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure.

Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are the most sensitive to SO_2. It also damages trees and crops. SO_2 and nitrogen oxides are the main precursors of acid rain. This contributes to the acidification of lakes and streams, accelerated corrosion of buildings and reduced visibility. SO_2 also causes the formation of microscopic acid aerosols, which have serious health implications and contribute to climate change.

Waste recovery process
Recycling of aluminium products only emits 5 % of the greenhouse gas emitted in primary aluminium production. Recycling of old scrap now saves an estimated 84 Mt of greenhouse gas emissions per year. Since its inception, the recycling of old scrap has already avoided over one billion metric tonnes of CO_2 emissions.[67]

The anode effect, which is known of emitting PFC (perfluorocarbon), a very potent and persistent greenhouse gas, does not take place in the recycling process.[68]

There are potential emissions into the air of dust, metal compounds, chlorides, HCl and products of poor combustion such as dioxins and other organic compounds from the melting and treatment furnaces. The formation of dioxins in the combustion zone and in the cooling part of the off-gas treatment system (de-novo synthesis) may be possible. The emissions can escape the process either as stack emissions or as fugitive emissions depending on the age of the plant and the used technology. Stack emissions are normally monitored continuously or periodically and reported by on-site staff or off-site consultants to the competent authorities.

Dust, ammonia and other gases can be emitted from the improper storage, handling, treatment and transport of skimmings. There are potential releases to water of suspended solids, metals and oils from the improper product and material storage.

The type and quality of scrap has a major influence on the significance of the releases.[69]

[67] http://www.world-aluminium.org/Sustainability/Recycling.

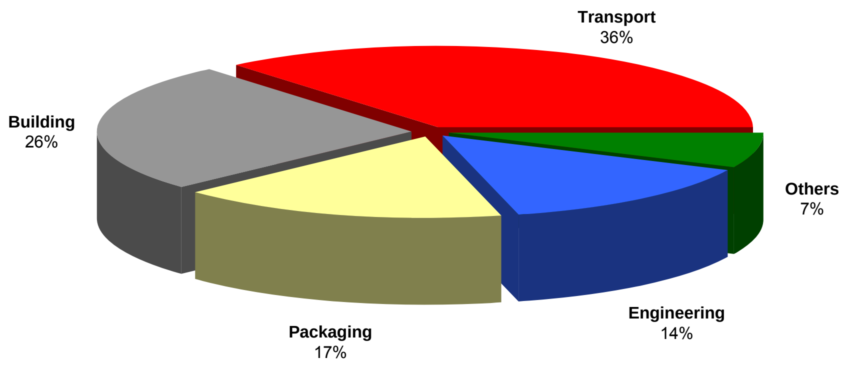
[68] http://www.world-aluminium.org/cache/fl0000153.pdf.

Market

Aluminium Industry

The aluminium industry is a growing industry. The unique combination of its physical properties (lightweight, strong, flexible, recyclable etc.) makes aluminium ideal for an almost endless range of applications and an essential part of modern living. Aluminium products are applied especially in the transportation sector, the building and construction sector, packaging, and the engineering sector.

Figure 66: Main end-use markets for aluminium products in Western Europe in 2004



Source: European Aluminium Association (www.eaa.net)

In 2006, about 33.6 Mt of primary aluminium were produced worldwide, of these, 5 Mt in Europe and 2.8 Mt in the EU 25 countries.[70]

Recycling market

Raw materials are the starting point of all economies and metals among them aluminium – and play an important role. Aluminium-containing raw material is recycled if it is relevant from an economic as well as an environmental point of view.

The demand for aluminium grows: its qualities, such as durability (less strain on resources) and lightness (requires less energy to transport) make it a favoured sustainable choice for transportation and building products.

In 2005, about 4.8 Mt of recycled aluminium (excluding internal scrap) were produced in Europe, about 4.6 Mt of these in the EU 25 member states. [71]

The European recycling industry has thus more than tripled its output in comparison to 1980. In the past, aluminium recycling industry was characterised as regional industry. This changed in the last years and today the aluminium recycling industry is a global market.

Until 2001, the EU 27 aluminium scrap trade balance was negative as the volume of imports was much higher than the volume of exports. Since 2002, EU 27 has become a net exporter;

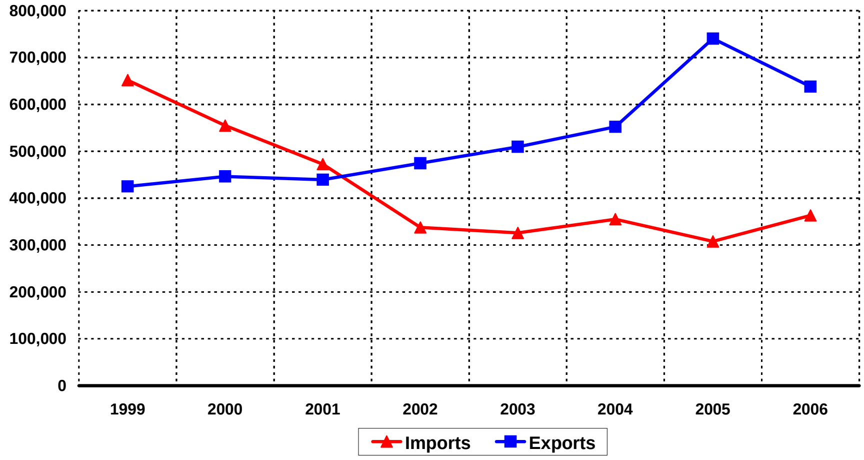
[69] Institute for Prospective Technological Studies (IPTS): Integrated Pollution Prevention and Control (IPPC), Reference Document on Best Available Techniques in the Non Ferrous Metals Industries; December 2001.

[70] European Aluminium Association: Sustainability of the European Aluminium Industry 2006.

[71] European Aluminium Association: Sustainability of the European Aluminium Industry 2006.

exports have increased by 56 % to 740,000 tonnes in 2005. In 2006 followed a drop of 14 % compared to 2005. From 1999 to 2002, imports have seen a decrease of 27 % to 474,396 tonnes. Since then, imports of aluminium scrap have fluctuated and, in 2006, reached a level of 363,000 tonnes.

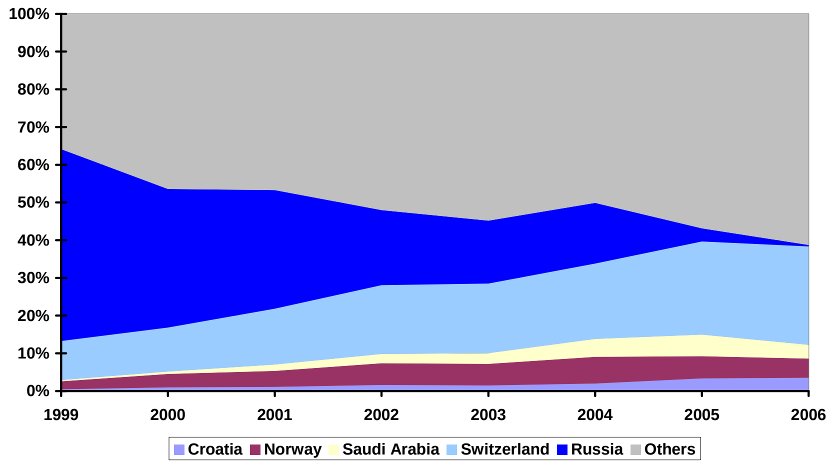
Figure 67: EU 27 aluminium waste and scrap trade 1999-2006 (tonnes)



Source: COMEXT

With regards to aluminium scrap imports, in 1999, Russia originated 51 % of EU 27 total imports. The major changes in import origins from 1999 to 2006 were the decreasing influence of Russia and the growing importance of Sitzerland. Since 1999 imports from Russia dropped dramatically by more than 97 % to 1,800 tonnes in 2006. In the meantime, imports from Switzerland have seen an increase 57 % up to 119,711 tonnes in 2006

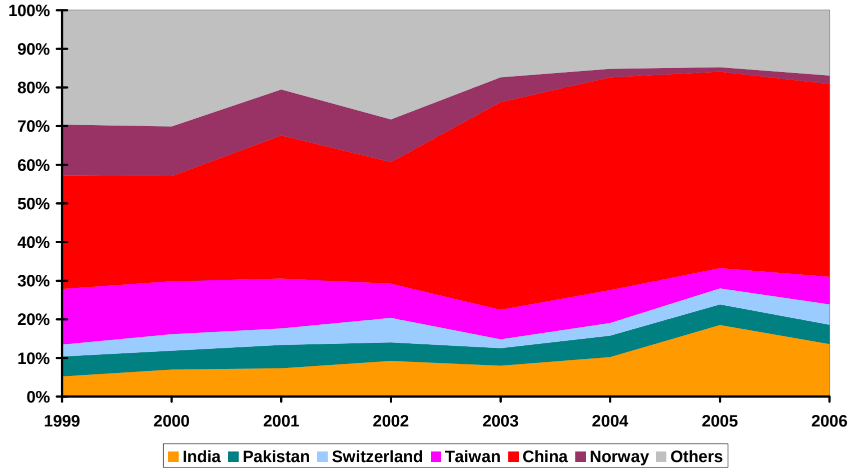
Figure 68: Share of EU 27 aluminium waste and scrap imports 1999-2006 by origin



Source: COMEXT

In 1999, China was already the largest importer of EU aluminium scrap with 125,000 tonnes, accounting for 29 % of the total EU 27 exports. In 2006, its share has increased to 50 % representing more than 318,000 tonnes. Another important export destination is India. Since 1999 exports to India have increased by 390 % up to almost 87,000 tonnes in 2006 and a climax in 2005 with 137,000 tonnes representing nearly 19 % of the total amount.

Figure 69: Share of EU 27 aluminium waste and scrap exports 1999-2006 by destination



Source: COMEXT

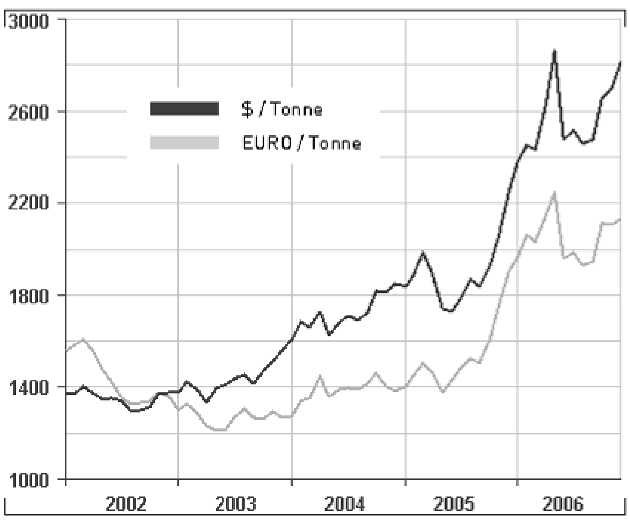
The aluminium recycling industry’s efforts in collecting, recycling and smelting of scrap are impressive.

The rate at which end-of-life aluminium is recycled varies depending on the product sector, scrap processing technology and on society's commitment to collect aluminium-containing products at end-of-life. Each application sector requires its own recycling solutions and the industry supports initiatives that seek to optimise the recycling rate.

Market prices

The production of primary aluminium is very energy-consuming, so energy costs clearly influence the prices for aluminium. From 2002 to 2006 the price in US$ has almost doubled. However, taken into account of the deflation of US$ in recent years, the market price of aluminium in € briefly decreased from 2002 to 2003, and since then it again sharply increased by some 700 € in 2005-6. The current price for primary aluminium is ca. 2,800 US$ (LME London Metal Exchange, 17.08.2007).

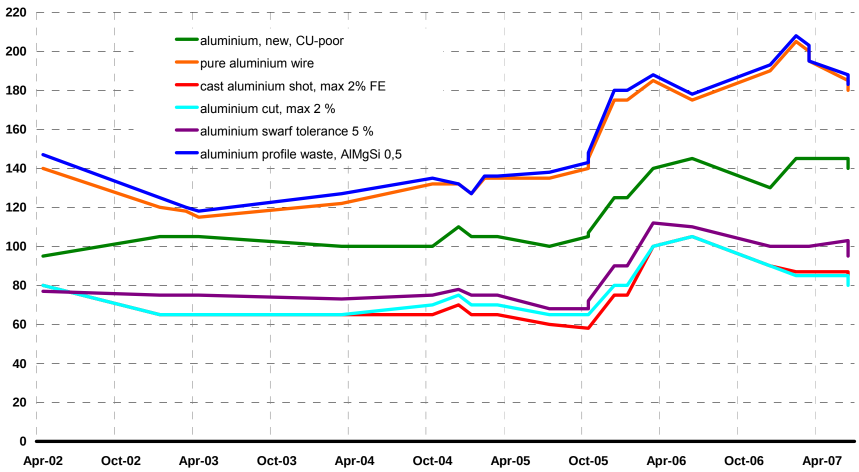
Figure 70: Development of the prices for primary aluminium 2002-2006



Source: Gesamtverband der deutschen Aluminiumindustrie e.V.

Aluminium scrap has a significant value and commands good market prices closely following the price fluctuation of aluminium. From 2002 to 2005 aluminium scrap prices rose slightly. During 2005/2006 the prices increased significantly. Until the middle of 2007, the prices for aluminium scrap rose slightly again and now are decreasing slowly. The current price for pure aluminium wire in Germany is about 175 - 180 € per 100 kg.[72]

Figure 71: Wholesale trade prices for aluminium scrap in Germany 2002 - 2007 (€ per 100 kg)



Source: EUWID Recycling und Entsorgung, Märkte

7.7.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream aluminium. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 21: Waste sources for the waste stream aluminium

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
VI	100308	salt slags from secondary production	☠	**01.2**	Acid, alkaline or saline wastes	
IV	100302	anode scraps		**03.1**	Chemical deposits and residues	
II	170402	aluminium		**06.2******	Non-ferrous metal waste and scrap	
	150104*	metallic packaging		**06.3******	Mixed metal wastes	
	020110*	waste metal				
	120103*	non-ferrous metal filings and turnings				
	120104*	non-ferrous metal dust and particles				
	160118*	non-ferrous metal				
	170407*	mixed metals				
	191002*	non-ferrous waste				
	191203*	non-ferrous metal				
	200140*	metals				

[72] Prices for pure aluminium wire on 13.06.2007, source: EUWID Recycling und Entsorgung, Märkte.

Group-ing***	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
V	160104*	end-of-life vehicles	☠	08.1	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
	160211*	discarded equipment containing chlorofluorocarbons, HCFC, HFC	☠	08.2*****	Discarded electrical and electronic equipment	☠/⚐
	160213*	discarded equipment containing hazardous components other than those mentioned in 16 02 09 to 16 02 12	☠			
	160214*	discarded equipment other than those mentioned in 16 02 09 to 16 02 13				
	200135*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components	☠			
	200136*	discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35				
	160215*	hazardous components removed from discarded equipment	☠	08.4 *****	Discarded machines and equipment components	☠/⚐
	160216*	components removed from discarded equipment other than those mentioned in 16 02 15				
I	200301*	mixed municipal waste		10.1	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		12.1 ******	Construction and demolition wastes	
IV	100304	primary production slags	☠	12.4	Combustion wastes	
	100305	waste alumina		12.5 ******	Various mineral wastes	

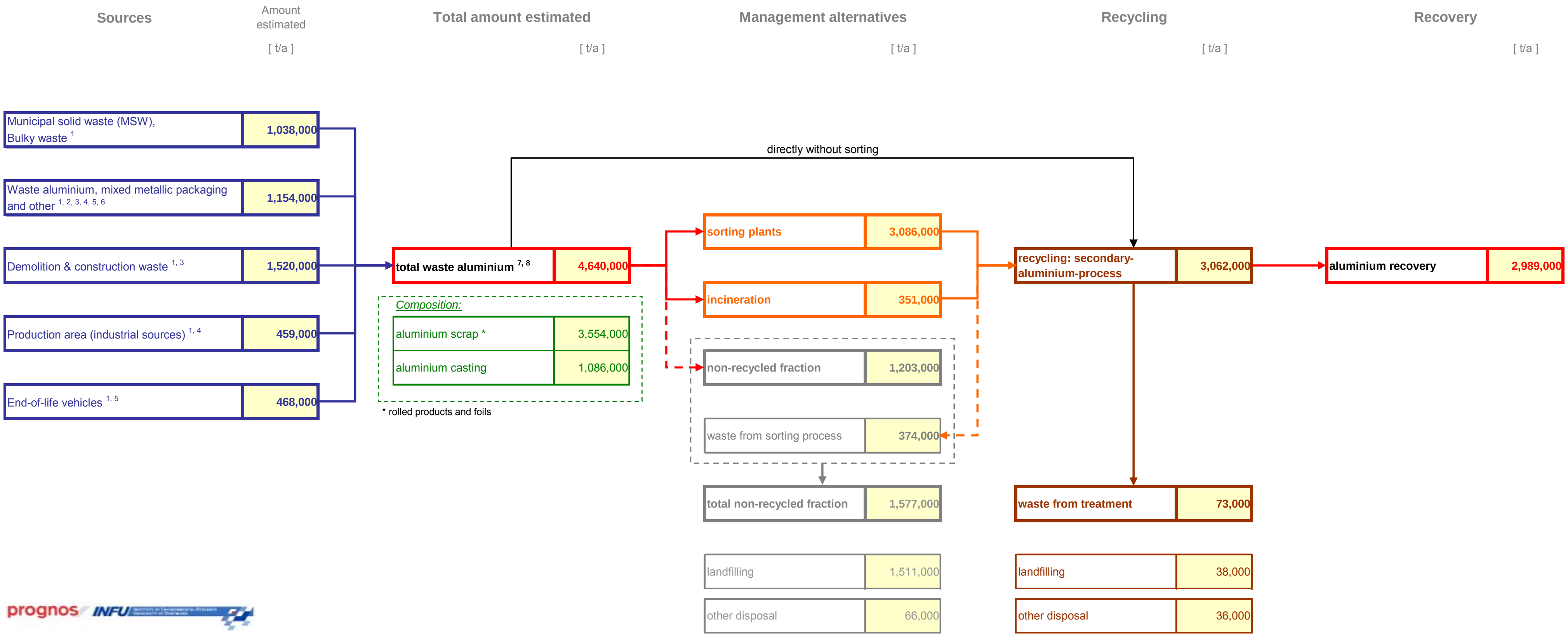
☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered aluminium waste amounts where estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of aluminium waste is necessary. The considered aluminium waste amounts where estimated as described in the Introduction.
*** Allocation of waste stream sources to the sources group in the flow sheet
I Municipal solid waste (MSW) and bulky waste
II Waste aluminium, mixed metallic packaging and other mixed metallic wastes (including separate collected fractions from MSW and separate recorded aluminium waste from industry), end-of-life-vehicles, construction & demolition such as treatment processes (as described in the table “waste sources”). For member states with EWC-6-digit-level data basis are considered only separate selected fractions 200140 and waste from treatment 191002 and 191203.
III Demolition and construction waste (including code 170407 for member states with EWC-6-digit-level data basis)
IV Production and industrial sources (including codes 120103, 120104 and 150104 for member states with EWC-6-digit-level data basis)
V End-of-life-vehicles and discarded electronic equipment (including code 160118 for member states with EWC-6-digit-level data basis and including 200135 and 200136 for member states with EWC-STAT data basis)
**** Data available only for the aggregated group 06
*****Data available only for the aggregated group “08 not 08.1 and 08.41”
******Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.7.3 Key figures

As a result of adjusting the available data basis the following flow sheet for the waste stream aluminium could be compiled.

It must be pointed out that - in addition to aluminium collected for refining and re-melting - the model includes, only a share of recycled aluminium from refining and re-melting. This recycled aluminium is evidently returned directly to aluminium manufacturing without further processing and therefore not recorded completely.

Figure 72: Estimation of waste aluminium flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "Waste aluminium, mixed metallic packaging and other mixed metallic wastes". Separate data available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 95,000 tonnes.
3. Aluminium collected separately from construction & demolition waste (170407) is included in the group "Waste aluminium, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "construction & demolition waste".
4. Aluminium recorded separately from production and industry (120103, 120104 and 150104) is included in the group "Waste aluminium, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "production and industrial sources". "Cycle aluminium" from refining and re-melting is not included.
5. Aluminium recorded separately from end-of-life-vehicles (160118) is included in the group "Waste aluminium, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "end-of-life-vehicles and electronic equipment".
6. Includes also aluminium waste from treatment processes, which are part of the aggregated group "Waste aluminium, mixed metallic packaging and other mixed metallic wastes". Separate data available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 19,000 tonnes.
7. Data for Latvia and Portugal reflects only municipal and commercial waste, no information is available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic was compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.

The main sources for waste aluminium as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows:

Based on the use of at least two different data sources (EWC and EWC-STAT)

- Aluminium waste collected separately from municipal solid waste is not reported separately, but included in the group "waste aluminium, mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with EWC data basis.

- Aluminium from construction and demolition sources covers several potentials. The separately collected fraction (170407) is only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "waste aluminium, mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

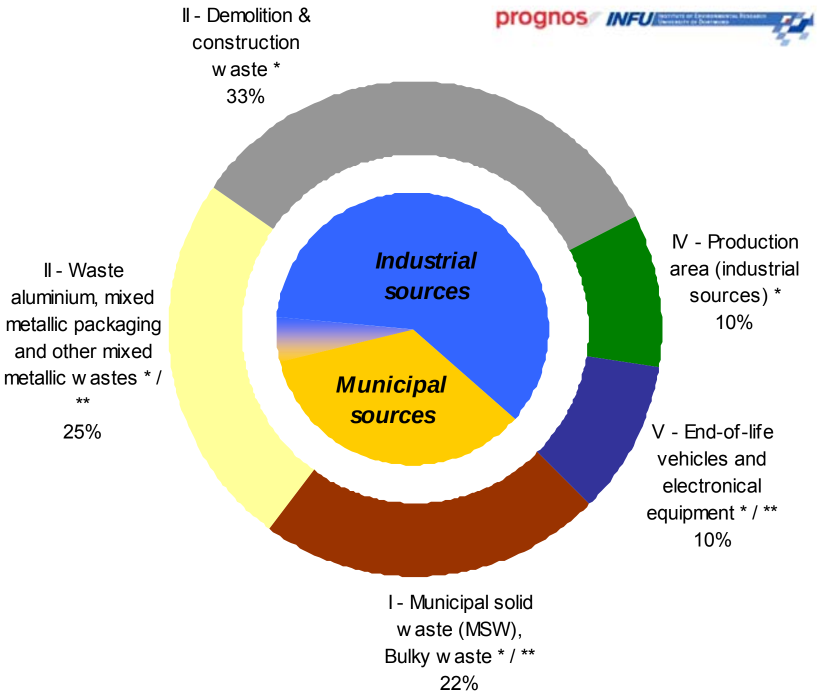
- Aluminium from production and industry sources covers several potentials. Separately recorded fractions (120103, 120104 and 150104) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "waste aluminium, mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis. "Cycle aluminium" from refining and re-melting is not included.

- Aluminium from end-of-life-vehicles and electronic equipment covers potentials from several sources. Separately collected fraction (160118) is only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "waste aluminium, mixed metallic packaging and other mixed metallic wastes", as an allocation is not possible due to the aggregated data basis.

- Aluminium from waste treatment processes is not reported separately, but also included in the group "waste aluminium, mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with an EWC data basis.

In **total, the amount** of aluminium waste generated in the EU 27 was **4.6 Mt in 2004**, of which 35 % - 40 % is originated from MSW[73].

Figure 73: Estimated aluminium waste generation by sources



* please also refer to notes on Table 21 and Figure 72
** includes waste fractions from MSW

The amount of aluminium waste collected separately or collected and then separated in sorting plants with the objective of recycling[74] was estimated at 3.4 Mt in 2004. Taking into account various losses during the sorting process, nearly 3.1 Mt of aluminium waste were returned to secondary aluminium process for recycling. Considering further losses during the aluminium recycling processes, the total recovery of secondary aluminium amounted to nearly 3.0 Mt in 2004. The estimated share of the aluminium waste for recycling of the total estimated aluminium waste generation (rate of recycling) was about 58 % at the level of the EU 27, also shown in

[73] No better estimates can be provided because the aggregated group "aluminium, mixed metallic packaging and other mixed metallic wastes" includes aluminium fractions from both MSW and from production and commercial sources.

[74] Total generated aluminium waste less directly disposed aluminium waste fractions.

Figure 76.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 74. Finland, Germany, Great Britain, and Luxembourg record the highest aluminium waste recycling rates of more than 70 %.

Figure 74: Recycling potential in kg per capita (2004)

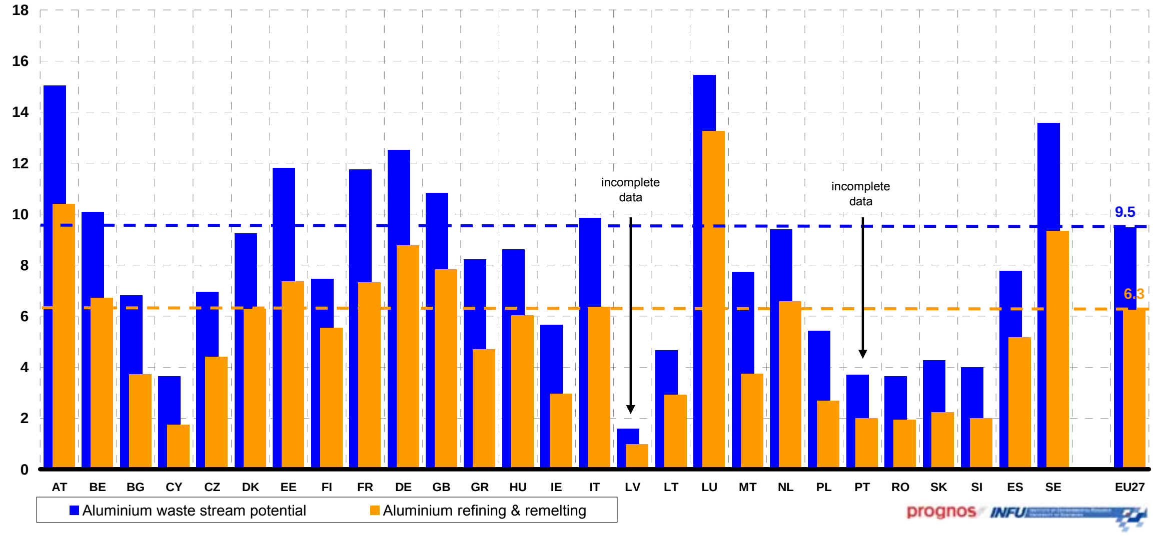


Figure 75 shows the estimated total amount of aluminium waste by different waste management alternatives, and the

Figure 76 presents the same data but in percentage.

Figure 75: Management alternatives for aluminium waste (in '000 tonnes)

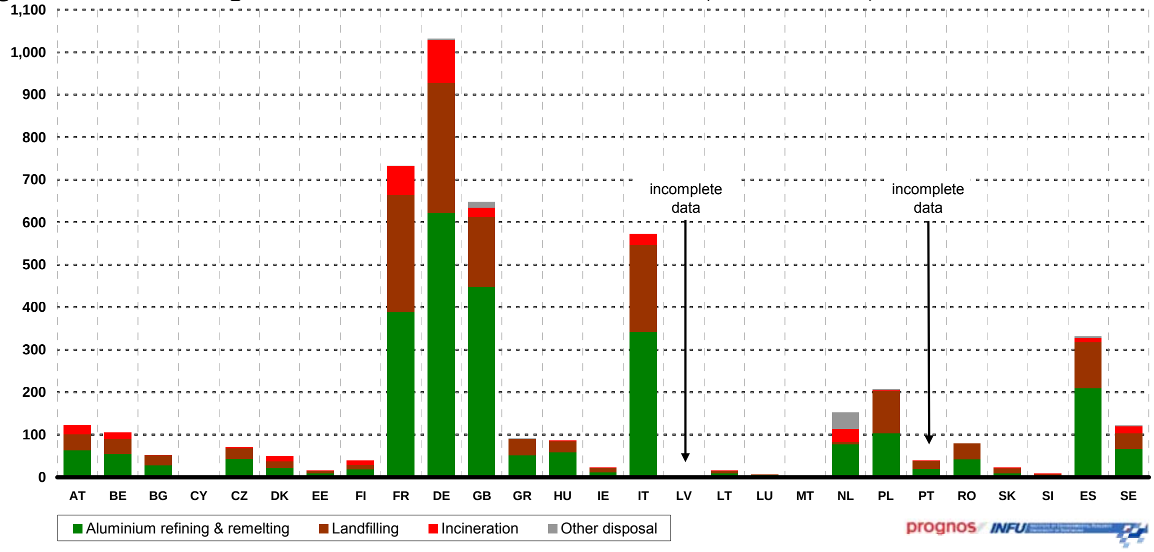
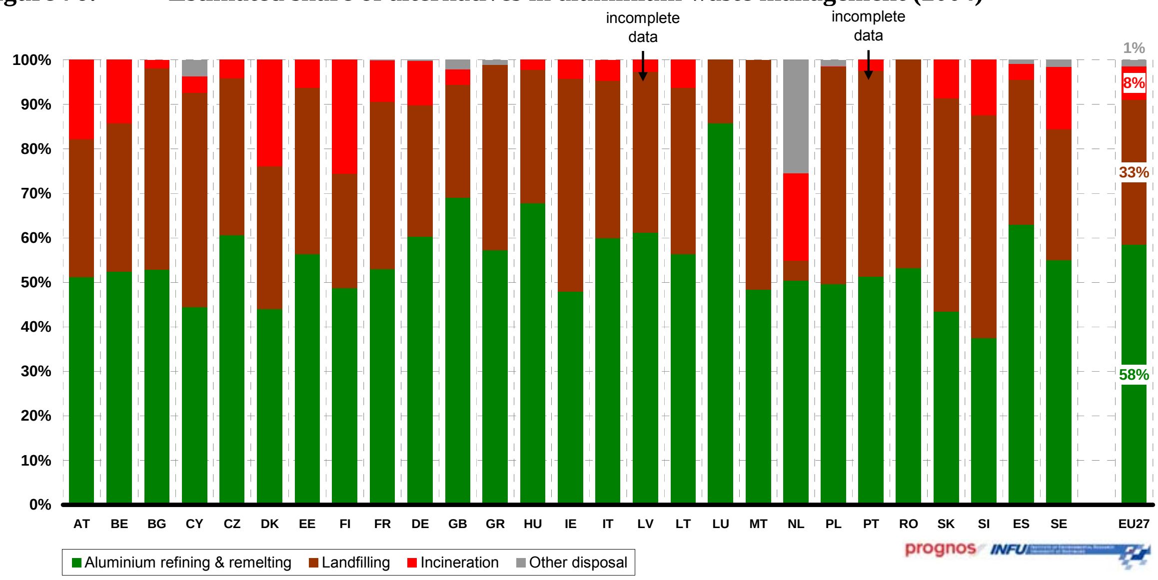


Figure 76: Estimated share of alternatives in aluminium waste management (2004)



7.8 Copper

Main findings:

- The amount of copper waste generated in the EU 27 can be estimated at 1.38 Mt in 2004.
- Of these, an estimated 0.86 Mt were recycled in copper smelting processes (about 62 %)
- Recycling of copper is possible for nearly all products.
- The copper demand will rise in the next years. Especially in Middle and Eastern Europe an even larger growth is expected, because of increasing financial investments in modern technologies and materials.
- The market is a global market; prices are at a high level.

7.8.1 Characterisation of the waste stream

Overview

General characteristics
Secondary copper account for over 50 % of the use of copper and its alloys in Europe.
Copper scrap can also be found in demolition and construction waste, in production areas and commercial waste, in automobile vehicles, and in municipal solid and bulky waste. The main sources are cables, car parts, computer scrap and printed circuit boards, all of which became more common over the last years. Some have a low copper content, however.

After collection, copper is sorted and melted to produce secondary copper which will then be transported to the various manufacturers. Copper itself does not cause much harm, however, excess quantities of copper in drinking water, or as fumes in the atmosphere can cause poisoning, which might be fatal for young children. On the other hand, the recovery processes generate emission and need to be addressed yet.

Waste recovery

Collection and sorting
Domestic copper recovery ranks high on the agenda of scrap processors and smelters. Players have been trying hard to streamline the recovery through organised routes. Even after years of concerted efforts, the results are far from what is desirable. The recovery is scattered across remelters. Rag-pickers collect the copper waste and sell it to small scrap traders. They, in turn, supply it to medium and big scrap buyers. Big buyers then supply the collected quantities to smelters.[75]

Pre-treatment and recovery technologies
Treatment depends heavily on the source of secondary copper. The material varies greatly in quality and cleanliness, which is why additional treatment might be needed.

Secondary copper recovery is divided into four operations:

[75] Minerals and Metals Review. Vol. 32, no. 9, pp. 38-40. Sept. 2006.

<u>Scrap pre-treatment</u>

Scrap pre-treatment is achieved through manual, mechanical, pyrometallurgical or hydrometallurgical methods. Manual and mechanical methods include sorting, stripping, shredding, and magnetic separation. The scrap is then pressed into briquettes by a hydraulic press.

Pyrometallurgical pre-treatment includes sweating, burning insulation from copper wire and drying in rotary kilns to volatilize oil and other organic compounds. Hydrometallurgical pre-treatment includes floating (if slag contains over 10 % copper) and leaching to recover copper from slag.

<u>Smelting</u>

In order to produce high quality copper, methods used in primary copper production are also applied to secondary copper.

Smelting of low-grade copper begins with melting in either a blast furnace or a rotary furnace, resulting in slag and impure copper. If the scrap contains less than 90 % copper, a blast furnace must be used. The resulting copper is charged into a converter, where purity is increased to 80 – 90 %. These stages are left out if the scrap has a higher copper concentration.

Afterwards, the copper is transported to a reverberatory furnace, where a purity of 99 % is achieved. In these fire-refining furnaces, flux is added to the copper and air is blown upward through the mixture to oxidize the impurities. These impurities are then removed as slag.

Then, by reducing the furnace atmosphere, cuprous oxide (CuO) is converted to copper. Fire-refined copper is cast into anodes, which are used during electrolysis. The anodes are submerged in a sulfuric acid solution containing copper sulfate. While the copper is dissolving from the anodes, it is depositing at the cathodes. Eventually, the cathode copper with a purity of 99 % is extracted and recast.

Preconditions and technical limitations

For an effective use of scrap, it needs to be collected and sorted according to different levels of purity. The subsequent treatment can then be determined by grade of purity.

There are no technical limitations to the reprocessing of copper, it can be smelted any number of times without losing its intrinsic properties. Over 80 % of all copper produced in the past is still in use today.

Copper does not need to be enriched with primary material in order to achieve a good quality.

Nonetheless, the market for secondary copper can not meet the total copper demand on its own, making additional mining necessary.

Alternative management

Copper that is not recycled or re-used is landfilled. However, the largest amounts of copper in landfills originate from copper sludges produced during different other metallurgical processes (processes which do not produce copper as a main product).

Environmental and health issues related to waste management

Key issues

Recycling copper results in a more efficient use of natural resources, but also in energy savings and a reduction in material sent for final disposal, such as to a landfill.[76]

There are, however, various emissions that occur during secondary copper processing such as particulate matter, volatile organic compounds, sulphur dioxide and zinc oxide. These can have serious effects on the environment (see below).

Waste recovery process

The principal pollutant emitted from secondary copper smelting activities is particulate matter.

The size of particulate matter (PM) particles largely determines the extent of environmental and health damage caused. Numerous studies have linked PM to aggravated cardiac and respiratory diseases such as asthma, bronchitis and emphysema and to various forms of heart disease. PM can also have adverse effects on vegetation and structures, and it contributes to visibility deterioration and regional haze.

As characteristic of secondary metallurgical industries, pyrometallurgical processes used to separate or refine the desired metal, such as the burning of insulation from copper wire, result in emissions of metal oxides and unburned insulation. Similarly, drying of chips and borings to remove excess oils and cutting fluids can cause discharges of volatile organic compounds (VOC) and products of incomplete combustion.

Volatile organic compounds (VOC) are known to, or suspected of, having direct toxic effects on humans, ranging from carcinogenesis to neurotoxicity. The more reactive VOC combine with nitrogen oxides in photochemical reactions in the atmosphere to form ground-level ozone, a major component of smog. VOC are also precursor pollutants to the formation of fine particulate matter.

The smelting stream utilizes large volumes of air to oxidize sulfides, zinc, and other undesirable constituents of the scrap. This oxidation procedure generates particulate matter in the exhaust gas stream. A broad spectrum of particle sizes and grain loadings exist in the escaping gases due to variation in furnace design and in the quality of furnace charges. Another major factor that contributes to differences in emission rates is the amount of zinc present in scrap feed materials. The low-boiling zinc volatilises and is oxidized to produce copious amounts of zinc oxide as submicron particulate.

Zinc oxide may damage in the human body when inhaled, swallowed or touched. It affects eyes and skin, and causes irritation on the mucosa and respiratory passages. Furthermore, it is considered dangerous for the environment.

[76] http://www.icsg.org/Factbook/copper_world/recycling.htm.

Sulphur dioxide, formed during smelting, can cause adverse effects on respiratory systems of humans and animals, and damage to vegetation. When dissolved by water vapour to form acids, it can again have adverse effects on the respiratory systems of humans and animals, and it can cause damage to vegetation, buildings and materials, and contribute to the acidification of aquatic and terrestrial ecosystems. When transformed into sulphate particles that are subsequently deposited on aquatic and terrestrial ecosystems, acidification can result; and when sulphate is combined with other compounds in the atmosphere, such as ammonia, it becomes an important contributor to the formation of particulate matter. Fugitive emissions occur from each process associated with secondary copper smelter operations. These emissions occur during the pre-treating of scrap, the charging of scrap into furnaces containing molten metals, the transfer of molten copper from one operation to another, and from material handling.

Although emissions can be reduced to a minimum by filters, by special treatment and precaution in handling, pollutants still find their way into the atmosphere and the environment.

Market

Copper market

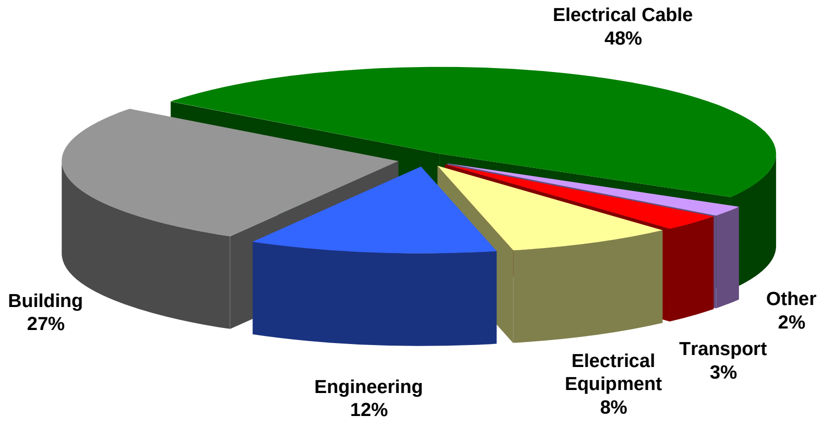
In the last 25 years the worldwide demand for copper has nearly doubled. While in 1980 about 9 Mt copper were produced, the current production reaches 18 Mt per year. In 2006, 5.2 Mt of copper were processed in the EU which meets 29 % of the worldwide demand. The EU's main producers are Germany, Poland, Belgium, Sweden, and Spain.[77] With a copper consumption of 3.5 Mt per year, China alone accounts for 21% of the worldwide demand.

According to the currently available information, demand for copper mainly comes from the electrical and electronics industries, which absorb almost 60 % of total EU usage. Information and data also show that the construction sector is the second largest user. Excluding building wire, it accounts for approximately 25 % of the total copper demand in the EU. A wide variety of semi-finished products, of both alloyed and unalloyed copper, are used in plumbing, roofing, decorative fittings etc. The remaining 20 % of the demand are covered by industrial machinery and equipment, transportation equipment, and user products.[78]

[77] Commission of The European Communities, Analysis of economic indicators of the EU metals industry: the impact of raw materials and energy supply on competitiveness, 2006.

[78] European Copper Institute

Figure 77: EU main uses for copper



Source: European Copper Institute

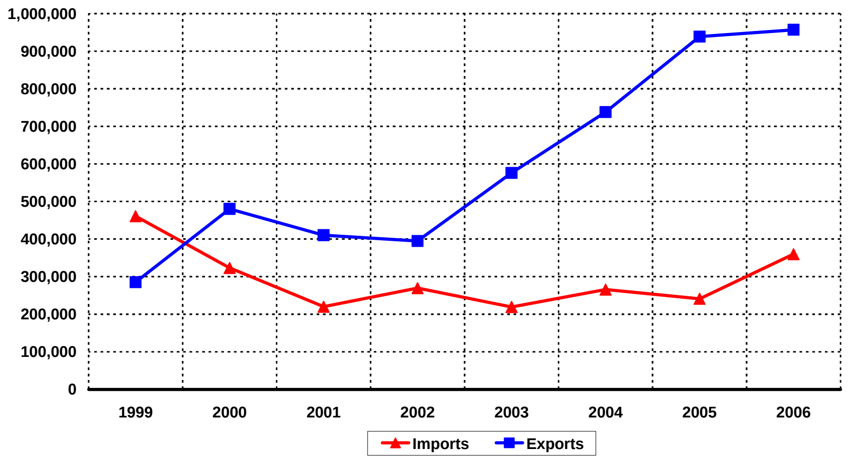
Copper consumption closely follows the cycle of overall industrial activity.
Recycling market

Europe has a high copper demand, but is low in natural resources. Metal recycling re-uses the metal reserves in products, thereby making a significant contribution to copper supplies. So recycling is an important economic activity with significant benefits.

Recycling of copper is possible for nearly all products. However, the rate of recycling depends on the quality and efficiency of the scrap collection system, technological and economic factors, product design, as well as on the incentives and barriers introduced by society.

In 2000, the EU 25 became a net exporter of copper scrap. Since then the gap between imports and exports has constantly increased. Imports have dropped sharply by 53 % between 1999 and 2001 and more or less stabilised afterwards. Exports have doubled between 2000 and 2006. With regard to decreasing imports, Russia and Ukraine were the most important suppliers of copper scrap. After the introduction of a non-ferrous scrap export tax in Russia and a ban on the export of non-ferrous scrap by the Ukrainian authorities, these important supply sources ceased to be available.

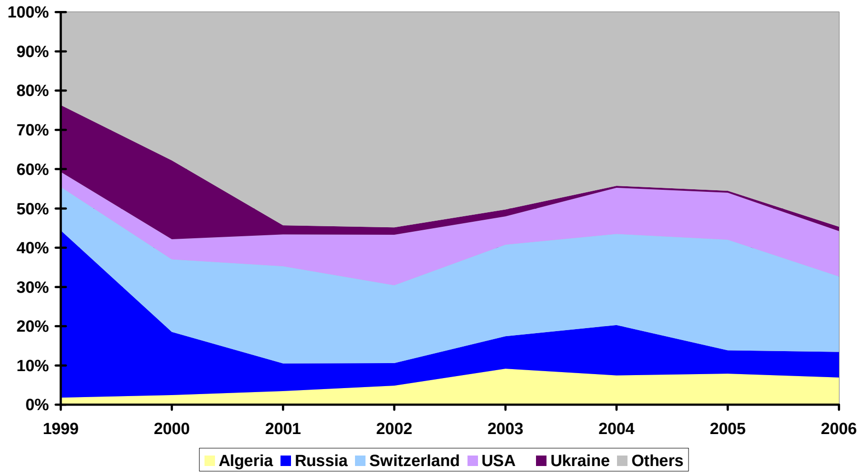
Figure 78: EU 27 Copper scrap trade 1999-2006 (tonnes)



Source: COMTEXT

Since then, new and diverse supply channels have been developed by the EU industry (South Africa, China, the Netherlands Antilles, etc.) but none of them have managed to compensate for the loss of former CIS suppliers. As a result of the closure of those essential markets and of the price increase of copper scrap, imports in EU 25 have dropped.

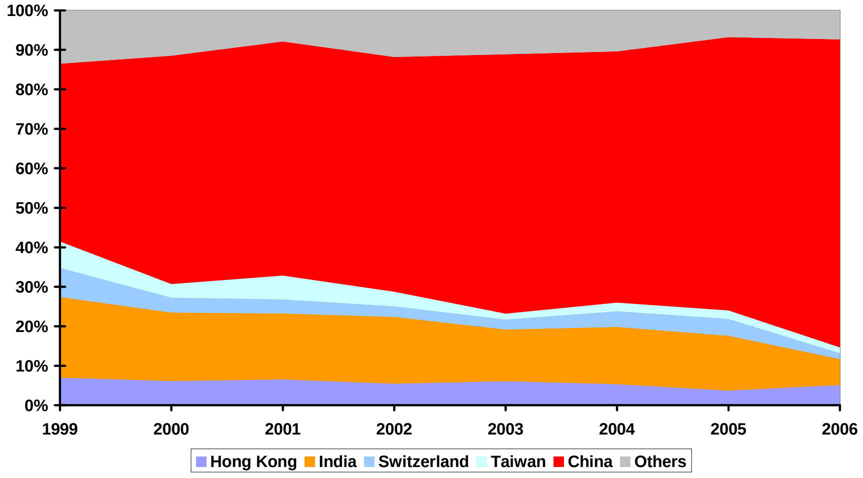
Figure 79: Share of EU 27 copper waste and scrap imports 1999 – 2006 by origin



Source: COMTEXT

In 1999, China was the principal destination of EU 25 copper scrap exports and accounted for 46 % (53 % including Hong Kong), totalling 128 Kt. Until 2006, this trend was confirmed by an important increase in EU exports to China. China now accounts for 78 % (83 % including Hong Kong) of the total EU exports.

Figure 80: Share of EU 27 copper waste and scrap exports 1999 – 2006 by destination



Source: COMTEXT

In sum, the decreasing imports and increasing exports of copper scrap have created a situation of scarcity of copper scrap within the EU. As a consequence, copper refineries have either switched to a more costly raw material input mix or have gone insolvent or bankrupt. In Europe, 174,000 tonnes of refining capacity were closed since 2000 with a loss of 840 jobs.

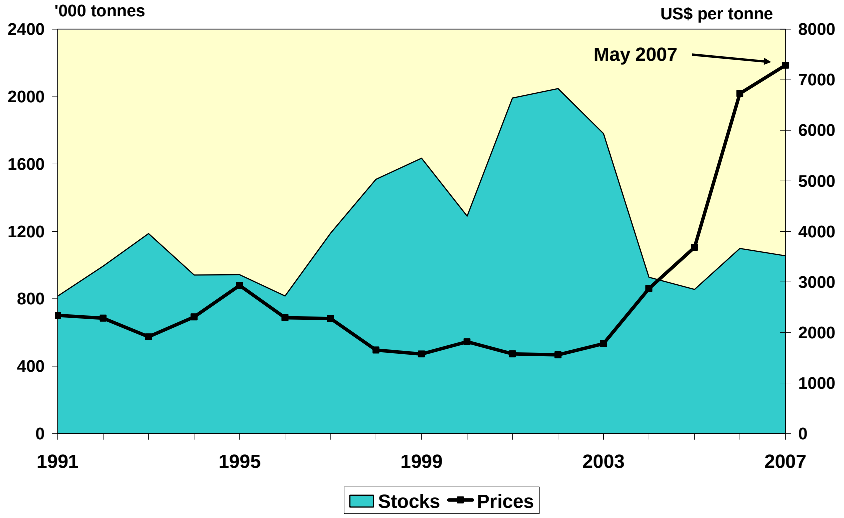
The share of secondary copper in total copper production will grow over the next years since its processing is less costly and more energy sufficient than the production of the primary metal and there is no limitation how often it can be recycled.

Market prices

The copper scrap market currently offers smelters good procurement possibilities with ample supplies.

The value of copper scrap depends on its purity, i.e. the higher the copper content in the scrap, the higher the price. Since 2004, the prices for copper have almost tripled. In parallel the price for copper scrap has increased strongly as well. Even if the market prices differ depending on country and copper waste quality, the market prices show an upwards trend.

Figure 81: Copper Stocks and Prices 1970 to 2007

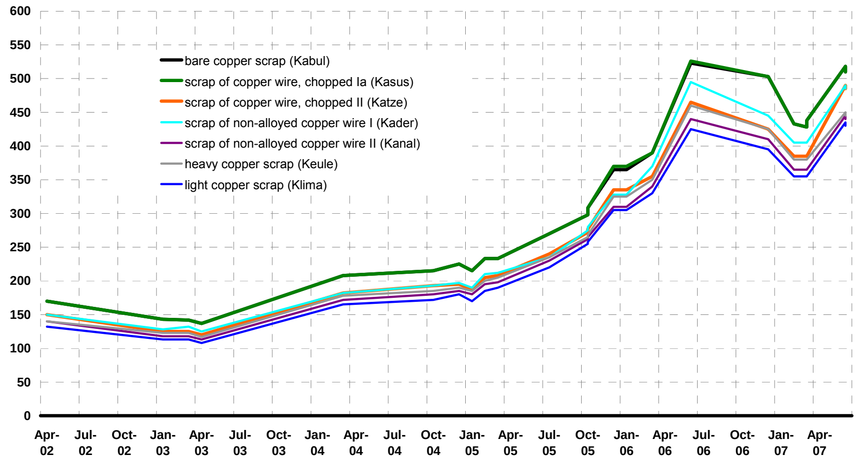


Source: International Copper and Zinc Study Group

Example:

Currently the price for bare copper scrap (Kabul) in Germany is 507-510 € per 100 kg.[79]

Figure 82: Wholesale trade prices for copper scrap in Germany 2002 - 2007 (€ per 100 kg)



Source: EUWID Recycling und Entsorgung, Märkte

7.8.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream copper. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 22: Waste sources for the waste stream copper

*Grouping****	EWC	Waste Description	Hazardous	EWC-STAT**	Waste Description	Hazardous

[79] Prices for blank copper scrap on 13.06.2007, source: EUWID Recyling und Entsorgung, Märkte.

*Grouping****	EWC	Waste Description	Hazardous	EWC-STAT**	Waste Description	Hazardous
IV	110205	wastes from copper hydrometallurgical processes containing dangerous substances	☠	**01.2**	Acid, alkaline or saline wastes	☠/⚐
	110206	wastes from copper hydrometallurgical processes other than those mentioned in 11 02 05				
II	170401	copper, bronze, brass		**06.2 ******	Non-ferrous metal waste and scrap	
	150104*	metallic packaging		**06.3 ******	Mixed metal wastes	☠/⚐
	020110*	waste metal				
	120103*	non-ferrous metal filings and turnings				
	120104*	non-ferrous metal dust and particles				
	160118*	non-ferrous metal				
	170407*	mixed metals				
	170410*	cables containing oil, coal tar and other dangerous substances	☠			
	170411*	cables other than those mentioned in 17 04 10				
	191002*	non-ferrous waste				
	191203*	non-ferrous metal				
	200140*	metals				
V	160104*	end-of-life vehicles	☠	**08.1 *******	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
	160211*	discarded equipment containing chlorofluorocarbons, HCFC, HFC	☠	**08.2 *******	Discarded electrical and electronic equipment	☠/⚐
	160213*	discarded equipment containing hazardous components other than those mentioned in 16 02 09 to 16 02 12	☠			
	160214*	discarded equipment other than those mentioned in 16 02 09 to 16 02 13				
	200135*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components	☠			
	200136*	discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35				
	160215*	hazardous components removed from discarded equipment	☠	**08.4 *******	Discarded machines and equipment components	☠/⚐
	160216*	components removed from discarded equipment other than those mentioned in 16 02 15				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1 ********	Construction and demolition wastes	

☠ Hazardous waste fraction

☠/⚐ As well as hazardous and non-hazardous fractions

* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered copper waste amounts where estimated as described in Sources of data collection.

** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of copper waste is necessary. The considered copper waste amounts where estimated as described in the Introduction.

*** Allocation of waste stream sources to the sources group in the flow sheet

I Municipal solid waste (MSW) and bulky waste

II Copper waste, mixed metallic packaging and other mixed metallic wastes (including separate collected fractions from MSW and separate recorded copper waste from industry), end-of-life-vehicles and discarded equipment, construction & demolition such as treatment processes (as described in the table “waste sources”). For member states with EWC-6-digit-level data basis are considered only separate selected fraction 200140 and waste from treatment 191002 and 191203).

III Demolition and construction waste (including codes 170407, 170410 and 170411 for member states with EWC-6-digit-level data basis)

IV Production and industrial sources (including codes 120103, 120104 and 150104 for member states with EWC-6-digit-level data basis)

V End-of-life-vehicles and discarded equipment (including code 160118 for member states with EWC-6-digit-level data basis and including 200135 and 200136 for member states with EWC-STAT data basis)

**** Data available only for the aggregated group “06”

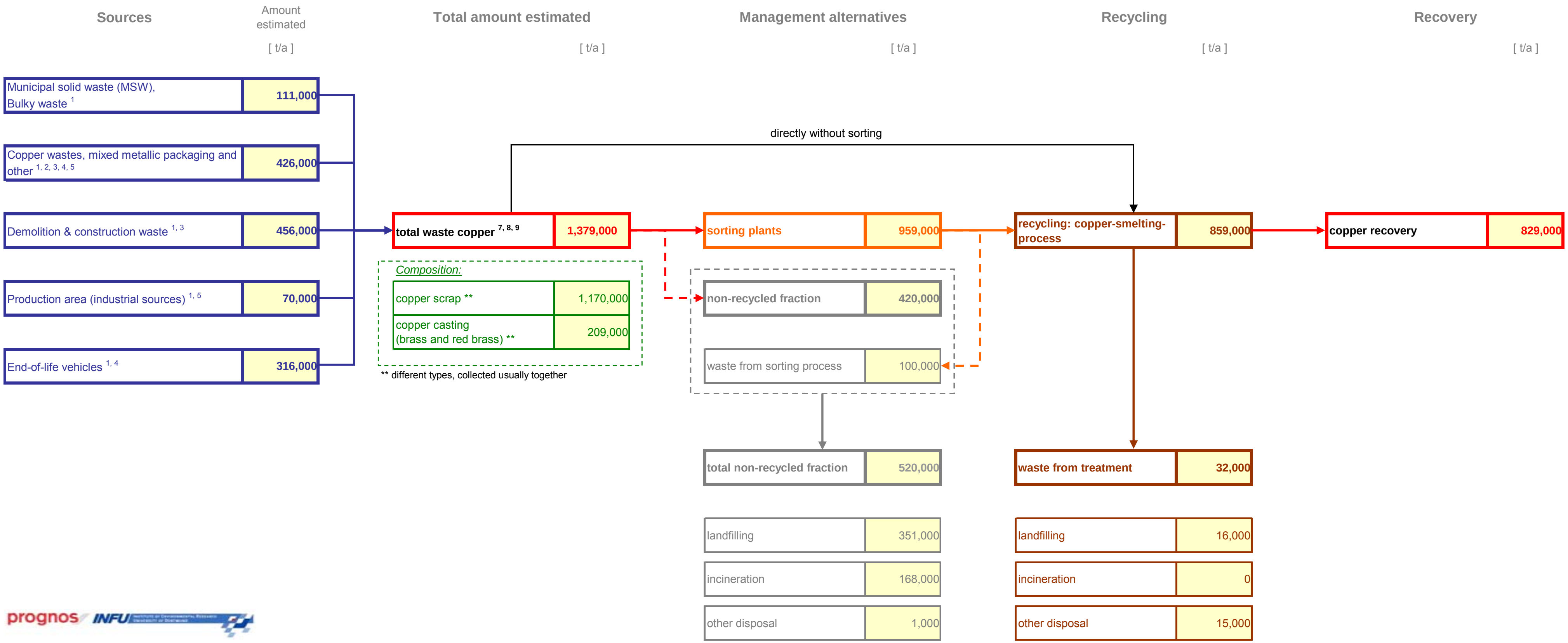
*****Data available only for the aggregated group “08 not 08.1 and 08.41”

******Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.8.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream copper could be compiled.

Figure 83: Estimation of copper waste flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group “copper waste, mixed metallic packaging and other mixed metallic wastes”. Separate data is available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 2,000 tonnes.
3. Copper collected separately from construction & demolition waste (170407, 170410 and 170411) is included in the group “copper waste, mixed metallic packaging and other mixed metallic wastes” for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group “construction & demolition waste”.
4. Copper recorded separately from end-of-life-vehicles (160117) is included in the group “copper waste, mixed metallic packaging and other mixed metallic wastes” for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group “end-of-life-vehicles”.
5. Copper recorded separately from production and industry (120103, 120104 and 150104) is included in the group “copper waste, mixed metallic packaging and other mixed metallic wastes” for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group “production and industrial sources”. “Cycle copper scrap” is not included.
6. Includes also copper waste from treatment processes, which are part of the aggregated group “copper waste, mixed metallic packaging and other mixed metallic wastes”. Separate data are formally available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to zero tonnes.
7. Data for Latvia reflects only municipal and commercial waste, no information is available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic is compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.
9. Data for Portugal is based on several estimations due to missing data for several EWC-STAT groups.

The main sources for copper waste as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.

Based on the use of at least two different data sources (EWC and EWC-STAT)

- Copper waste collected separately from municipal solid waste is not reported separately, but included in the group “copper waste, mixed metallic packaging and other mixed metallic wastes”, as separate data is only available for member states with EWC data basis.

- Copper from construction and demolition sources covers several potentials. Separately collected fractions (170407, 170410 and 170411) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group “copper waste, mixed metallic packaging and other mixed metallic wastes”, because an allocation is not possible due to the aggregated data basis.

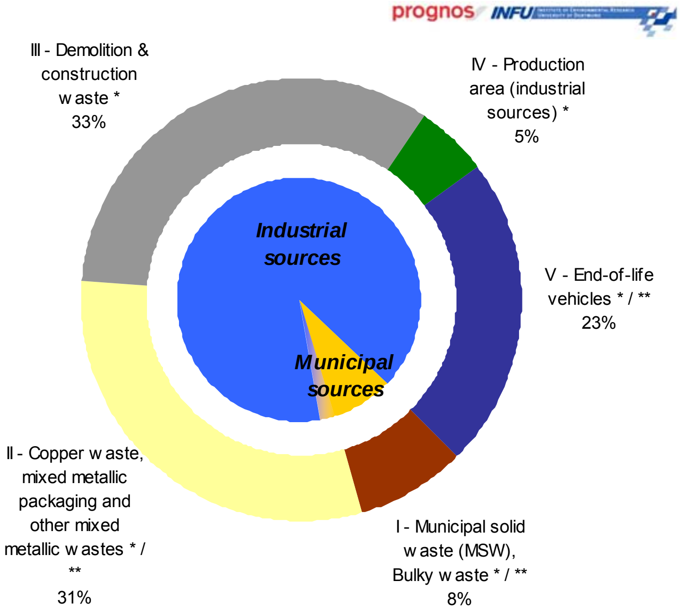
- Copper from production and industry sources covers several potentials. Separately recorded fractions (120103, 120104 and 150104) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group “copper waste, mixed metallic packaging and other mixed metallic wastes”, because an allocation is not possible due to the aggregated data basis. “Cycle copper scrap” is not included.

- Copper from end-of-life-vehicles and discarded electronic equipment covers several potentials. Separately collected fractions (160118) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group “copper metal waste, mixed metallic packaging and other mixed metallic wastes”, as an allocation is not possible due to the aggregated data basis.

- Copper from waste treatment processes is not reported separately, but also included in the group “copper waste, mixed metallic packaging and other mixed metallic wastes”, as separate data is only available for member states with an EWC data basis.

In **total, the amount** of copper waste generated in the EU 27 was **1.38 Mt in 2004**, of which 8 % - 10 % originates from MSW[80].

Figure 84: Estimated copper waste generation by sources



* please also refer to notes on Table 22 and Figure 83
** includes waste fractions from MSW

The amount of copper waste collected separately or collected and then separated in sorting plants with the objective of recycling 81 was estimated at 0.96 Mt in 2004. Taking into account various losses during the sorting process, about 0.86 Mt of copper waste were returned to the copper smelting process for recycling. Considering further losses within the copper recycling processes, the total recovery of copper waste amounted to about 0.83 Mt in 2004. Therefore, the estimated share of the copper waste for recycling of the total estimated copper waste generation (rate of recycling) was about 62 % at the level of the EU 27, also shown in

[80] No better estimates can be provided because the aggregated group “copper waste, mixed metallic packaging and other mixed metallic wastes” includes copper fractions from both MSW and from production and commercial sources.

[81] Total copper waste generated less directly disposed copper waste fractions.

Figure 87.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 85. Denmark and Sweden record the highest copper waste recycling rate of >70 %.

Figure 85: Recycling potential in kg per capita (2004)

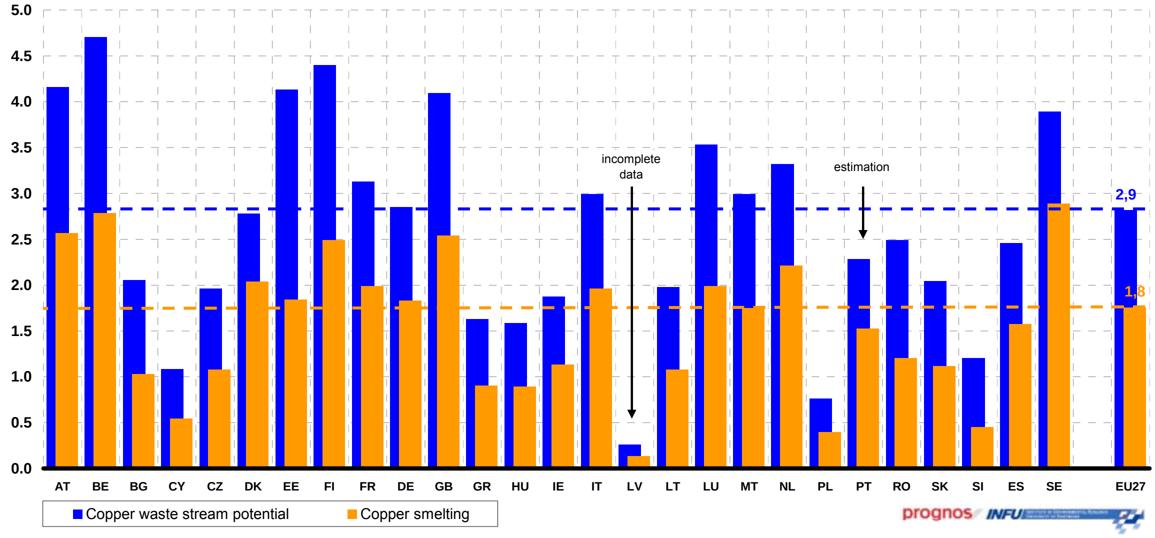


Figure 86 shows the estimated total amount of copper waste potentials per country by different waste management alternatives, and the

Figure 87 presents the same data but in percentage

Figure 86: Management alternatives for copper waste (in '000 tonnes)

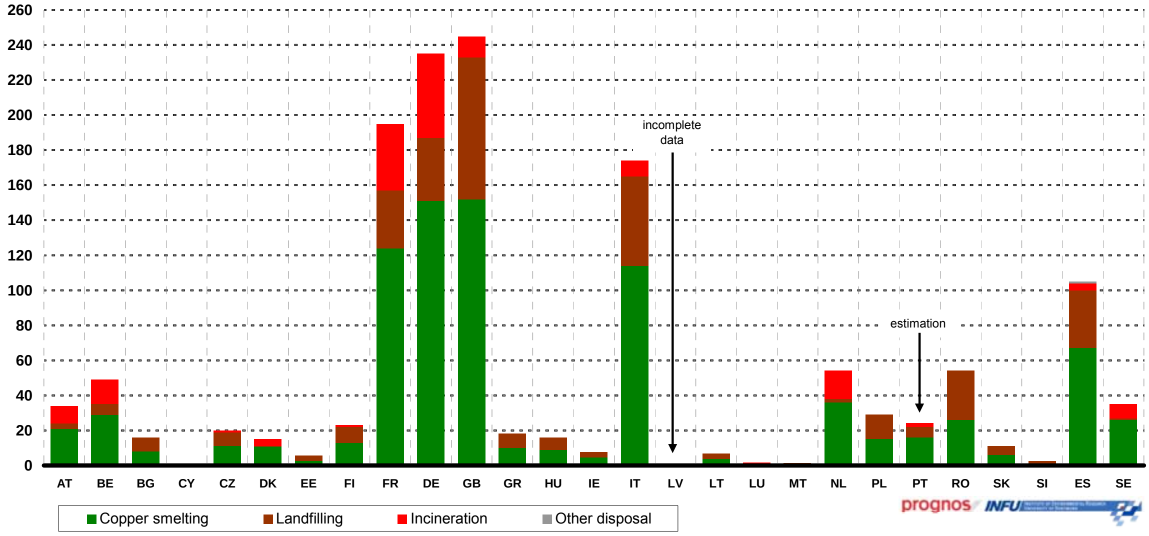
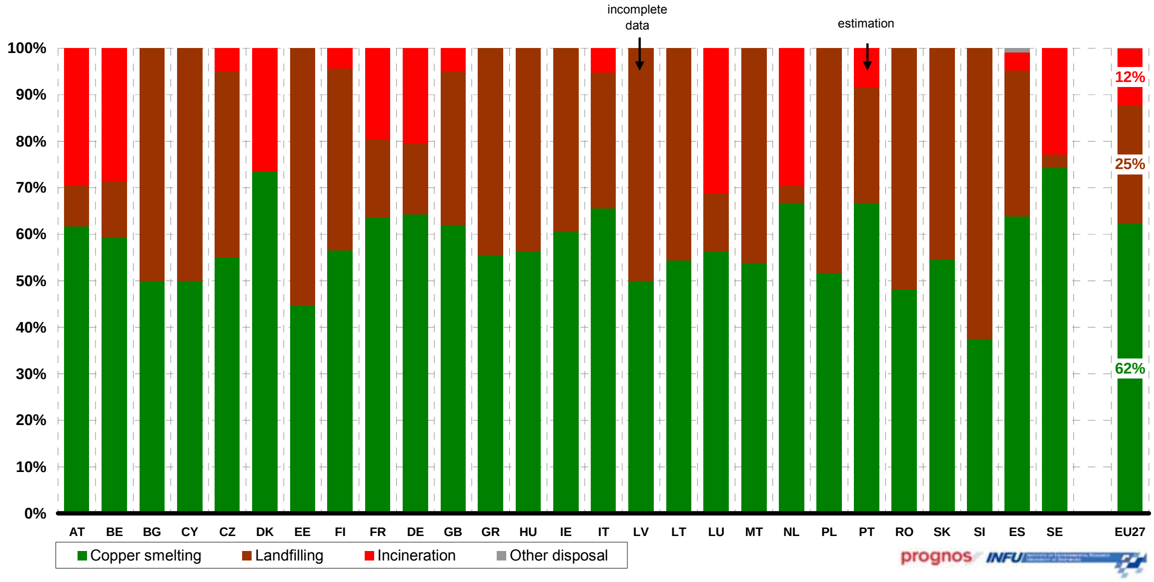


Figure 87: Estimated share of alternatives in copper waste management (2004)



7.9 Zinc

Main findings:

- The amount of zinc waste generated in the EU 27 can be estimated at nearly 1.2 Mt in 2004.
- Of these, an estimated 0.68 Mt were recycled (approx. 58 %).
- Traditionally, EU zinc scrap export has been far bigger than import. The EU 27 is an important zinc scrap source for the international market.
- The international zinc market had to cope with several fluctuations over the last decades, the last one in February 2007. Even if the market prices differ depending on country and zinc waste quality the market prices show an upward trend.

7.9.1 Characterisation of the waste stream

Overview

General characteristics
Zinc has the third highest usage rate among non-ferrous metals after aluminium and copper. It is used for the production of numerous alloys, such as brass. It can easily be applied to other metal surfaces, such as steel (galvanising).

Zinc is also used in the pharmaceutical, nutrient, construction, battery and chemical industries.

Waste streams such as galvanising residues (ashes, skimmings, sludges, etc.), flue dust from steel plants, brass processing, and die-casting scrap are sources of zinc.

Residues and scrap, which are relevant and significant to the secondary zinc industry, include:

- dust from copper alloy making,
- residues from the die casting industry,
- ashes, bottom and top drosses from the galvanising industry,
- old roofing and other sheet materials,
- non-ferrous fraction from the shredding of old cars and of other mainly steel containing products,
- dust from electric arc steel making and cast iron making,
- residues from chemical uses of zinc and burnt tyres.

Waste recovery

Collection and sorting
Zinc coated steel and other zinc products are very durable and therefore very slow in entering the recycling circuit. The life of zinc products can range from 10 to 15 years in household and car appliances and up to 100 years for zinc sheets in roof-protection.

There are two different kinds of zinc scrap:

- The new scrap, which accrues in the production of lead, is filtered and reprocessed to primary zinc. If this process is not economical, the dust is stored in repositories with the expectation of further development which might make it profitable. New scrap occurs during a production process of something else, like a by-product, but has never been in use.
- The old scrap, mainly from brass scrap and zinc coated materials, is collected by local waste disposal companies and then sold to the remelters. (Old scrap is something that has been used before and is then recovered.)
- New scrap is either directly processed or deposited for more profit at the production side. Old scrap is collected by local companies and sold to remelters (sorting see pre-treatment and recovery).

Pre-treatment and recovery technologies
Generally, there are three different operations necessary to gain secondary zinc from scrap:

Pre-treatment
In a first step, products containing zinc like zinc-carbon / air or alkaline-manganese batteries are crushed to separate zinc from contaminants. The successive pneumatic and manual screening concentrates the zinc for further processing. The scrap is sorted according to the content of zinc in the refuse and then cleaned using a number of different methods, which include smelting and other thermal-metallurgical processes to recover the metal content. The objective of these proceeding is to remove any foreign materials (e.g. chlorides) to improve product quality and processing efficiency.

Galvanisers ashes which arise during galvanisation of pieces, wire, and tubes are essentially a mixture of zinc metal and zinc oxide, contaminated with ammonium and zinc chloride. They are ball-milled to liberate the phases.

Re-melting
Afterwards, the scrap is charged into a furnace, where the metals are slowly heated up, until the melting point of zinc is reached. Since other metals have higher melting points, the zinc can be recovered and the remaining scrap is sold to other secondary processors.
The type of furnaces can be kettle, crucible, reverberatory and electric induction furnaces depending on the type and quality of the scrap. Flux is used to trap impurities from the molten zinc which float up to the surface and are skimmed. Leaching converts dross and skimmings into zinc oxides which can then be reduced to zinc metal by smelting.

The remaining zinc can be poured into moulds or transported to the refining operations in a molten state.

Zinc alloys are usually produced during sweating or melting; alloys are much stronger than unalloyed zinc.

Refining
Refining processes clean the zinc scrap from further impurities. Molten zinc is heated until it vaporises. The vapour is then condensed and recovered in several forms depending upon temperature, recovery time, presence or absence of oxygen, and the equipment used.

Final products from refining processes include zinc ingots, dust, zinc oxide, and zinc alloys.

Preconditions and technical limitations

Zinc can be recovered any given number of times with a minimum of energy and without quality loss.

Aluminium, steel, and plastics can substitute zinc for galvanized sheet. Aluminium, plastics, and magnesium are major competitors as die-casting materials. Plastic coatings, paint and cadmium and aluminium alloy coating replace zinc for corrosion protection; aluminium alloys are used instead of brass. Many elements are substitutes in chemical, electronic, and pigment uses.

Alternative management

In some cases, zinc is also landfilled, which might cause the leaching of zinc to groundwater (see below).

Environmental and health issues related to waste management

Key issues

Zinc is a natural element and essential for living organisms. On the other hand, free zinc ions in solutions are toxic. The main environmental impact when recycling metals comes from metal containing dust as well as fume from the smelting processes. Dust emissions occur from storage, handling of raw materials and products, and the furnace operation, where both stack and fugitive emissions play an important role.

There is, on the other hand, a fixation of impurities in the furnace slag or in the effluent treatment sludge.
Water emissions are produced from cooling, granulation and other processes and site related effluents. An important issue is the wastewater generated by wet cleaning abatement systems.

Waste recovery process

Emissions from sweating and melting consist of particulate matter, zinc fumes, other volatile metals, flux fumes and smoke generated by the incomplete combustion of grease, rubber and plastics in zinc scrap. Zinc fumes are negligible at low furnace temperatures. Flux emissions may be minimized by using no fuming flux. If fluxes are required that do generate fumes, fabric filters are used to limit emissions.

Substantial emissions may arise from incomplete combustion of carbonaceous material in zinc scrap, which are usually controlled by afterburners.

Crushing and screening processes are also a source of dust emissions, which are composed of zinc, tin, copper, lead, aluminium, iron, cadmium, and chromium. They can be recovered by hooded exhausts and controlled by fabric filters.

The sodium carbonate leaching process emits zinc oxide dust during the calcining operation, which can also be caught in fabric filters.

Emissions from refining processes mainly consist of metallic fumes. Distillation and oxidation operations also emit part of their entire zinc oxide product in the exhaust gas. Zinc oxide is usually recovered in fabric filters.

Emissions from waste recovery processes are filtered with an efficiency of about 96 % to 99 %, making zinc recovery a relatively clean and environmentally compatible process.

However, exposure to the substances emitted from the process can cause various problems:

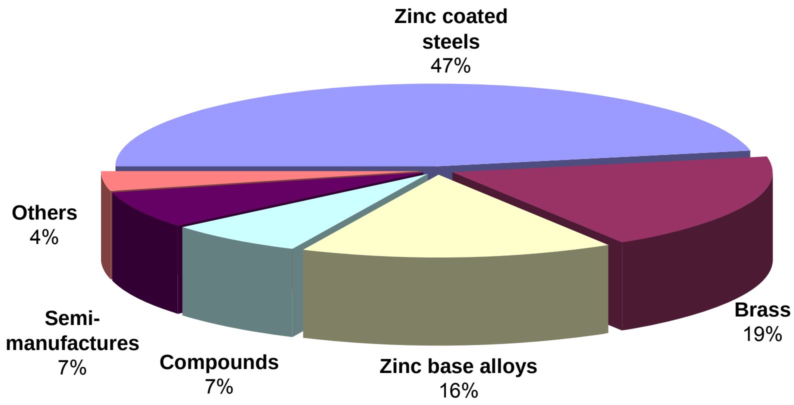
- The size of particulate matter (PM) particles largely determines the extent of environmental and health damage caused. Numerous studies have linked PM to aggravated cardiac and respiratory diseases such as asthma, bronchitis and emphysema and to various forms of heart disease. PM can also have adverse effects on vegetation and structures, and contributes to visibility deterioration and regional haze.
- Zinc oxide as well as other metal and flux fumes can cause damage in the human body when inhaled, swallowed or touched. They affect eyes and skin and cause irritation on the mucosa and respiratory passages. Zinc oxide can cause the so-called metal fume fever. Furthermore, it is considered dangerous for the environment.

Incomplete combustion of carbonaceous materials emits carbon monoxide.

Market

Zinc industry
Zinc is used in the production of galvanising alloys, die-casting alloy and special products. Additionally it is component of brass, an important material for architecture and interior decoration (brass doorknobs, taps and lighting fixtures). Its strong resistance to corrosion gives zinc excellent protective properties. It is used to protect steel and often zinc sheets are used as roofing material and in rainwater systems. A recent development for the use of zinc has been the Electric Fuel Zinc-Air Battery System used to power vehicles with zero emissions.

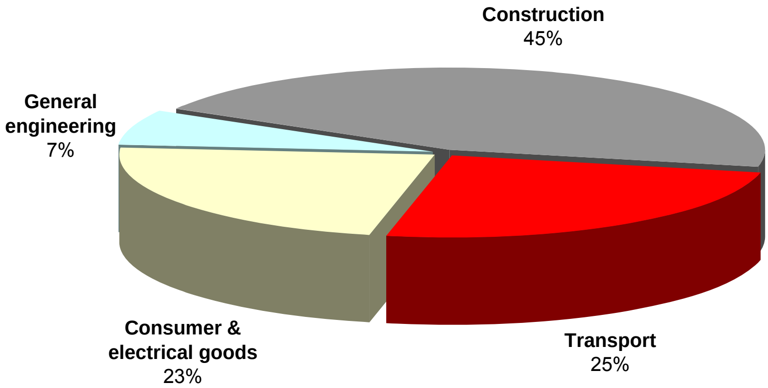
Figure 88: Zinc demand: by products, 2003 estimate



Source: International Zinc Association

The main end uses of zinc are: construction (45 %) followed by transport / automotive industries (25 %), consumer goods & electrical appliances (23 %) and general engineering (7 %).

Figure 89: Zinc demand: by end-use 2003 estimate



Source: International Zinc Association

According to the International Zinc Study Group, the demand for zinc is on a high level, so that a worldwide supply deficit of around 700,000 t was witnessed in 2006. Especially China has increased its zinc imports although it already produces 25 % of its own demand.

Main EU producers of zinc are Spain, Germany, Finland, Belgium, and France. The main sources for zinc concentrates for EU producers are North America, Peru and Australia.[82]

Recycling Market

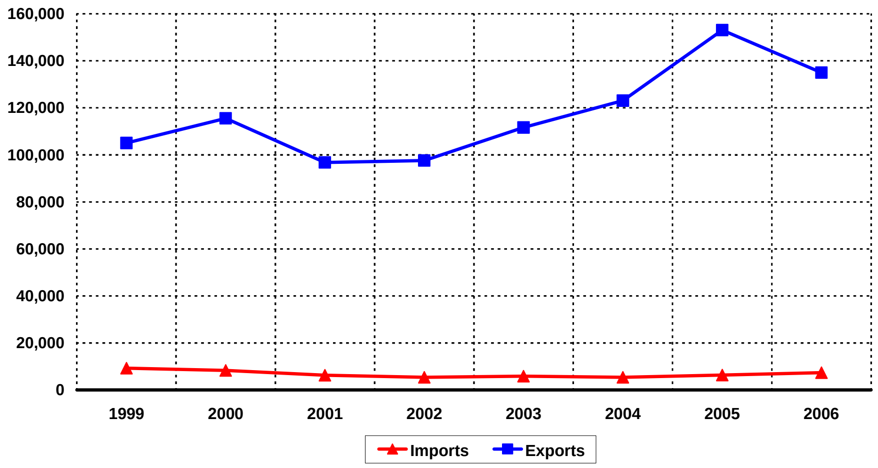
According to the International Zinc Association, currently about 70 % of the zinc produced worldwide originates from mined ores and 30 % from secondary zinc. The level of recycling

[82] Commission of The European Communities, Analysis of economic indicators of the EU metals industry: the impact of raw materials and energy supply on competitiveness, 2006.

is increasing each year with progress in the technology of zinc production and zinc recycling. Today, over 80 % of the zinc scrap generated is indeed recycled.

EU zinc scrap exports have been much larger than imports. The EU 27 is an important zinc scrap source for international markets. Since 1999 exports have increased by 28 % to 134,000 tonnes while imports have decreased by 20 % to 7,300 tonnes.

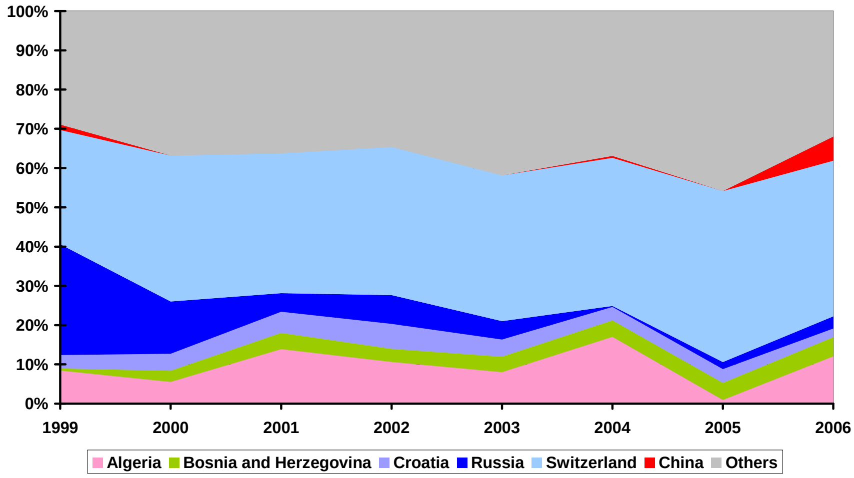
Figure 90: EU 27 zinc waste and scrap trade 1999 - 2006 (tonnes)



Source: COMEXT

In 1999, 57 % of zinc scrap imports came from Switzerland and Russia. After the introduction of export tax on ferrous metal scrap in Russia that ceased to be a major supplier for the EU. Switzerland consolidated its position as the major zinc scrap exporter to the EU (39.7 % in 2006). Algeria has increased its exports to the European market and holds a share of 12 % (2006) of the total EU imports.

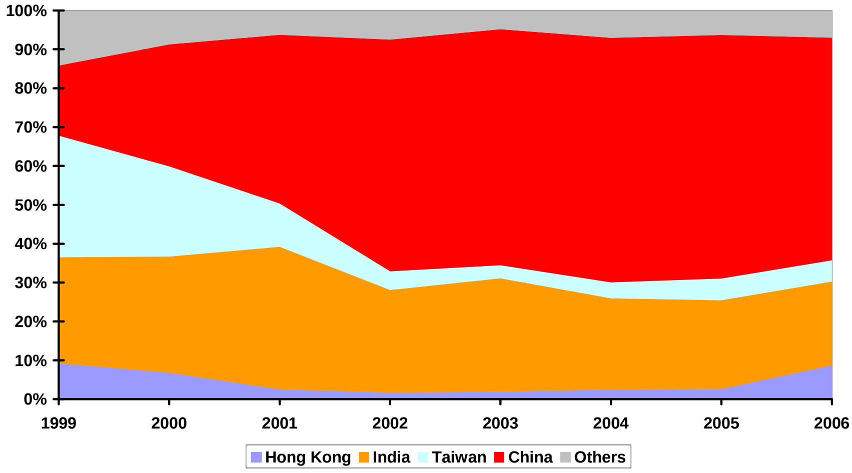
Figure 91: Share of EU 27 zinc waste and scrap imports 1999 - 2006 by origin



Source: COMEXT

Regarding exports, China increased its share of total EU zinc scrap exports dramatically from 18 % in 1999 to 57 % in 2006.

Figure 92: Share of EU 27 zinc waste and scrap exports 1999 - 2006 by destination



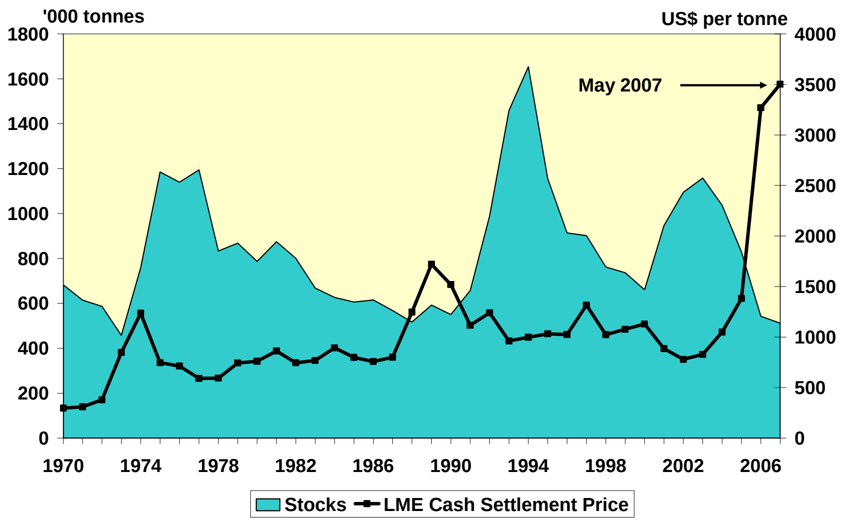
Source: COMEXT

The supply of zinc coated steel scrap for recycling is expected to double over the coming five years, as more zinc-coated vehicles enter the recycling stream. By 2005, half of world steel output is expected to come from electric arc furnaces (EAF). As a result, growing quantities of EAF flue dust with higher zinc contents will be treated and more recycled zinc will become available.

Market prices

The international zinc market had to cope with several fluctuations over the last decades, the last one in February 2007. Due to a smelter strike in Peru, prices increased again and are expected to rise even further as a reaction to the booming world market.

Figure 93: Zinc stocks and prices 1970 – 2006



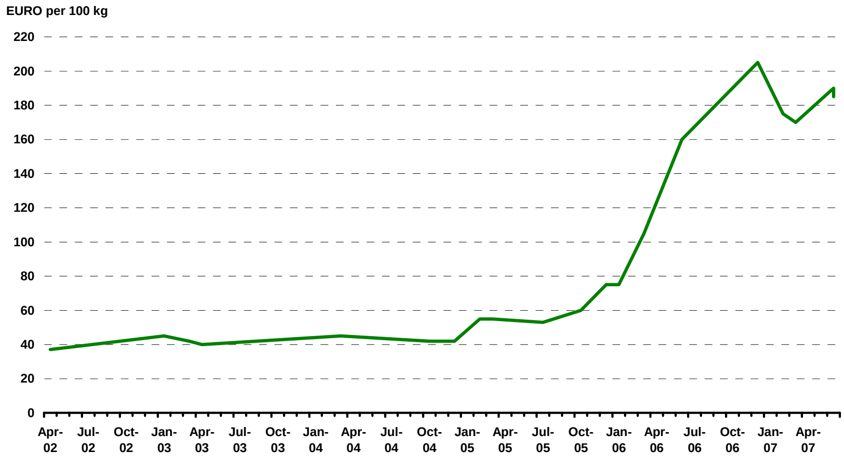
Source: International Lead and Zinc Study Group

Example:

Currently the price for zinc scrap in Germany is 180-185 € per 100 kg.[83]

[83] Prices for zinc scrap in Germany on 13.06.2007, source: EUWID Recycling und Entsorgung, Märkte.

Figure 94: Wholesale trade prices for zinc scrap in Germany 2002 - 2007 (price ceiling)



Source: EUWID Recycling und Entsorgung, Märkte

7.9.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream zinc. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 23: Waste sources for the waste stream zinc

*Grouping****	**EWC**	**Waste Description**	**Hazar-dous**	**EWC-STAT****	**Waste Description**	**Hazar-dous**
II	110501	hard zinc		**06.2 ******	Non-ferrous metal waste and scrap	
	170404	zinc				
	150104*	metallic packaging		**06.3 ******	Mixed metal wastes	
	020110*	waste metal				
	120103*	non-ferrous metal filings and turnings				
	120104*	non-ferrous metal dust and particles				
	160118*	non-ferrous metal				
	170407*	mixed metals				
	191002*	non-ferrous waste				
	191203*	non-ferrous metal				
	200140*	metals				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1 *******	Construction and demolition wastes	

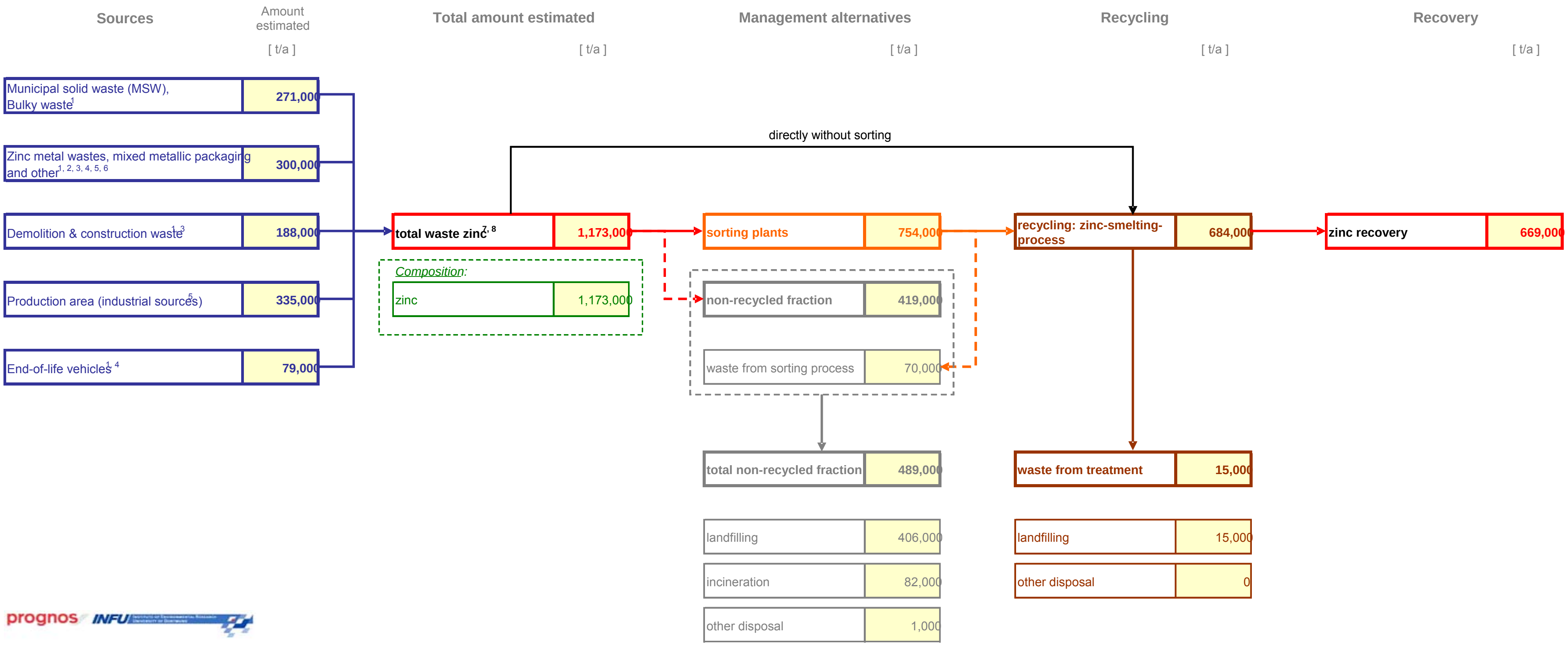
*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
IV	100503	flue-gas dust	☠	**12.4**	Combustion wastes	☠/⚐
	110502	zinc ash				
	110202	sludges from zinc hydrometallurgy (incl. jarosite, goethite)	☠	**12.5 ***** **	Various mineral wastes	☠

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered zinc waste amounts where estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of zinc waste is necessary. The considered zinc waste amounts where estimated as described in the Introduction.
*** Allocation of waste stream sources to the sources group in the flow sheet
I Municipal solid waste (MSW) and bulky waste
II Zinc waste, mixed metallic packaging and other mixed metallic wastes (including separate collected fractions from MSW and separate recorded zinc waste from industry), end-of-life-vehicles, construction & demolition such as treatment processes (as described in the table "waste sources"). For member states with EWC-6-digit-level data basis only separate selected fraction 200140 and waste from treatment 191002 and 191203 was considered.
III Demolition and construction waste (including codes 170404 and 170407 for member states with EWC-6-digit-level data basis)
IV Production and industrial sources (including codes 110501, 120103, 120104 and 150104 for member states with EWC-6-digit-level data basis). "Cycle scrap" is not included.
V End-of-life-vehicles and discarded equipment (including code 160118 for member states with EWC-6-digit-level data basis)
**** Data available only for the aggregated group 06
*****Data available only for the aggregated group "12.1 to 12.5 not 12.4"

7.9.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream zinc could be compiled.

Figure 95: Estimation of zinc waste flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group “zinc waste, mixed metallic packaging and other mixed metallic wastes”. Separate data are formally available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share is very small.
3. Zinc collected separately from construction & demolition waste (170404 and 170410) is included in the group “zinc waste, mixed metallic packaging and other mixed metallic wastes” for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group “construction & demolition waste”.
4. Zinc recorded separately from end-of-life-vehicles (160118) is included in the group “zinc waste, mixed metallic packaging and other mixed metallic wastes” for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group “end-of-life-vehicles”.
5. Zinc recorded separately from production and industry (120103, 120104, 110501 and 150104) is included in the group “zinc waste, mixed metallic packaging and other mixed metallic wastes” for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group “production and industrial sources”. “Cycle zinc” is not included.
6. Includes also zinc waste from treatment processes, which are part of the aggregated group “zinc waste, mixed metallic packaging and other mixed metallic wastes”. Separate data is available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 3,000 tonnes.
7. Data for Latvia and Portugal reflects only municipal and commercial waste, no information is available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic is compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.

The main sources for zinc waste as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.

Based on the use of at least two different data sources (EWC and EWC-STAT)

- Zinc waste collected separately from municipal solid waste is not reported separately, but included in the group “zinc waste, mixed metallic packaging and other mixed metallic wastes”, as separate data is only available for member states with EWC data basis.

- Zinc from construction and demolition sources covers several potentials. Separately collected fractions (170404 and 170407) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group “zinc waste, mixed metallic packaging and other mixed metallic wastes”, because an allocation is not possible due to the aggregated data basis.

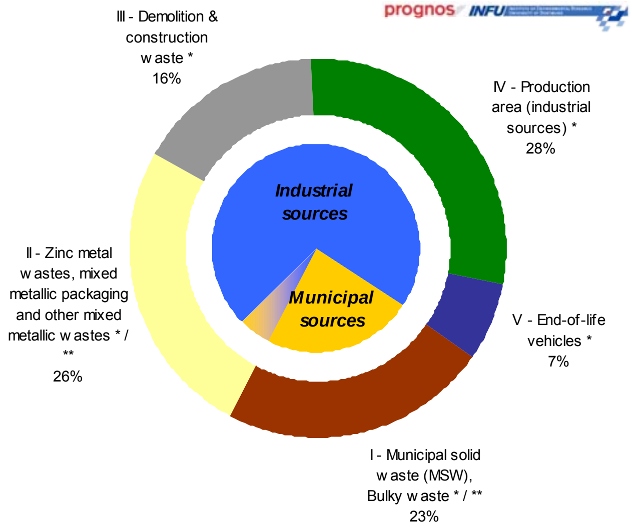
- Zinc from production and industry sources covers several potentials. Separately recorded fractions (110501, 120103, 120104 and 150104) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group “zinc waste, mixed metallic packaging and other mixed metallic wastes”, because an allocation is not possible due to the aggregated data basis. “Cycle zinc” is not included.

- Zinc from end-of-life-vehicles covers several potentials. Separately collected fractions (160118) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group “zinc metal waste, mixed metallic packaging and other mixed metallic wastes”, as an allocation is not possible due to the aggregated data basis.

- Zinc from waste treatment processes is not reported separately, but also included in the group “zinc waste, mixed metallic packaging and other mixed metallic wastes”, as separate data is only available for member states with an EWC data basis.

In **total, the amount** of zinc waste generated in the EU 27 was **nearly 1.2 Mt in 2004**, of which 23 % - 28 % is originated from MSW[84].

Figure 96: Estimated zinc waste generation by sources



* please also refer to notes on Table 23 and Figure 95
** includes waste fractions from MSW

The amount of zinc waste collected separately or collected and then separated in sorting plants with the objective of recycling [85] was estimated at 0.75 Mt in 2004. Taking into account various losses during the sorting process, about 0.68 Mt of zinc waste were returned to zinc smelting process for recycling. Considering further losses within zinc recycling processes, the total recovery of zinc waste amounted to about 0.67 Mt in 2004. The estimated share of the zinc waste for recycling of the total estimated zinc waste generation (rate of recycling) was about 58 % at the level of the EU 27, also shown in

[84] No better estimates can be provided because the aggregated group "Zinc metal, mixed metallic packaging and other mixed metallic wastes" includes zinc fractions from both MSW and from production and commercial sources.

[85] Total zinc waste generated less directly disposed zinc waste fractions.

Figure 99.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 97. Italy, Sweden, Austria, Germany, and Finland record the highest zinc waste recycling rates of more than 65 %.

Figure 97: Recycling potential in kg per capita (2004)

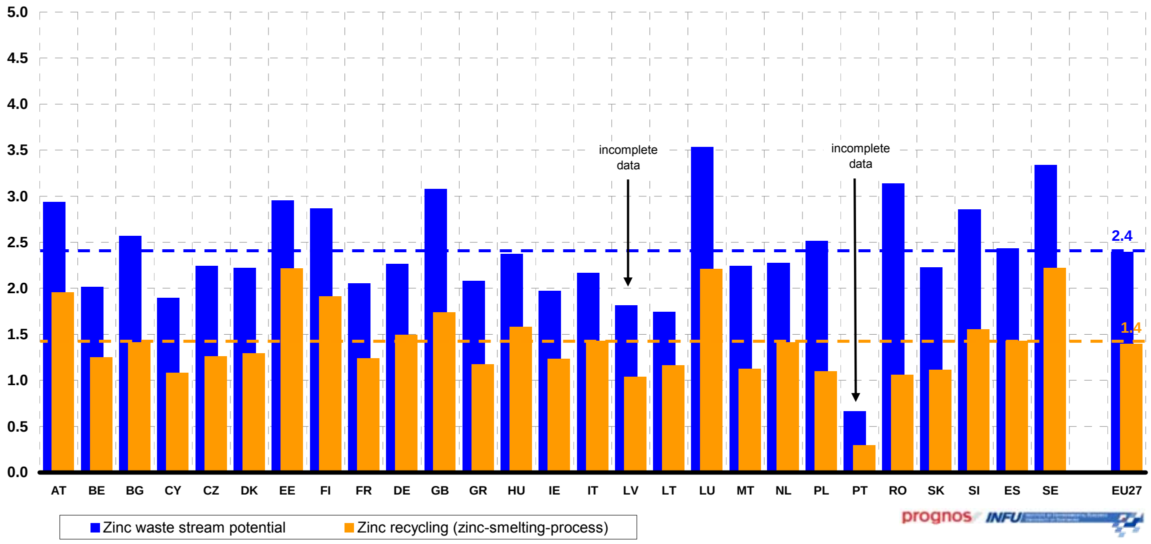


Figure 98 shows the estimated total amount of zinc waste by different waste management alternatives, and the

Figure 99 presents the same data but in percentage.

Figure 98: Management alternatives for zinc waste (in '000 tonnes)

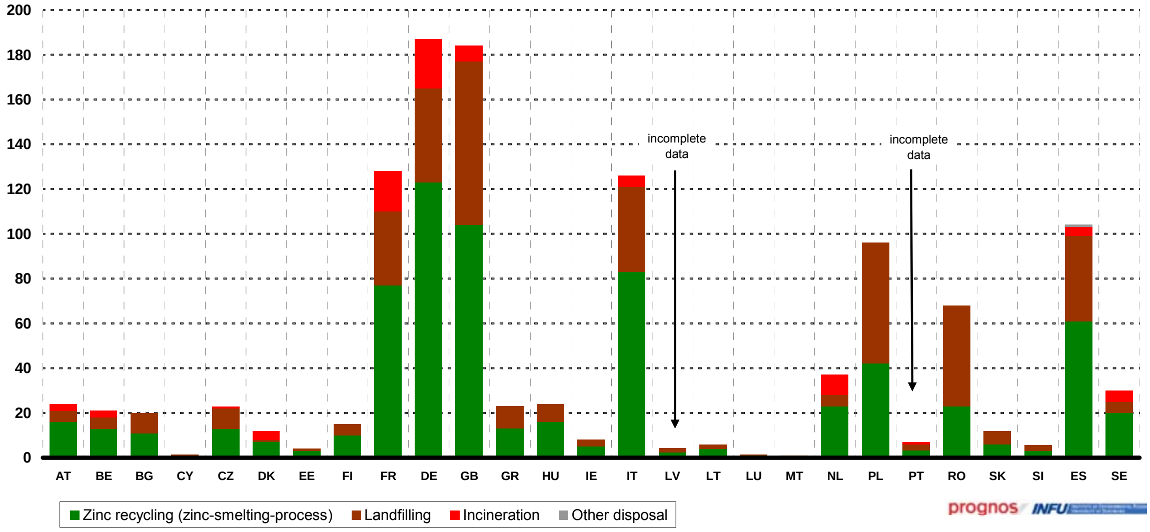
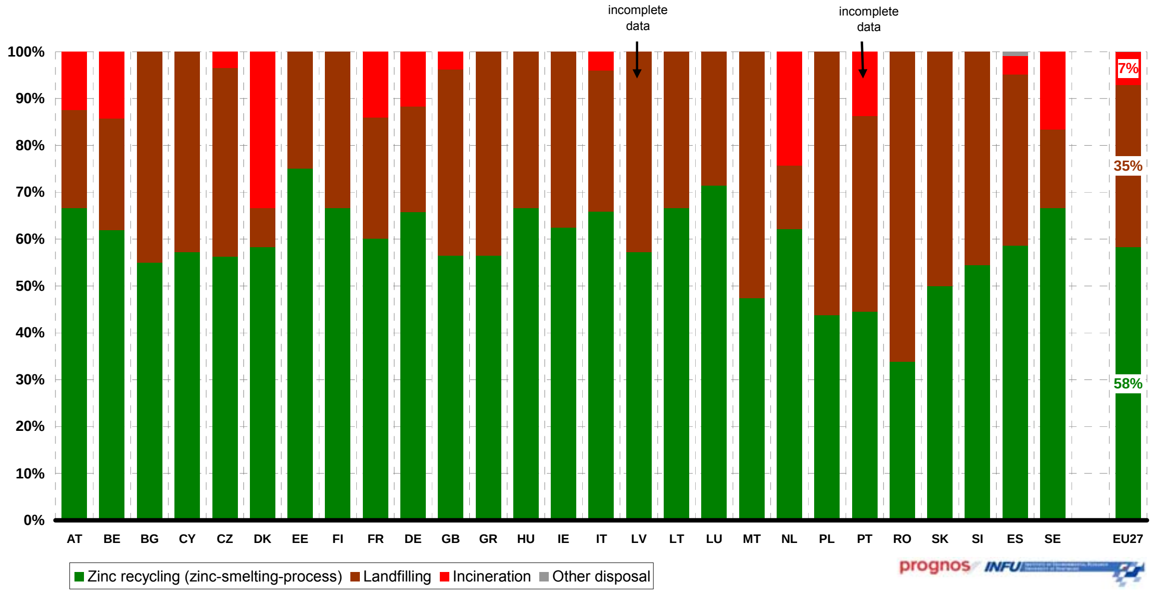


Figure 99: Estimated share of alternatives in zinc waste management (2004)



7.10 Lead

Main findings:

- The amount of lead waste generated in the EU 27 can be estimated at 1.0 Mt in 2004.
- Of these, an estimated 0.64 Mt were recycled (about 63 %).
- Lead is of great environmental concern and many lead compounds are classified as toxic.
- Lead can easy be recycled with high efficiency any number of times.
- Although the market prices differ depending on country and the quality of the lead waste, the market prices show an upward trend. The lead market is an international market.

7.10.1 Characterisation of the waste stream

Overview

General characteristics
Lead is the most abundant heavy metal in the earth’s crust; it is soft, has a low melting point and is resistant to corrosion.

Lead is mainly used for batteries (70 % of all lead); other applications are, for example, pipes and sheets. In buildings, lead is used in flat and pitched roofing, cladding, flashings, gutters and parapets.

Waste recovery

Collection and sorting
The high recycling rate is due to the well-developed processes for recovery and to high collection rates:

- The biggest consumer of lead is the battery industry which has a very high rate of collection and return of scrap batteries in most EU member states.
- Many other products used in much smaller amounts are also suitable for recycling, and may be returned via scrap merchants.
- In conjunction with the iron and steel industries, zinc, copper, and lead are recovered within the recycling processes of these industries.
- Some applications which result in unrecoverable dispersal into the environment – in particular as petrol additives and some paint uses – are being drastically reduced.

Pre-treatment and recovery technologies
Secondary lead accounts for more than 50 % of the consumed lead.

At least three quarters of all lead used goes into products which are suitable for recycling. This is why lead has one of the highest recycling rates of all the common non-ferrous metals.

Scrap preparation, sorting

Lead scrap preparation and sorting generally involves breaking and grinding the materials into small pieces which can then be separated. This can be done immediately after collection, e.g. at car scrap yards, or as an initial preparation stage at the smelters.
Lead scrap from pipes and sheet is "clean" and can be melted and refined without the need for a smelting stage.

The lead from batteries can only be obtained by breaking the case. That is done by a machine, which also separates all the different components and deposits them in hoppers. Thus the pastes (oxide and sulphate), grids, separators and fragmented cases are all separated from one another. The battery acid is drained, neutralised and disposed of. The metallic components are sorted ready for smelting.

Re-smelting

Smelting can be done in a blast or a rotary furnace. However, since the blast furnace became too cost-intensive and presented difficulties in preventing the escape of dust and fume, the rotary furnace is used primarily in Europe today.

The charge can either be tailored to give a lead of approximately the desired composition; or after two-stage smelting procedure yields crude soft lead and crude antimonial lead. In stage one, the furnace conditions allow oxidisation of antimony but are inert for lead, thus forming antimony oxides which are insoluble in molten lead. In the second stage, conditions reducing for both lead and antimony are used, reducing any metallic oxides to the metal and generating carbon monoxide and carbon dioxide. Coke or anthracite fines and soda ash are charged, both lead and antimony oxides and lead sulphate are reduced and at the end of the cycle the furnace is being emptied of antimonial lead and of slag for discarding.

Refining

Once smelting is complete, the molten lead is removed from the smelting furnace and transferred into refining kettles. Alternatively, in more modern plants, the molten lead is pumped directly from the smelting furnace to the refinery pots, thus saving time and energy by avoiding re-heating.

The principal impurities that are removed in secondary lead refining are copper, tin, antimony, and arsenic. Arsenic, antimony and tin are removed by oxidation.

There are two methods of refining crude lead: electrolytic refining and pyrometallurgical refining. Electrolytic refining uses anodes of de-copperised lead bullion and starter cathodes of pure lead. This is a high cost process and is used infrequently.

Some companies use iron pyrites and sulphur, which works at a higher temperature and can also remove any nickel present. Bismuth and silver levels tend to be slightly higher than in primary lead but are rarely lowered because they are insignificant.

Preconditions and technical limitations

Before treatment, the scrap has to be sorted into different grades of purity.

Alternative management
Lead scrap is considered a hazardous waste and therefore can not be disposed without any additional measures. Nevertheless, lead is often found in electronic devices sent to landfills, thus creating a danger to the environment.

Environmental and health issues related to waste management

Key issues
Lead is of great environmental concern and many lead compounds are classified as toxic.

Workers in the lead processing industry are exposed to health hazards such as lead poisoning by inhalation.

In the vicinity of plants, rather high concentrations of lead can be measured in the air, soil and water, which is harmful to the local eco-system and can lead to poisoning of humans or animals in the area.

Exposure to high amounts of lead can have biochemical effects on plants causing dysfunctions and can lead to an excess mucous formation which impairs respiration. It is also reported that exposure to large quantities of lead is known to increase the risk of cancer, especially lung cancer.

Emissions such as sulphur dioxides as well as antimony can cause extreme irritation of the respiratory system, eyes and lungs.

Waste recovery process
The main emissions from secondary lead production are solid wastes; a relatively small amount of emissions is emitted to the air, and even less into water. In detail the emissions from re-smelting and refining are:

<u>Solid wastes</u>
There are two different kinds of slags generated in lead smelting and refining which will need to be phased out with ongoing environmental regulations.

- Slags usually contain less than 5 % of lead and may also contain other contaminants such as antimony and arsenic.

- Silica slags mainly comprise glassy and crystalline phases which are subject to varying degrees of weathering, and which may release lead in more soluble forms. Lead has been found to occur in several different forms in weathered slags.

- Soda slags contain a lot of soluble metals.

- Dusts from pollution control equipment and drosses may contain lead and other metals in relative reactive forms. These are usually recycled, although a small proportion containing, for example, arsenic and cadmium may be disposed of in landfills.

Airborne emissions
Lead begins to fume significantly at temperatures above 500 C. Vapours and dust of lead and lead oxide as well as other chemicals present in the raw materials (such as acidic sulphur-containing gases, arsenic, and other metals) can be present in air, both within the plant and in the external environment.

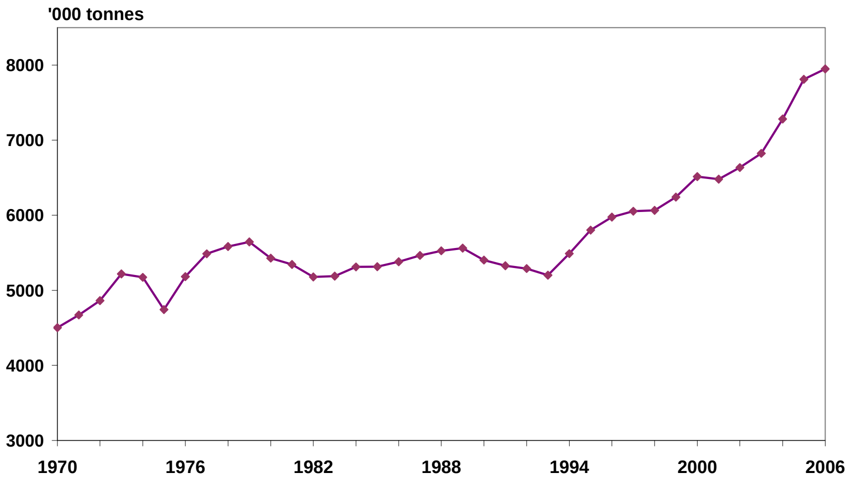
There is also the potential for the formation of dioxins in combustion due to the presence of small amounts of chlorine in lead scrap.

Waterborne emissions
Besides neutral salts, water used at several process stages and from surface rain water, may contain some lead, arsenic, tin, cadmium, and other metal ions, depending on the water cleaning technology used.

Market

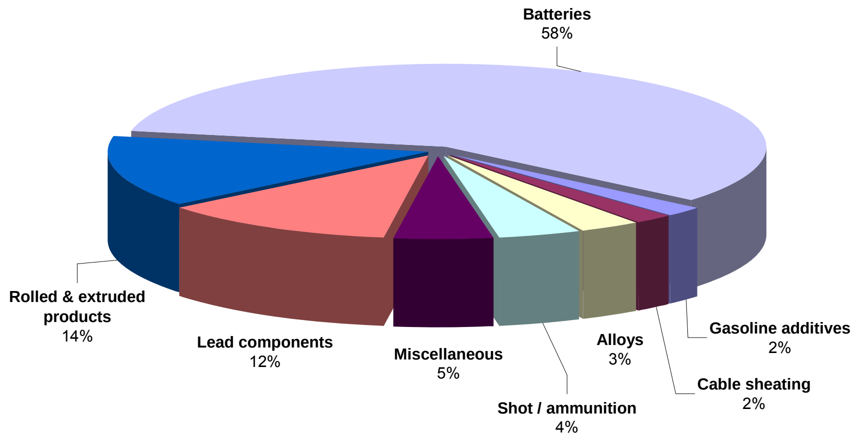
Lead industry
Lead is the third most widely used non ferrous metal following aluminium and zinc.

Figure 100: World lead demand 1970 - 2006



Source: International Lead and Zinc Study Group

Figure 101: Main uses for lead in France, Germany, Italy, and UK



Source: International Lead and Zinc Study Group

Lead is predominantly consumed in industrialised countries but its use is increasing rapidly in the developed world. The international lead market has a contingent of around 8 Mt and has not been able to meet the demand for the last five years in a row. This is said to be due to the increasing demand for lead from China because of the increasing automobile production.

The EU authorities are continuing in their attempts to limit the use of lead.

Main EU producers of lead are Germany, UK, Italy, France, and Spain. The main suppliers of lead concentrate to the EU 25 are Australia, Sweden, Ireland, and the USA.[86]

Recycling market

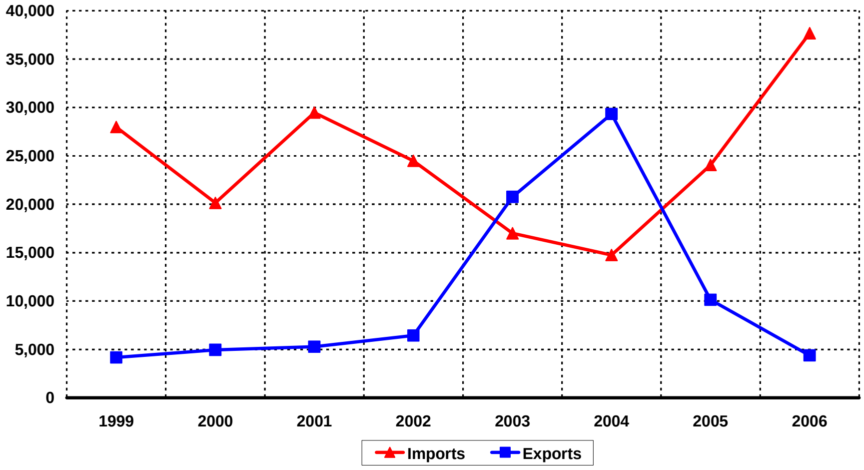
The amount of lead recycled is already reasonably high in relation to the total lead production. Driven by the implementation of the EC Directive on Batteries and Accumulators, battery collection systems have been introduced in many countries.

According to information of the Lead Development Association the main recyclers of lead are the USA, Germany, Great Britain, Japan, and Italy.

Until 2002, the trade balance of lead scrap in the EU 27 was negative and the volume of imports was significantly higher than the volume of exports. In 2003, EU 27 has become a net exporter; in 2004, exports increased by 346 % to 29,000 tonnes. However, this situation changed in 2005 and the EU 27 has again become a net importer with exports still decreasing.

[86] Commission of The European Communities, Analysis of economic indicators of the EU metals industry: the impact of raw materials and energy supply on competitiveness, 2006.

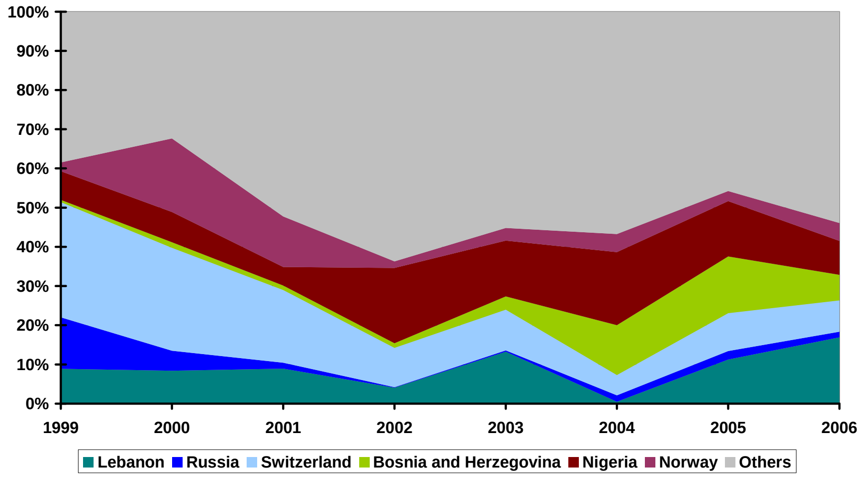
Figure 102: EU 27 lead waste and scrap trade 1999 - 2006 (tonnes)



Source: COMEXT

The import origin of lead scrap has always been quite diversified. The graph below shows the major supply sources with import shares over the time period 1999 to 2006.

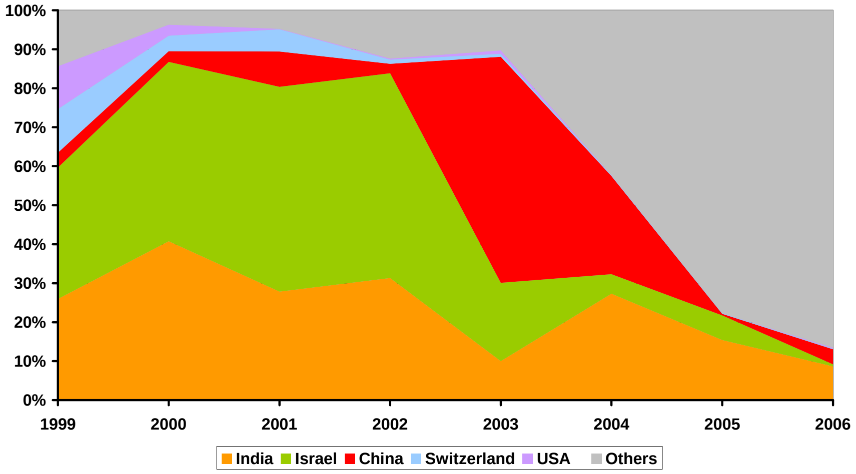
Figure 103: Share of EU 27 lead waste and scrap imports 1999 - 2006 by origin



Source: COMEXT

From 1999 to 2004, China, Israel and India were by far the main destinations for the export of lead scrap from EU 27. However, this situation has changed in the last two years: Exports decreased dramatically especially to China and Israel.

Figure 104: EU 27 lead waste and scrap exports 1999 - 2006 by destination

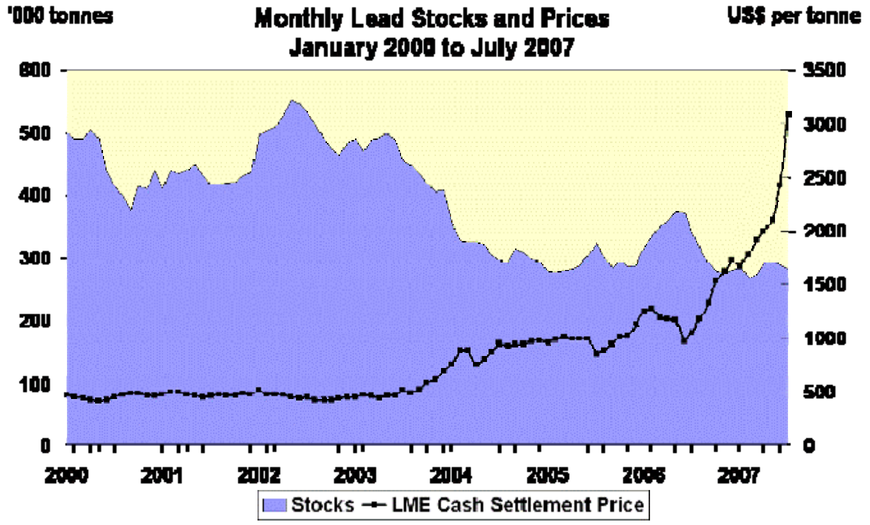


Source: COMEXT

Market prices

Before 2003, the lead market prices remained stable. Since then, the lead market has seen a steady price increase.

Figure 105: Lead stocks and prices 2000 - 2007



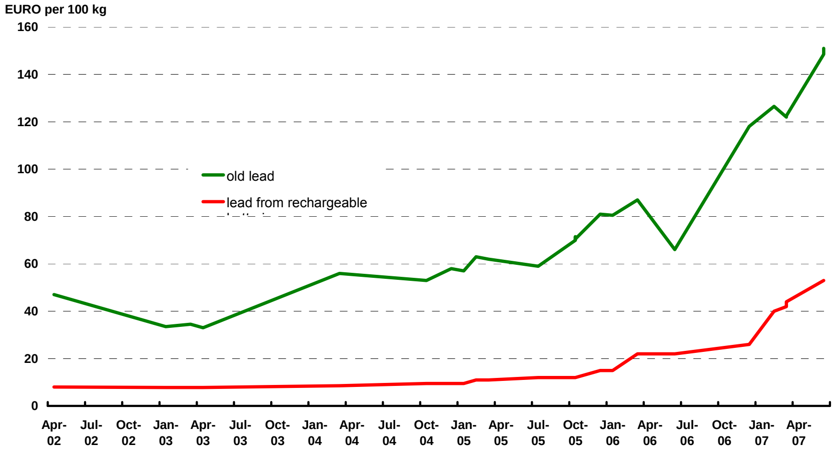
Source: International Lead and Zinc Study Group

Example:

Currently the price for lead scrap waste in Germany is 150 € per 100 kg. The price for lead from batteries was around 52 € per 100 kg in June 2007.[87]

[87] Prices for lead waste in Germany on 13.06.2007, source: EUWID Recycling und Entsorgung, Märkte.

Figure 106: Wholesale trade prices for lead scrap in Germany 2002 - 2007 (price ceiling)



Source: EUWID Recycling und Entsorgung, Märkte

7.10.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream lead. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT basis were identified according to the official equivalence table.

Table 24: Waste sources for the waste stream lead

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
II (IV)	170403	lead		**06.2*******	Non-ferrous metal waste and scrap	
	150104*	metallic packaging		**06.3*******	Mixed metal wastes	
	020110*	waste metal				
	120103*	non-ferrous metal filings and turnings				
	120104*	non-ferrous metal dust and particles				
	160118*	non-ferrous metal				
	170407*	mixed metals				
	191002*	non-ferrous waste				
	191203*	non-ferrous metal				
	200140*	metals				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/[symbol]
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
	160601	lead batteries	☠	**08.4 ********	Discarded machines and equipment components	
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in		**12.1 ***********	Construction and demolition wastes	

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
		17 09 01, 17 09 02 and 17 09 03				

☠ Hazardous waste fraction

☠/⚐ As well as hazardous and non-hazardous fractions

* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered lead waste amounts where estimated as described in Sources of data collection.

** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of lead waste is necessary. The considered lead waste amounts where estimated as described in the Introduction.

*** Allocation of waste stream sources to the sources group in the flow sheet

- I Municipal solid waste (MSW) and bulky waste
- II Lead waste and other mixed metallic wastes (including separate collected fractions from MSW and separate recorded lead waste from industry), end-of-life-vehicles and discarded equipment, construction & demolition such as treatment processes (as described in the table “waste sources”). For member states with EWC-6-digit-level data basis are considered only separate selected fraction 200140 and waste from treatment 191002 and 191203).
- III Demolition and construction waste (including codes 170407 and 170403 for member states with EWC-6-digit-level data basis)
- IV Production and industrial sources separate only for codes 120103, 120104 and 150104 for member states with EWC-6-digit-level data basis. Data for member states with EWC-STAT basis are included in “lead waste and other mixed metallic wastes”.
- V End-of-life-vehicles and discarded equipment (including code 160118 for member states with EWC-6-digit-level data basis)

**** Data available only for the aggregated group “06”

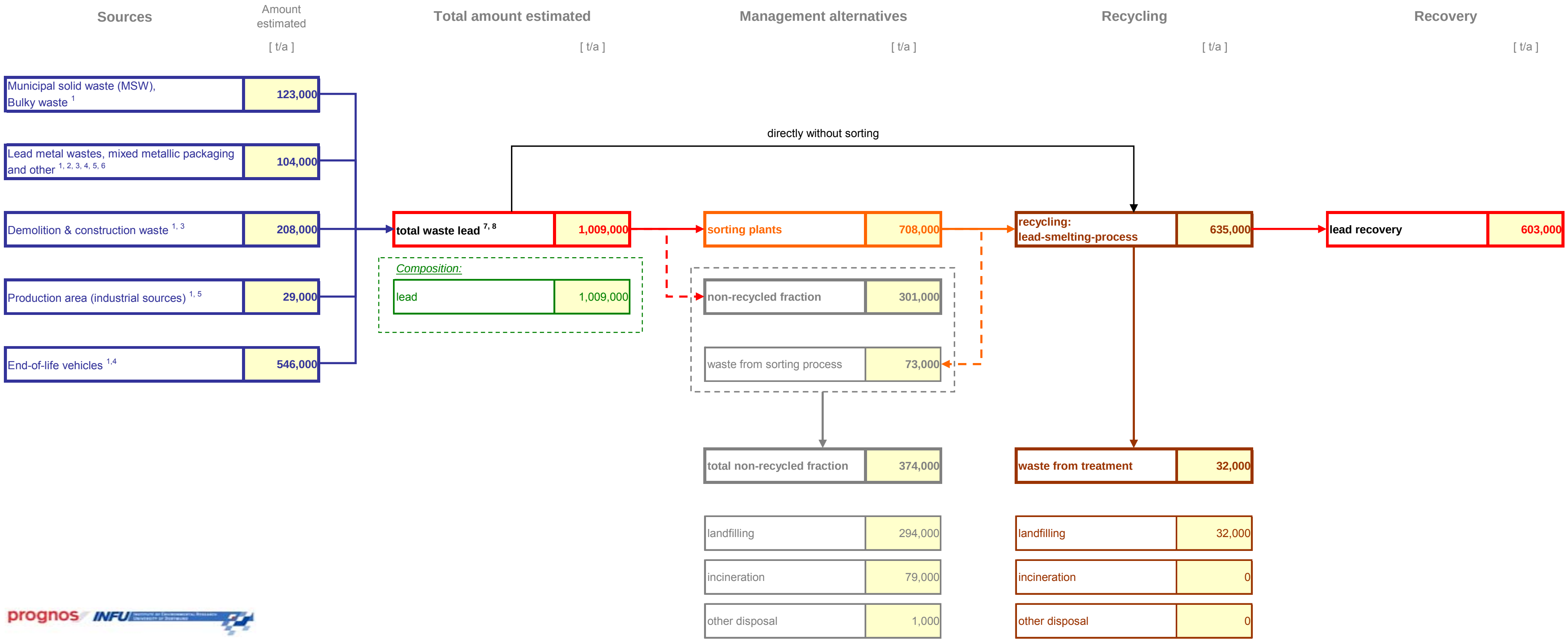
*****Data available as group 08.41

******Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.10.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream lead could be compiled.

Figure 107: Estimation of lead waste flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "lead waste and other mixed metallic wastes". Separate data available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 9,000 tonnes.
3. Lead recorded separately from construction & demolition waste (170407 and 170403) is included in the group "lead waste and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "construction & demolition waste".
4. Lead recorded separately from end-of-life-vehicles and discarded equipment (160118) is included in the group "lead waste and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "end-of-life-vehicles and discarded equipment".
5. Lead recorded separately from production and industry (120103, 120104 and 150104) is included in the group "lead waste and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "production and industrial sources". "Cycle scrap" is not included.
6. Includes also lead waste from treatment processes, which are part of the aggregated group "lead waste and other mixed metallic wastes". Separate data is available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 11,000 tonnes.
7. Data for Latvia and Portugal reflects only municipal and commercial waste, no information is available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic was compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.

The main sources for lead waste as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.

Based on the use of at least two different data sources (EWC and EWC-STAT)

- Lead waste collected separately from municipal solid waste is not reported separately, but included in the group "lead waste and other mixed metallic wastes", as separate data is only available for member states with EWC data basis.

- Lead from construction and demolition sources covers several potentials. Separately recorded fractions (170407 and 170403) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "lead waste and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

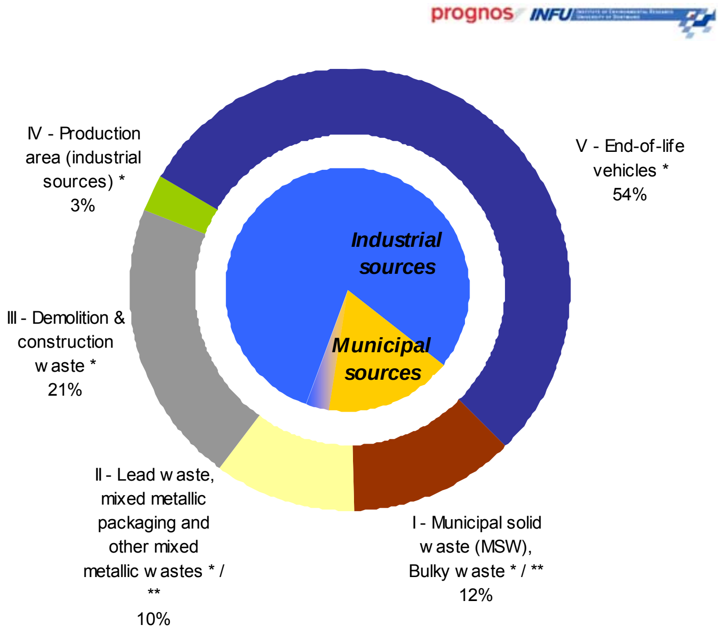
- Lead from production and industry sources covers several potentials. Separately recorded fractions (120103, 120104 and 150104) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "lead waste and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

- Lead from end-of-life-vehicles and discarded equipment covers several potentials. Separately collected fractions (160118) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "lead metal waste and other mixed metallic wastes", as an allocation is not possible due to the aggregated data basis.

- Lead from waste treatment processes is not reported separately, but also included in the group "lead waste and other mixed metallic wastes", as separate data is only available for member states with an EWC data basis.

In **total, the amount** of lead waste generated in the EU 27 was **1.0 Mt in 2004**, of which 17 % - 20 % is originated from MSW[88].

Figure 108: Estimated lead waste generation by sources



* please also refer to notes on Table 24 and Figure 107

** includes waste fractions from MSW

The amount of lead waste collected separately or collected and then separated in sorting plants with the objective of recycling [89] was estimated at 0.7 Mt in 2004. Taking into account various losses during the sorting process, nearly 0.64 Mt of lead waste were returned to lead smelting process for recycling. Considering further losses during the lead recycling processes, the total recovery of lead waste amounted to about 0.6 Mt in 2004. The estimated share of the lead waste for recycling of the total estimated lead waste generation (rate of recycling) was about 63 % at the level of the EU 27, also shown in

[88] No better estimates can be provided because the aggregated group "lead waste, mixed metallic packaging and other mixed metallic wastes" includes lead fractions from both MSW and from production and commercial sources.

[89] Total lead waste potential less directly disposed lead waste fractions.

Figure 111.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 109. Austria, Belgium and Germany record the highest lead waste recycling rate of more than 70 %.

Figure 109: Recycling potential in kg per capita (2004)

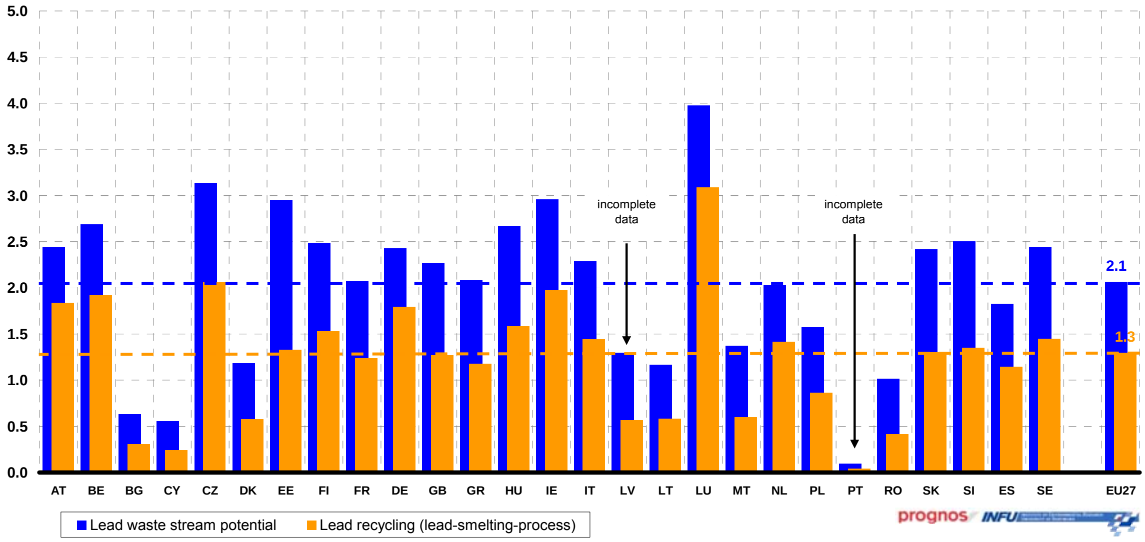


Figure 110 shows the estimated total amount of lead waste by different waste management alternatives, and the

Figure 111 presents the same data but in percentage.

Figure 110: Management alternatives for lead waste (in '000 tonnes)

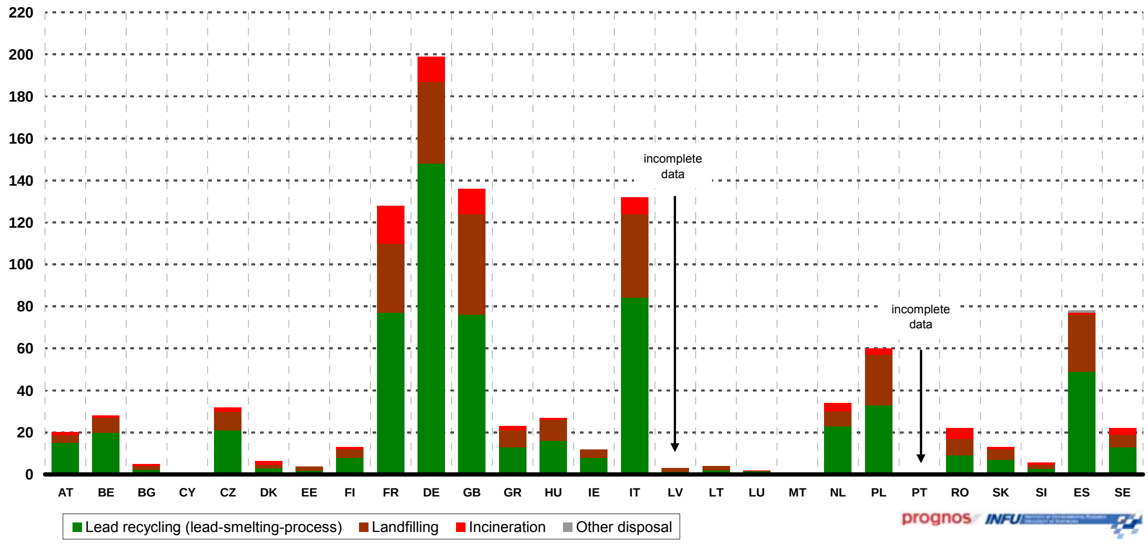
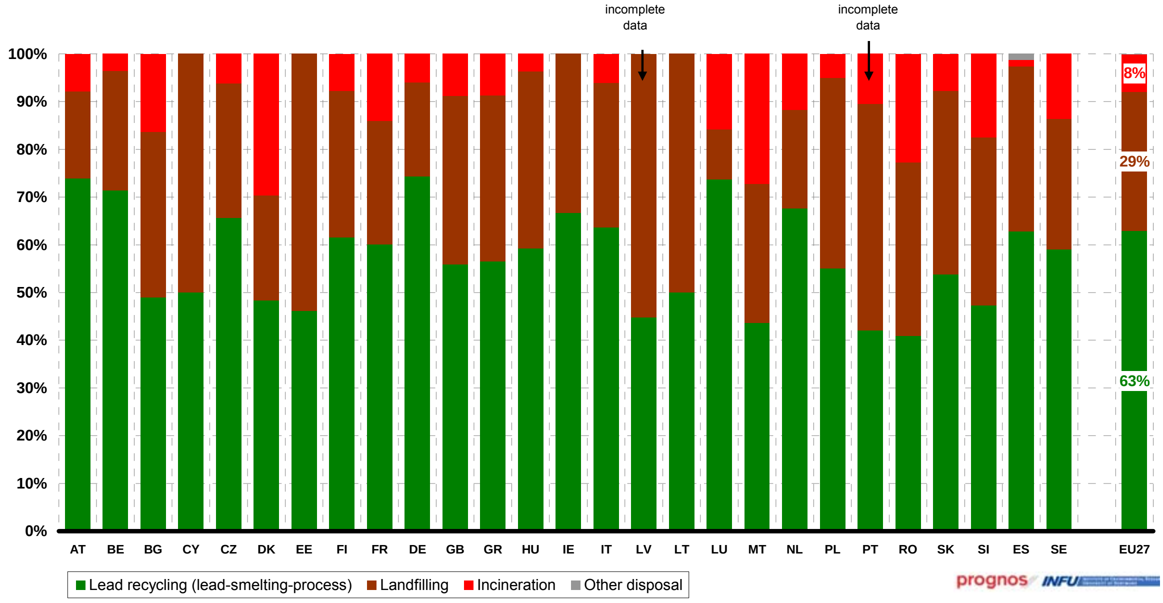


Figure 111: Estimated share of alternatives in lead waste management (2004)



7.11 Tin

Main findings:

- The amount of tin waste generated in the EU 27 can be estimated at 114,000 tonnes in 2004.
- Of these, an estimated 35,000 tonnes were recycled (approx. 31%)
- Tin possesses a unique combination of properties, which has led to its use in a wide range of applications. Tin can be recycled any number of times.

In 2005 the EU was the world's second-largest tin market. Prices are increasing; a reversal of this process is not expected due to increasing demand.

7.11.1 Characterisation of the waste stream

Overview

General characteristics
Tin is a rather scarce metal which does not occur naturally on earth. Tin is not toxic, resists corrosion, readily forms alloys with other metals and is therefore often used as coating.

Waste recovery

Collection and sorting
Tin containing wastes in the form of salts, slags, and mud are generated as a result of smelting and refining of other metals. These are the so called "new scraps" that are often recirculated within the plant or sold to scrap dealers who then sell them on to similar manufacturers.

"Old scrap" consists of tin-containing products such as tins, cans, and electronic equipment, which have been discarded after use. These wastes are generated by both domestic and industrial users and have a very low recovery rate (South Africa, as one of the highest rate in the world, reached 66 % in 2003).

Tinplate scrap is suitable for detinning (the process of separating tin from other materials, e.g steel. Not all sorts of scrap are suitable for this (due to chemical composition etc.). It is accumulated at different stages:

- Off-specification tinplate generated in the tin mills in steel plants
- Reject tinplates and tin cans at can making facilities
- Reject cans at can-filling operations
- Old scrap tin cans collected by municipalities via kerbside collection programmes.

Pre-treatment and recovery technologies
The recovery process is made up of a series of chemical and electrical steps which separate, purify, and recover the steel and tin. In the batch process of detinning, the cans first are loaded into large (10' x 14') perforated steel drums and dipped into a caustic chemical solution which dissolves the tin from the steel. The now-detinned steel cans are drained, rinsed, and baled

into 14"x14"x30" 400-lb. squares. Then they are sold to steel mills to be turned into new products.

Meanwhile, the liquid containing the tin, a salt solution called sodium stannate, is filtered to remove scraps of paper and garbage. Then it is chemically treated to eliminate other metals. Next, the solution is transferred to an electrolysis bath which works like a battery in reverse. When electricity is applied, tin forms on one of the plates in the solution. After the plate is covered, the tin is melted off and cast into ingots. The ingots are at least 99.98 percent pure tin and are used in the chemical and pharmaceutical industries. Pure tin also is alloyed with other metals to make solder, babbitt, pewter, and bronze products.90

Preconditions and technical limitations
Like all metals, tin can be reprocessed any number of times without loss of quality.

Alternative management
Tin containing wastes can be disposed of in sealed containers in landfills as they are not listed as hazardous wastes.

Environmental and health issues related to waste management

Key issues
Ammonia from dissolving tin from steel in a chemical solution is a highly toxic gas and can be fatal when inhaled, or it can damage the vegetation if released.

Volatile organic compounds (VOC) are known to, or suspected of having direct toxic effects on humans, ranging from carcinogenesis to neurotoxicity. The more reactive VOCs combine in photochemical reactions in the atmosphere with nitrogen oxides to form ground-level ozone, a major component of smog. VOCs are also precursor pollutants to the formation of fine particulate matter.

Waste recovery process
In leaching processes for de-tinning (see above), ammonia is released (0.048 kg ammonia per kg tin).

Volatile organic compounds (VOCs) are released from pyro-metallurgical refining processes.

Market

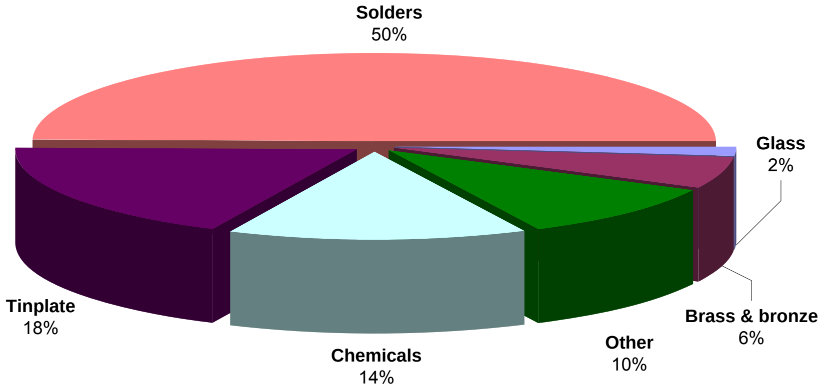
Tin Industry
Tin possesses a unique combination of properties, which has led to its use in a wide range of applications, such as metal, alloy or as a chemical compound. The two most significant uses of tin are in solder and tinplate. In February 2007, ITRI released new data from a recently completed study on global tin use by market sector. Solder is found to account for almost 50 % of the global consumption in 2005, up from 46% in 2004. Tinplate production has also continued to grow in China and remains the largest market of the export from Europe, while

[90] http://www.uoregon.edu/~recycle/after_collection.html#tincans

tin chemicals are very important in some large national markets such as the USA and Germany.

In 2005 the EU was the world's second-largest tin market, accounting for about 21 % of world tin consumption, followed by the US, at around 18 % of consumption. With more than 60 % of world consumption of tin, the Asian tin market plays the most important role.

Figure 112: World tin use by application in 2005



Source: International Tin Research Institute

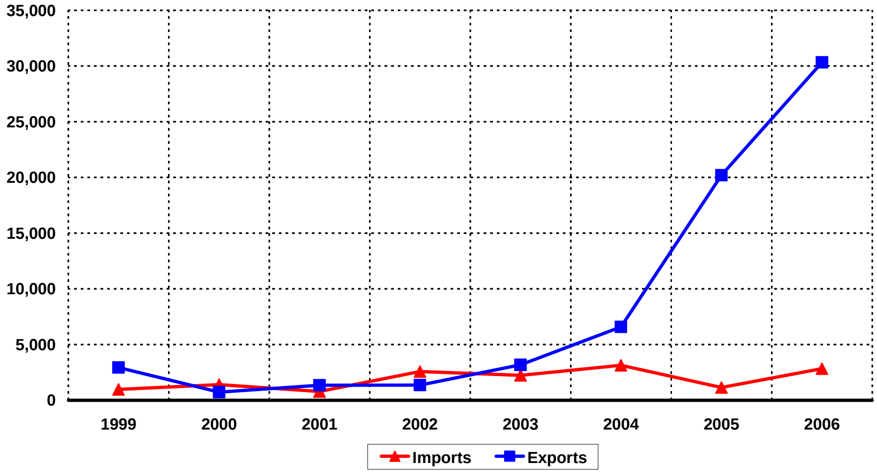
The increasing demand of the solder reflects both the strong growth of the Asian electronics sector and the successful implementation of lead-free technology, which is shown to have reached a high level of global penetration (59 % of electronic solder production by surveyed companies) in 2005.

The tin production is concentrated in South East Asia, Latin America and China, with most smelters close to the mining regions.

Recycling market

Since 2003, EU 27 has become a net exporter; exports of tin waste and scrap have increased tenfold to 30,000 tonnes in 2006. Imports have fluctuated with drops in 2001, 2003 and 2005. In 2006 imports reached a level of 2,800 tonnes.

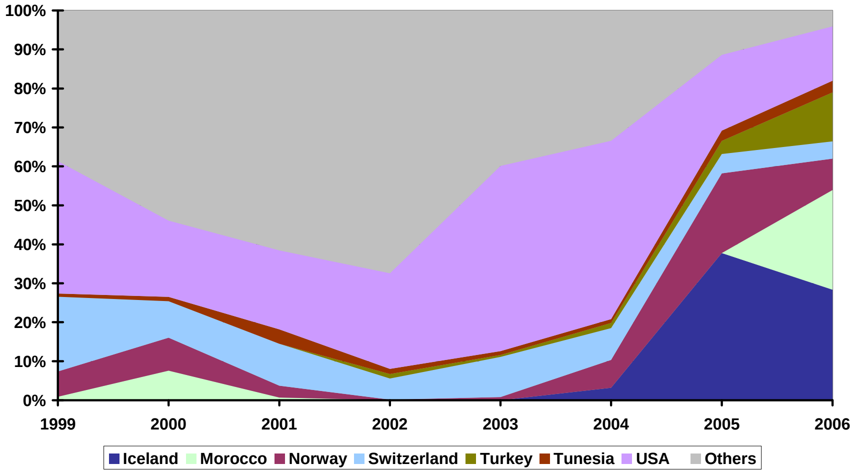
Figure 113: EU 27 tin waste trade 1999 - 2006 (tonnes)



Source: COMEXT

In 2006, the main suppliers of tin waste and scrap to the EU were Iceland (28 % of total EU 27 imports), Morocco (25 %), the USA (14 %), and Turkey (12 %). These countries imported around 2,275 tonnes of tin waste and scrap to the EU 27.

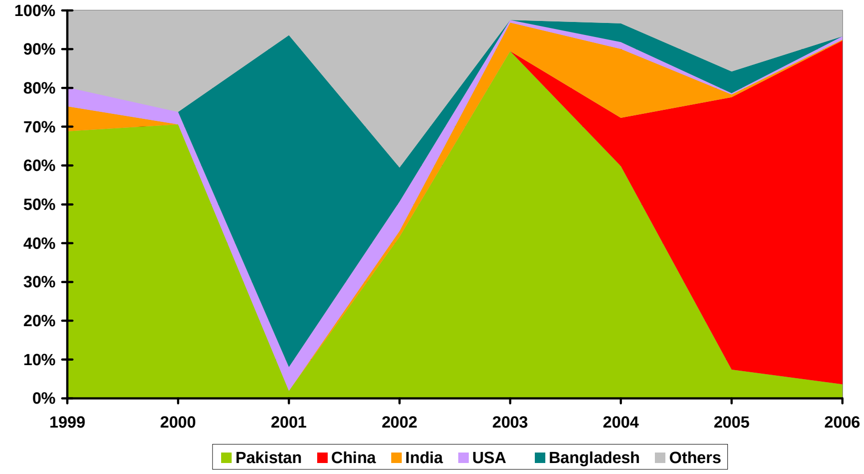
Figure 114: Share of EU 27 tin waste imports 1999 - 2006 by origin



Source: COMEXT

From 2003 to 2006 the major change in export destinations was the substitution of Pakistan by China. Exports to China have increased from 862 tonnes in 2003 to 26,900 tonnes and accounted for nearly 90 % of total EU 27 tin waste and scrap imports in 2006.

Figure 115: Share of EU 27 tin waste exports 1999 - 2006 by destination



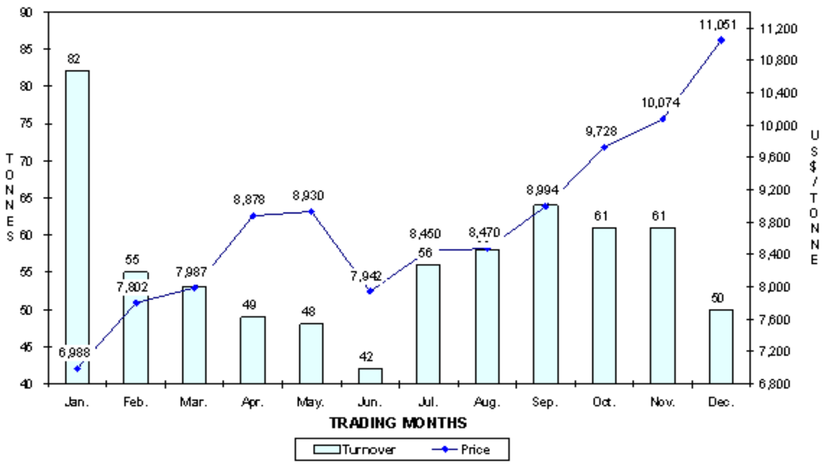
Source: COMEXT

Market prices

Production is currently insufficient to meet the demand. During the 1990's and early 2000's stocks had built up to levels that were keeping tin prices below the cost of production. The low production level is now drawing down these stocks, which will make the market more responsive to market forces in the future.

In July 2007, tin was traded with a price of US$ 14,540 per tonne at the Kuala Lumpur Tin Market (KLTM). In comparison, the price for tin in 2002 was only a third (US$ 4,359 per tonne).[91] It is likely that prices will decrease to some extent since current levels are estimated to be well above the long-term equilibrium. However, it is unlikely that prices will return to the low levels of the early part of this decade since production costs have increased and demand has risen substantially in relation to available resources.

Figure 116: Monthly average tin price & turnover 2006



Source: The Kuala Lumpur Tin Market

[91] The Kuala Lumpur Tin Market (www.kltm.com)

7.11.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream tin. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 25: Waste sources for the waste stream tin

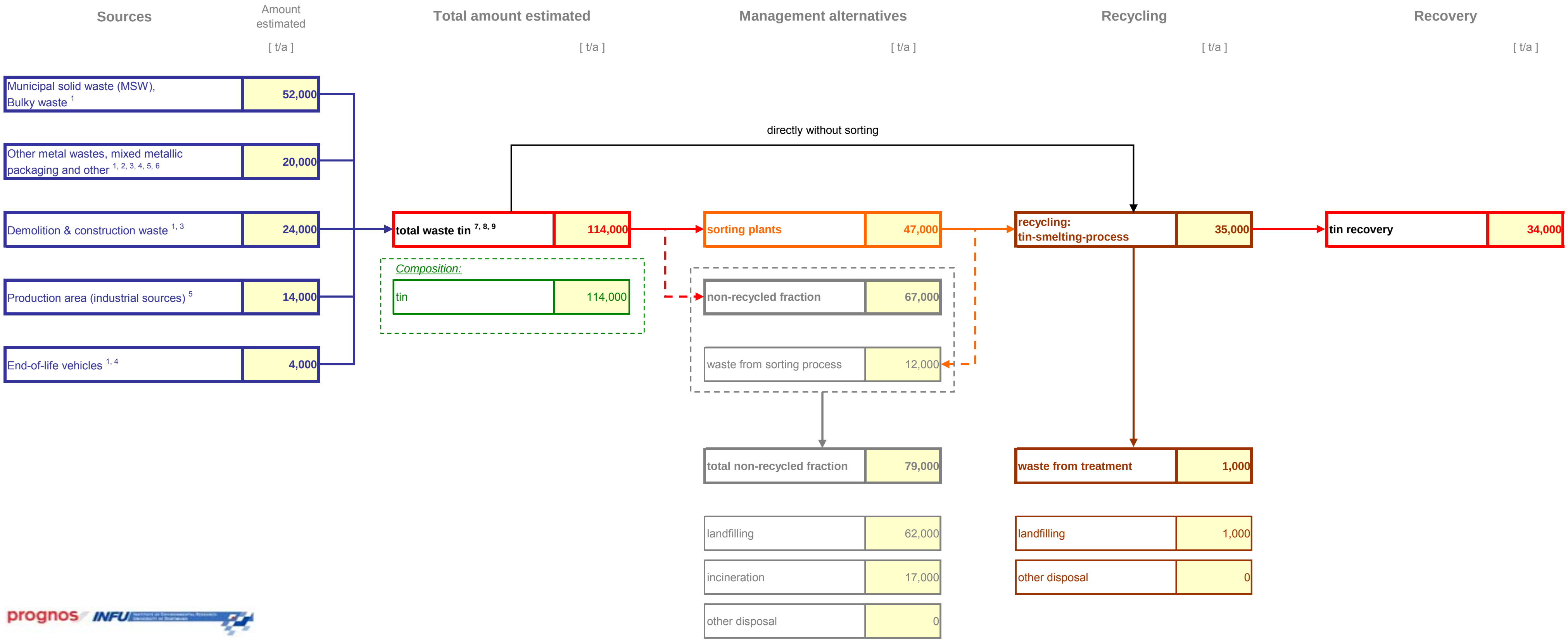
*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
II	170406	tin		**06.2** ****	Non-ferrous metal waste and scrap	
	150104*	metallic packaging		**06.3** ****	Mixed metal wastes	
	020110*	sludges from washing and cleaning				
	120103*	non-ferrous metal filings and turnings				
	120104*	non-ferrous metal dust and particles				
	160118*	non-ferrous metal				
	170407*	mixed metals				
	191002*	non-ferrous waste				
	191203*	non-ferrous metal				
	200140*	metals				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1** *****	Construction and demolition wastes	
IV	101009	flue-gas dust containing dangerous substances	☠	**12.4**	Combustion wastes	
	101010	flue-gas dust other than those mentioned in 10 10 09				

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered tin waste amounts where estimated as described in Sources of data collection.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of tin waste is necessary. The considered tin waste amounts where estimated as described in the Introduction.
*** Allocation of waste stream sources to the sources group in the flow sheet
I Municipal solid waste (MSW) and bulky waste
II Tin waste, mixed metallic packaging and other mixed metallic wastes (including separate collected fractions from MSW and separate recorded tin waste from industry), end-of-life-vehicles, construction & demolition such as treatment processes (as described in the table “waste sources”). For member states with EWC-6-digit-level data basis are considered only separate selected fraction 200140 and waste from treatment 191002 and 191203).
III Demolition and construction waste (including codes 170407 and 170406 for member states with EWC-6-digit-level data basis)
IV Production and industrial sources (including codes 120103, 120104 and 150104 for member states with EWC-6-digit-level data basis)
V End-of-life-vehicles (including code 160118 for member states with EWC-6-digit-level data basis)
**** Data available only for the aggregated group 06
*****Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.11.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream lead could be compiled.

Figure 117: Estimation of tin waste flow (all figures rounded to thousands)



Notes related to the flow sheet:
1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "tin waste, mixed metallic packaging and other mixed metallic wastes". Separate data is available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 400 tonnes.
3. tin recorded separately from construction & demolition waste (170407and 170406) is included in the group "tin waste, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "construction & demolition waste".
4. tin recorded separately from end-of-life-vehicles (160118) is included in the group "tin waste, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "end-of-life-vehicles".
5. tin recorded separately from production and industry (120103, 120104 and 150104) is included in the group "tin waste, mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "production and industrial sources". "Cycle scrap" is not included.
6. Includes also tin waste from treatment processes, which are part of the aggregated group "tin waste, mixed metallic packaging and other mixed metallic wastes". Separate data available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 1,000 tonnes.
7. Data for Latvia pertains only to municipal and commercial waste, no information was available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic is compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.
9. Data for Portugal is available only for MSW, all other figures roughly estimated.

The main sources for tin waste as the starting point of the waste flow sheet is displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.

Based on the use of at least two different data sources (EWC and EWC-STAT) Tin waste collected separately from municipal solid waste is not reported separately, but included in the group "tin waste, mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with EWC data basis.

Tin from construction and demolition sources covers several potentials. Separately collected fractions (170407and 170406) are included only for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "tin waste, mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

Tin from production and industry sources covers several potentials. Separately recorded fractions (120103, 120104 and 150104) are included only for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "tin waste, mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

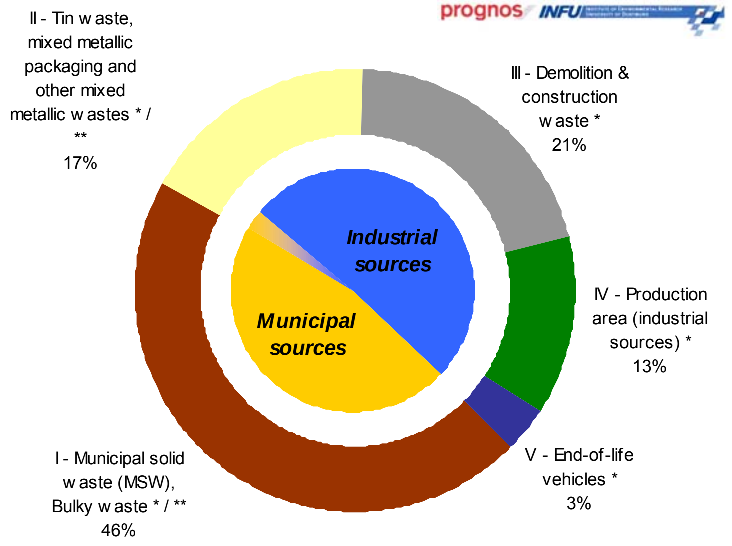
Tin from end-of-life-vehicles covers several potentials. Separately collected fractions (160118) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "tin metal waste, mixed metallic packaging and other mixed metallic wastes", as an allocation is not possible due to the aggregated data basis.

Tin from waste treatment processes is not reported separately, but also included in the group "tin waste, mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with an EWC data basis.

In **total, the amount** of tin waste generated in the EU 27 was **116,000 tonnes in 2004**, of which 47 % - 49 % is originated from MSW[92].

[92] No better estimates can be provided because the aggregated group "tin waste, mixed metallic packaging and other mixed metallic wastes" includes tin fractions from both MSW and from production and commercial sources.

Figure 118: Estimated tin waste generation by sources

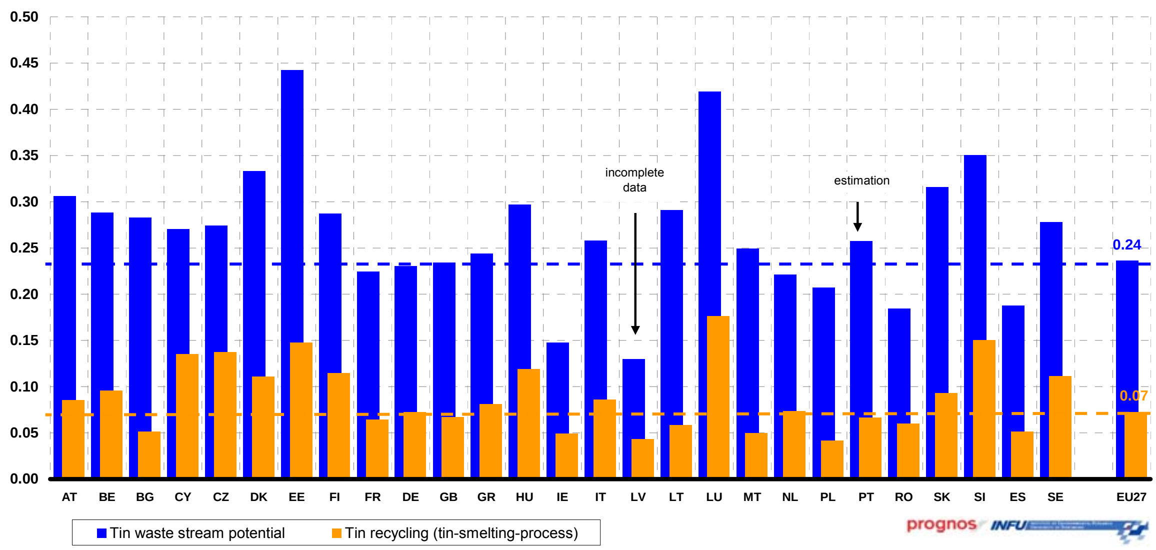


* please also refer to notes on Table 25 and Figure 117
** includes waste fractions from MSW

The amount of tin waste collected separately or collected and then separated in sorting plants with the objective of recycling [93] was estimated at 47,000 tonnes in 2004. Taking into account several losses during the sorting process, about 35,000 tonnes of tin waste were returned to tin manufacturing industry for recycling. Considering any further losses during the tin recycling processes, the total recovery of tin waste amounted to about 34,000 tonnes in 2004. Therefore, the estimated share of the tin waste for recycling of the total estimated tin waste generation (rate of recycling) was approx. 31 % at the level of the EU 27.

At country level the generation and rate of recycling differ from country to country, as shown in Figure 119.

Figure 119: Recycling potential in kg per capita (2004)



[93] Total tin waste potential less directly disposed tin waste fractions.

Due to small volumes and missing additional information on country level, a country specific estimation for tin management alternatives is not possible. For the EU 27 it can be estimated, that approx. 31 % of tin is recycled, about 54 % is landfilled and the rest of 15 % disposed by other methods.

7.12 Precious metals

Main findings:

- The amount of precious metals waste generated in the EU 27 can be estimated at 24,800 tonnes in 2004.
- Of these, an estimated 9,900 tonnes were recycled in precious metals smelting processes (40 %).
- Precious metals can be recycled any number of times without loss of quality.
- The precious metal market is a global market. European demand for precious metals is high. The amount of metal recovered rose strongly for all precious metals. Market prices are still increasing.

7.12.1 Characterisation of the waste stream

Ovrview

General characteristics
By common definition, precious metals include such well-known metals as gold and silver as well as the six platinum-group metals: platinum, palladium, rhodium, iridium, ruthenium, and osmium. They are termed precious metals because of their rarity and corrosion resistance.

The EU has the largest refining and fabricating capacity for precious metals in the world, even though its actual mineral resources of such metals are very limited. The recycling of precious metals from scrap is an important source of input material for the EU industry.

Waste recovery

Collection and sorting
Europe has a number of companies specialising in the collection, pre-processing and trading of scrap and waste materials, e.g. discarded printed circuit boards, obsolete computers, old photographic film, X-ray plates and solutions, spent electro-plating baths etc.

Pre-treatment and recovery technologies
The recycling of gold, silver and platinum-group metals in the EU takes place either at the specialised precious metal refining and fabricating companies or at base metal refineries. The process details depend on the proportion of metals that are present. Pyro-metallurgical or hydro-metallurgical routes are used and solvent extraction stages are incorporated in some cases.

Most of the precious metals are fairly easily fabricated either as pure metals or as alloys. Gold in particular is usually turned into specific alloys for jewellery or dental purposes in order to improve its wear-resistance or colour. Because of the high intrinsic value and the wide range of forms and alloys required, such metals are usually fabricated or processed in relatively small quantities compared to the quantities of base metals. One of the few precious metal products manufactured in tonnage is silver nitrate for the photographic industry.

Preconditions and technical limitations
Precious metals, like most metals, can be recovered any number of times without loss of quality. There is, however, a technical limitation regarding the catalysts used in the process. They have to be discarded when they cannot be regenerated to at least 75 % of their original activity level. When discarding these catalysts, a small amount of the precious metals gets lost.

Alternative management
Recycling has become necessary because the tolerable amount of metal content of waste materials for discarding has been restricted.

Environmental and health issues related to waste management

Key issues
There are numerous ways of limiting and avoiding emissions from recovery processes that are well-developed and in use. Therefore, no environmental implications from precious metal processing have been documented.

Precious metals themselves can be poisonous in compounds, but they are not dangerous as pure metals.

Waste recovery process
Emissions to the air:

- Sulphur dioxide. These gases are formed from the combustion of sulphur contained in the raw material or the fuel or are produced from acid digestion stages.
- Oxides of nitrogen and other nitrogen compounds. They are produced to a certain extent during combustion processes and in significant amounts during acid digestion using nitric acid.
- Dust, metals and their compounds. These are generally emitted from incinerators, furnaces and cupels as fugitive or as collected and abated emissions.
- Chlorine and HCl. These gases can be formed during a number of digestion, electrolytic and purification processes. Chlorine is recovered for re-use whenever possible. The presence of chlorine in wastewater can lead to the formation of organic chlorine compounds if solvents etc. are also present in a mixed wastewater.
- Ammonia and ammonium chloride
- VOCs and dioxins. VOCs can be emitted from solvent extraction processes. The organic carbon compounds that can be emitted from smelting stages may include dioxins resulting from the poor combustion of oil and plastic in the feed material and from de-nuovo synthesis if the gases are not cooled rapidly enough.

Emissions to water:

Pyro-metallurgical and hydro-metallurgical processes use significant quantities of cooling water. Liquors from leaching cycles are normally re-circulated in sealed systems. Suspended solids, metal compounds and oils can be emitted into the water from these sources.

Market

Precious metalsindustry
European demand for precious metals is high. The demand for precious metals is driven not only by their industrial use and private demand as valuable items, but also influenced by their role as investments and reserve.

Consumption of gold in the EU is mainly for jewellery, with smaller amounts used in electronics and other industrial and decorative applications. The principal users of silver are the photographic and jewellery industries. The platinum-group metals are used extensively as catalysts, and the imposition of strict emission limits on vehicles sold in the EU has stimulated demand for their use in catalytic converters. Other principal uses are in chemicals, dentistry and investment such as coinage.

The global gold supply in 2005 was around 3,997 tonnes and the silver supply 25,852 tonnes.

Table 26: World supply of selected precious metals in 2005

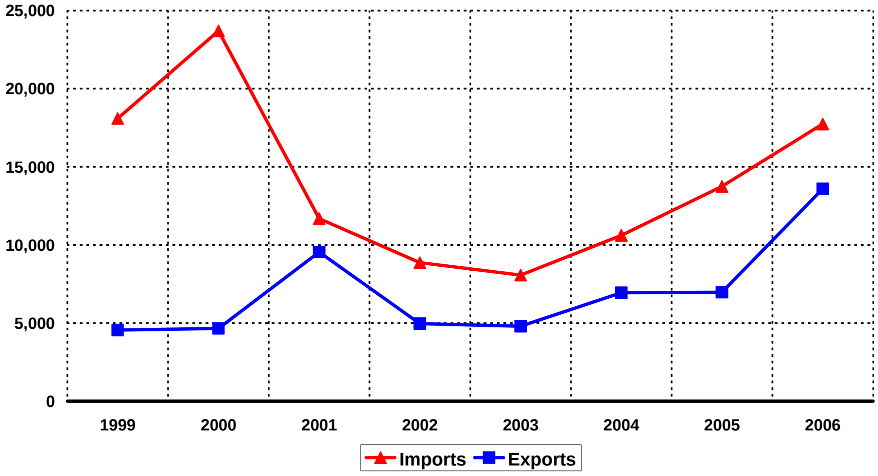
	mine production	scrap	other sources	total supply
gold	2 494	840	663	3 997
silver	18 189	5 310	2 353	25 852
platinum	188	23	0	211
palladium	196	18	0	214

Sources: Gold Fields Mineral Service – Gold survey 2005, Update 2,
The Silver Institute - World silver survey 2006,
Gold Fields Mineral Service – Platinum & Palladium Survey 2007.

The most important gold producer is South Africa with about 50 % of all gold produced. Other major producers are the USA, Australia, China, Russia, and Peru.
In 2005, Peru was the top producer of silver with almost one-seventh of the world share, closely followed by Mexico. Other major producers are Australia, China, Poland, and Canada.

In 2006, the EU 27 exported nearly 13,600 tonnes of precious metals. On the other hand the EU 27 has imported 17,744 tonnes in 2006.

Figure 120: EU 27 precious metal waste and scrap trade 1999 - 2006 (tonnes)



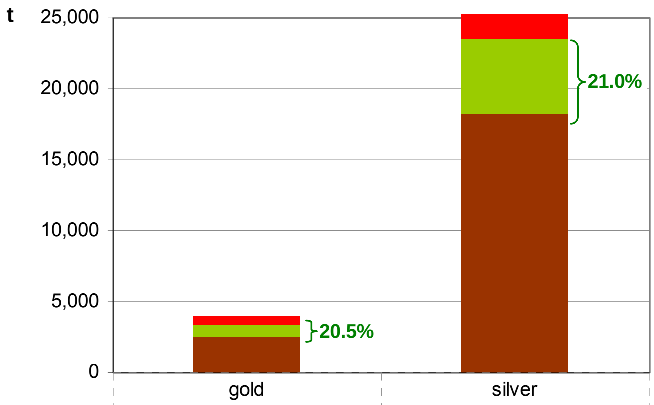
Source: COMEXT

The main importer is the USA with 36 % in 2006.

At the same time, most of the exports also go to the USA and Canada.
Recycling market

The amount of recovered of precious metals has increased. The share of scrap in the total supply amounts to 21% for gold and 20.5 % for silver. For other precious metals the share is much smaller with approx. 10 % for platinum and 8.5 % for palladium (2005).

Figure 121: Share of silver and gold scrap within silver and gold supply



	gold	silver
other sources	663	2,353
scrap	840	5,310
mine production	2,494	18,189

Sources: Gold Fields Mineral Service – Gold survey 2005,
Update 2 The Silver Institute - World silver survey 2006

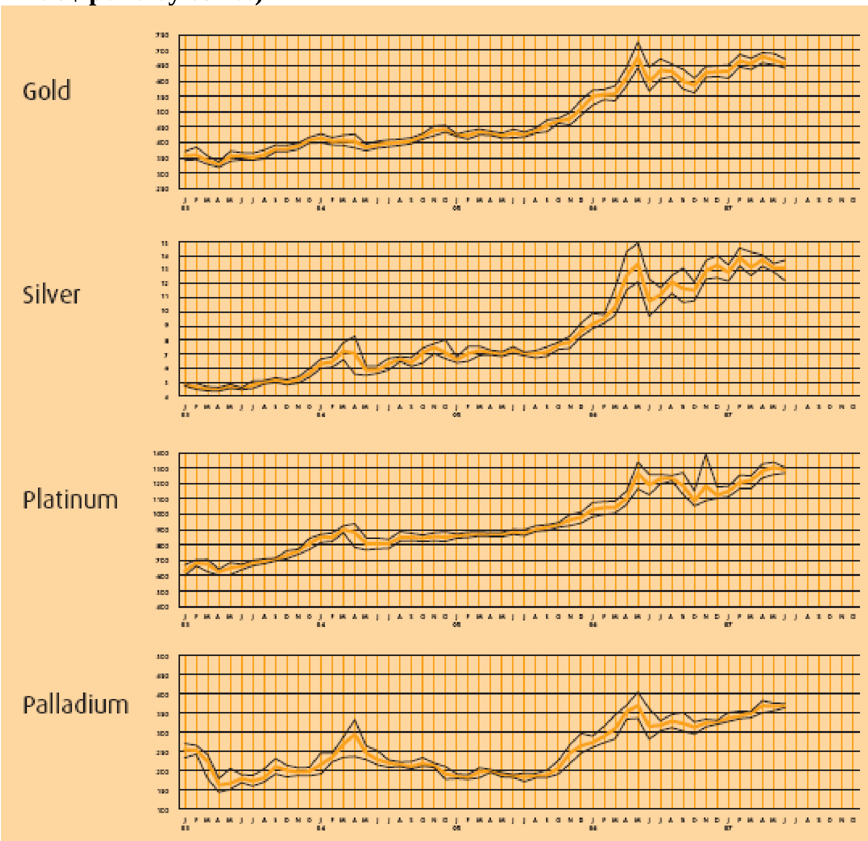
In Europe, the amount of platinum recovered has quadrupled over the last five years. This is driven mainly by automobile industry where the demand for catalyst equipment has doubled since 1999.

A similar trend can be observed for palladium. However, most recently and in contrary to platinum, the auto catalyst demand for palladium is decreasing due to substitutions by other materials. Instead, the demand for uses in electronic and other industry is increasing.

Market prices

The price development for precious metals shows an abrupt rise in the mid- 2006. It is expected that prices for all precious metals will rise further in the near future.

Figure 122: Fluctuations of the London Fixings for precious metals since 2003 (monthly averages, highs and lows in US$ per troy ounce)



Source: umicore – Precious Metals Market Report, 2th quarter 2007

7.12.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream precious metals. As different statistical data sources were used, the equivalent waste groups on a EWC-STAT-basis were identified according to the official equivalence table.

Table 27: Waste sources for the waste stream precious metals

*Grouping***	EWC	Waste Description	Hazardous	EWC-STAT**	Waste Description	Hazardous
I	090104*	fixer solutions	☠	**01.2**	Acid, alkaline or saline wastes	
	090105*	bleach solutions and bleach fixer solutions	☠			
	090101*	water-based developer and activator solutions	☠			

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
	090103*	solvent-based developer solutions	☠			
	160801*	spent catalysts containing gold, silver, rhenium, rhodium, palladium, iridium or platinum (except 16 08 07)		**01.4**	Spent chemical catalysts	
	090113*	aqueous liquid waste from on-site reclamation of silver other than those mentioned in 09 01 06	☠	**03.1**	Chemical deposits and residues	
	090106*	wastes containing silver from on-site treatment of photographic wastes	☠	**06.2 ******	Non-ferrous metal waste and scrap	
	160118*	non-ferrous metal		**06.3 ******	Mixed metal wastes	
II	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
	160211*	discarded equipment containing chlorofluorocarbons, HCFC, HFC	☠	**08.2**	Discarded electrical and electronic equipment	☠/⚐
	160213*	discarded equipment containing hazardous components other than those mentioned in 16 02 09 to 16 02 12	☠			
	160214*	discarded equipment other than those mentioned in 16 02 09 to 16 02 13				
	200135*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components	☠			
	200136*	discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35				
III	160605*	other batteries and accumulators		**08.4 *******	Discarded machines and equipment components	☠/⚐
	200133*	batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries	☠			
	200134*	batteries and accumulators other than those mentioned in 20 01 33				
IV	160215*	hazardous components removed from discarded equipment	☠	**08.4 *******	Discarded machines and equipment components	☠/⚐
	160216*	components removed from discarded equipment other than those mentioned in 16 02 15				
I	090107*	photographic film and paper containing silver or silver compounds				
	090108*	photographic film and paper free of silver or silver compounds				

☠ Hazardous waste fraction

☠/⚐ As well as hazardous and non-hazardous fractions

* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered precious metal waste amounts where estimated as described in Sources of data collection.

** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of precious metal waste is necessary. The considered precious metal waste amounts where estimated as described in the Introduction.

*** Allocation of waste stream sources to the sources group in the flow sheet

- I Production and industrial sources
- II End-of-life-vehicles and discarded equipment (including codes 200135 and 200136 from MSW)
- III Batteries and accumulator waste (including code 200133 from MSW)
- IV Discarded machines

**** Data available only for the aggregated group “06”

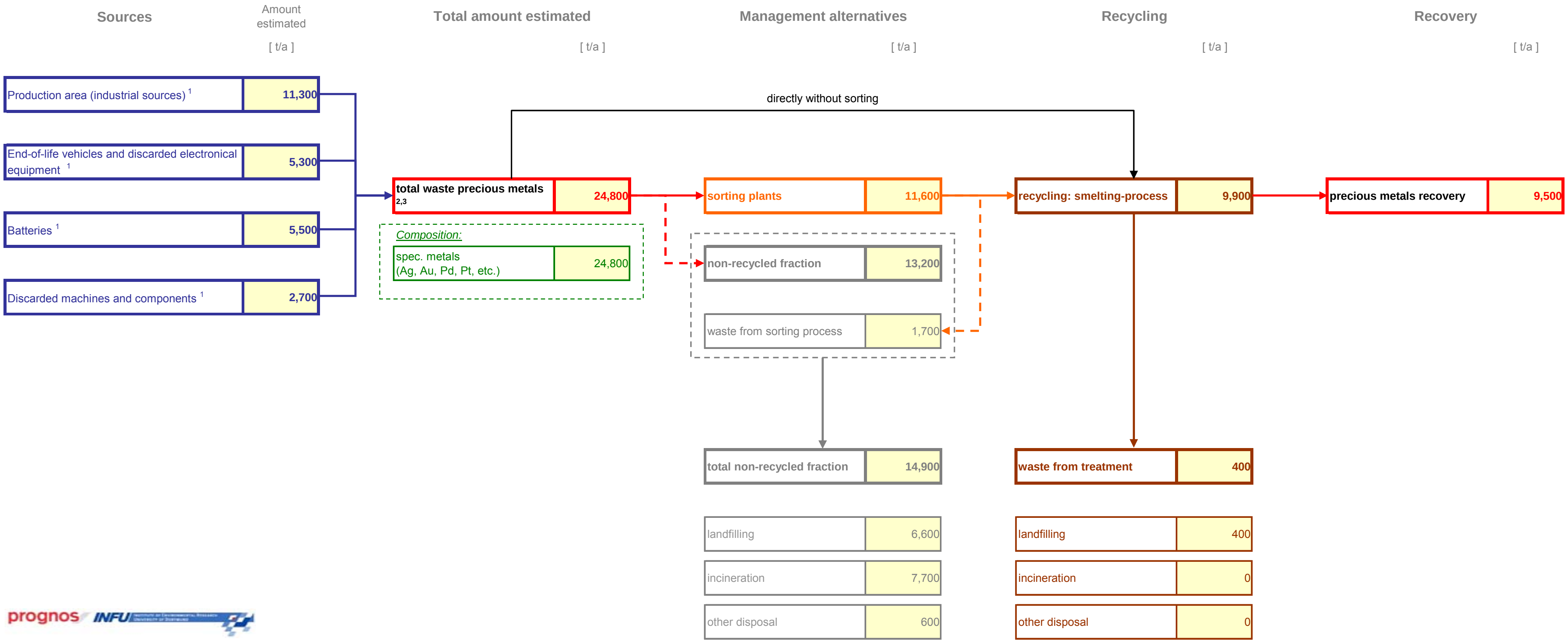
*****Data for codes 160605, 200133 and 200134 available as group “08.41”

******Data available only for the aggregated group “08 not 08.1 and 08.41”

7.12.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream precious metals could be compiled.

Figure 123: Estimation of precious metals waste flow (all figures rounded to hundreds)

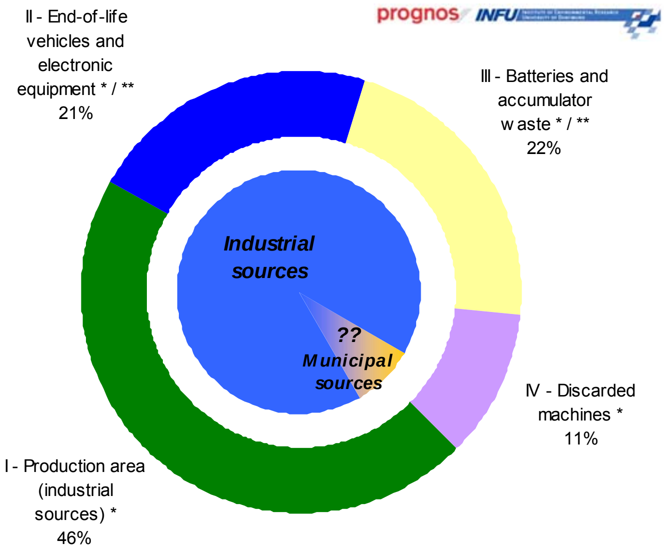


Notes related to the flow sheet:
1. Sorting or separation from these mixed wastes is necessary.
2. Data for Portugal is available only for batteries (08.41); data for Latvia is also incomplete.

The main sources for precious metals waste as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations.

In total, the amount of precious metal waste generated in the EU 27 was 24,800 tonnes in 2004. The share of precious metals potentials from MSW can not be estimated.

Figure 124: Estimated precious metals waste generation by sources



* please also refer to notes on Table 27 and Figure 123
** includes waste fractions from MSW

The amount of precious metals waste collected separately or collected and then separated in sorting plants with the objective of recycling [94] was estimated at 11,600 tonnes in 2004. Taking into account various losses during the sorting process, about 9,900 tonnes of precious metals waste were returned to precious metals manufacturing industry for recycling. Considering further losses during the recycling processes, the total recovery of precious metals waste amounted to about 9,500 tonnes in 2004.

Due to small volumes and missing additional information on country level, a country specific estimation for precious metals management alternatives is not possible. For the EU 27 it can be roughly estimated, that approx. 40 % of precious metals are recycled, about 30 % are landfilled, and a further 30 % incinerated.

[94] Total precious metals waste generated less directly disposed precious metals waste fractions.

7.13 Other metals

Main findings:

- The amount of other metal waste generated in the EU 27 can be estimated at 1.0 Mt in 2004.
- Of these, an estimated 0.4 Mt were recycled in other metals smelting processes (40%)
- Generally, metals under this group can be recycled any number of time without quality-loss.
- The metals are traded globally but in small quantity. The demand is increasing, especially from Asia. Prices are volatile.

7.13.1 Characterisation of the waste stream

Overview

General characteristics
'Other metals' in the context of this report are: cadmium, mercury, refractory metals, ferro-alloys, alkali and alkaline earth metals, nickel, and cobalt.

The main uses of cadmium today are: electroplated cadmium coatings, nickel-cadmium batteries, some pigments and stabilisers for plastics, alloys for solders, in fire protection, for control rods in nuclear reactors, for electrical conductors.

Sources of mercury are the ores and concentrates of other metals such as copper, lead and zinc etc. Mercury is produced from the purification of gases emitted during the production of these metals. Mercury is further recovered from secondary materials such as dental amalgam and batteries, and it is also obtained from the refining of oil.

Ferro-alloys are master alloys containing some iron and one or more non-ferrous metals as alloying elements. Ferro-alloys enable alloying elements such as chromium, silicon, manganese, vanadium, molybdenum etc. to be safely and economically introduced into metallurgical processes, thus giving certain desirable properties to the alloyed metal, for instance an increased corrosion resistance, hardness or wear resistance. Their importance grew with the advance of steel metallurgy, e.g. more diversified alloying elements, in better controlled quantities, in purer steel. The ferro-alloy industry became a key supplier to the steel industry.

The great importance of nickel lies in its ability as alloy element to increase various desirable properties of the alloying metal, e.g. strength, toughness and corrosion resistance over a wide temperature range. Nickel is therefore an extremely important commercial element. Given these beneficial properties, nickel is used in a wide variety of products. One of the most important applications is to make stainless steel. Other uses include electroplating, foundries, catalysts, batteries, coinage, and miscellaneous other applications. Therefore, at the end use level, nickel is found in transportation products, electronic equipment, chemicals, construction materials, petroleum products, aerospace equipment, durable consumer goods, paints, and ceramics.

Cobalt is used as alloying element to create alloys including super alloys for aircraft engines, magnetic alloys for powerful permanent magnets, hard metal alloys for cutting tool materials, cemented carbides, wear or corrosion resistant alloys, and electro-deposited alloys to provide wear and corrosion resistant metal coatings. Its use in rechargeable batteries has been a fast growing application over the last few years. Cobalt chemicals are used as pigments in the glass, ceramics, and paint industries, as catalysts in the petroleum industry, as paint dryers, and as trace metal additives for agricultural and medical products.

Refractory metals are heat and corrosion resistant and therefore are applied as coatings for materials and structures. Refractory metals are: W, Mo, Nb, Ta, Re.

The alkali metals found in group 1 of the periodic table are very reactive metals that do not occur freely in nature. Most of the alkali metals are softer than other metals. The alkali metals are: Li, Na, K, Rb, Cs, Fr. Sodium hydroxide, chloride and carbonate are among the most important industrial chemicals associated with this group. Sodium hydroxide is produced by the electrolysis of saturated brine in a cell with steel cathodes and titanium anodes. Sodium carbonate is made by the Solvay Process, in which soluble sodium chloride is converted into insoluble sodium hydrogen carbonate and filtered off, then heated to produce the carbonate.

Alkaline earth metals are also very reactive and therefore do not occur freely in nature. Alkaline earth metals are: Be, Mg, Ca, Sr, Ba, Ra. Magnesium is the only group 2 element used on a large scale. It is used in flares, tracer bullets and incendiary bombs as it burns with a brilliant white light. It is also an alloy element to aluminium to produce a low-density and strong material used in aircraft. Magnesium oxide has such a high melting point that it is used to line furnaces.

Waste recovery

Collection and sorting

Nickel-cadmium batteries are virtually 100 % recyclable once they have been collected. Today, there are 9 major NiCd battery recycling plants located in the United States, Europe and Japan capable of recycling approximately 20,000 Mt of industrial and consumer NiCd batteries and their manufacturing scraps. This is more than adequate capacity to recycle all NiCd batteries presently being collected. National Collection and Recycling Associations (NCRAs) have been created around the world to promote the collection and recycling of all batteries, both from the general public and from industrial consumers. Some of them focus on rechargeable batteries and on NiCd batteries in particular. Nickel-cadmium battery collection programs in Europe are now being organized and promoted by CollectNiCad (CNC) which maintains a complete listing of national collection organizations and recyclers throughout Europe.

Mercury is recovered from secondary materials such as dental amalgam and batteries, and it is also obtained from the refining of oil.

Ferro alloys can be recovered from scrap. This is most often the case for the iron share of the composition, which comes from iron and steel scrap; but also for the alloying element itself, titanium for example. Residues from steel mills like electric arc furnace and converter filter dust as well as shot blasting and grinding dust are important secondary raw materials with increasing significance.

The production of refractory metals from secondary raw material is normally based on hardmetal scrap and residues from other production processes like spent catalysts. 30 % of the world tungsten supply is produced from secondary raw materials. The tungsten industry is able to treat almost every kind of tungsten containing scrap and waste to recover tungsten and, if present, other valuable constituents.

Pre-treatment and recoverytechnologies

Recycling of cadmium takes place, but only very few companies take part. Mainly, used batteries are recycled to recover cadmium and Ni.

Recovery of cobalt from secondary sources can occur through the introduction of the recycled material at an appropriate stage in a primary refining or transformation process, depending on its technical and economical capabilities. Additional or pre-treatment steps may be necessary. The final products can be cathodes, powders, oxides, salts or solutions.

Most ferro alloy plants lose considerable amounts of metal in their slag and metal–slag mix. A potential source of income for alloy smelters are the massive reserves of metal contained in their slag dumps. Depending on the smelting process and the age of the slag dump, the metal contents vary between 3 % and 15 %.[95]

Secondary nickel units that arise in the first-use or fabrication stages of metal products can generally be recycled quickly and effectively within the industry. Technology exists and is widespread for handling all common arisings from nickel first-use and fabrication.

It is usual practice to recycle special alloys into the same special alloy wherever possible.

Mercury has to be separated from various appliances such as thermostats, lamps, switches, and batteries, before it can be purified and re-used in various industries.

Increased usage in the aerospace and electronics industries of refractory metals, titanium, and their alloys has led to the use of the HDH process for recycling spent materials. Gaseous hydrogenation of spent parts containing tantalum, niobium, vanadium, or titanium provides a process in which unwanted end use material can be converted to a crushed aggregate, including fine powder, and later degassed to provide clean material for new applications. Parts arriving in various forms, from sponge to waste clippings to ingots, require different reaction parameters in the vacuum furnace. The development of hydrogenation production cycles depends on the reaction kinetics of the particular metal or alloy and its starting configuration, as well as the degree of embrittlement desired. Economic dehydrogenation cycles require care in order to prevent product sintering and / or reaction with the work fixturing while removing the hydrogen to sufficient levels for end use.

Preconditions and technical limitations

Generally, recycled metals are not subject to quality-loss and can be re-used any given number of times.

Alternativemanagement

[95] R. Sripriya: Recovery of metal from slag/mixed metal generated in ferroalloy plants—a case study, International Journal of Mineral Processing Volume 75, Issues 1-2, 6 January.

The disposal of metals is regulated by the EU by restrictions concerning the amount of metals present in soil or water.

Environmental and health issues related to waste management

Key issues

Cadmium emissions arise from two major source categories: natural sources and man-made or anthropogenic sources. Emissions occur to the three major compartments of the environment - air, water and soil, but there may be considerable transfer between the three after initial deposition. Emissions to the air are considered more mobile than those into water which in turn are considered more mobile than those to soils.

There are strict EU regulations concerning the disposal of mercury, making recycling necessary.

Mercury is found in many rocks, including coal. When coal is burned, mercury is released into the environment. Coal-burning power plants are the largest human-caused source of mercury emissions to the air.

Refractory metals and their compounds are mostly not toxic. Some may cause irritation when inhaled.

Nickel is released into the air by power plants and trash incinerators. It will than settle to the ground or descend after reactions with raindrops. It usually takes a long time for nickel to be removed from the air. Nickel can also end up in surface water when it is a part of wastewater streams.

The main environmental issues associated with the production of non-ferrous metals from secondary raw materials are related to the off-gases from the various furnaces and transfers that contain dust, metals and – in some process steps – acid gases. There is also the potential for the formation of dioxins due to the presence of small amounts of chlorine in the secondary raw materials; the destruction and / or capture of dioxin and VOCs is an issue that is being pursued.

The toxicity of mercury and its compounds is a significant issue. Mercury in the environment can interact with various organic compounds to produce highly toxic organo-mercury compounds.
In the human body, cadmium accumulates mainly in the kidneys. At high levels, it can reach a critical threshold and can lead to kidney failure.

An uptake of certain quantities of nickel may have the following consequences:

- Higher risk of the development of lung cancer, nose cancer, larynx cancer, and prostate cancer
- Sickness and dizziness after exposure to nickel gas
- Lung embolism
- Respiratory failure

- Birth defects
- Asthma and chronic bronchitis
- Allergic reactions such as skin rashes, mainly from jewellery
- Heart disorders

Waste recovery process
For the production of ferro-alloys, alkali and alkaline earth metals, cadmium and mercury, nickel and cobalt: mercury vapour dust, metal compounds, VOCs (including dioxins), odours, CO, CO_2, SO_2, chlorine, other acid gases, wastewater (metal compounds), residues such as sludge, the iron rich residues, filter dust and slag.

Market

Other metals industry
Nickel

Nickel is traded globally as are most products which are fabricated from nickel. According to the International Nickel Study Group (INSG), the world's primary refined nickel production was 1.30 million tonnes in 2005, which increased to 1.36 million tonnes in 2006, and is forecast to be 1.48 million tonnes in 2007. Europe holds a share of 37 %, followed by America with 24 %.[96]

The world-wide primary nickel use (consumption) grew from 300,000 t in 1960 to 1.25 million tonnes in 2005, an average growth rate of 3.3 % per year. Asia accounted for 48 % of global primary nickel usage, followed by Europe with 35 %.[97] The main EU producers of nickel are Finland, the UK, Greece, and France.[98]

Between 2000 and 2005, the nickel usage in China increased by 130,000 tonnes. In 2006, the total worldwide primary nickel consumption increased to 1.36 Mt, and is forecast to reach 1.48 Mt in 2007.

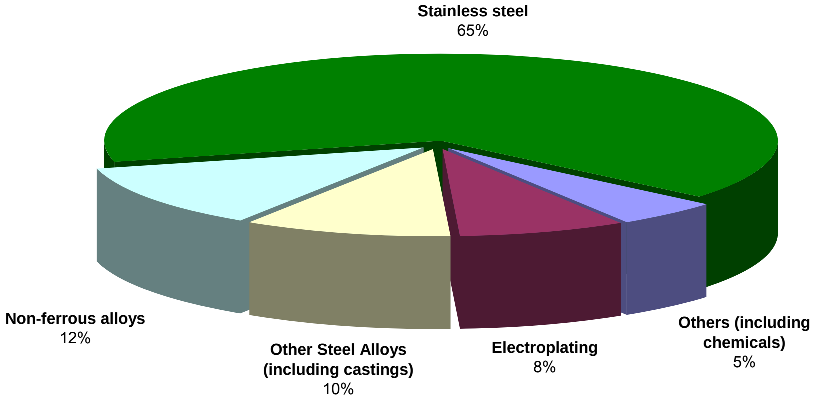
The production of stainless steel is the major use for nickel. Other main uses are non ferrous alloys, steel alloys, foundry, and plating. Nickel plating is a process used for example by the automotive industry, domestic appliances, and electronics. Products containing nickel are used for transportation, engineering, construction, tubular products, and other metal goods industries. More specific end uses are in dairy production, high precision replication technology, aircraft engines, and televisions.

[96] International Nickel Study Group (www.insg.org)

[97] International Nickel Study Group (www.insg.org)

[98] Commission of The European Communities, Analysis of economic indicators of the EU metals industry: the impact of raw materials and energy supply on competitiveness, 2006.

Figure 125: World main uses for nickel



Source: International Nickel Study Group (INSG)

Mercury

The global market for mercury is very limited.

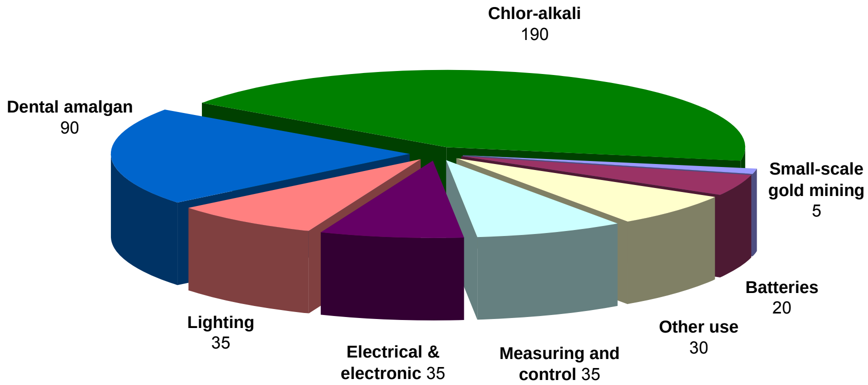
China is the top producer of mercury with almost two-thirds of the global share followed by Kyrgyzstan.

In 2005, the EU 25 supply of mercury amounted to 625 tonnes, about 17 % of the world supply. The main importers are Belgium, the Netherlands, France, Germany, and Spain. The share for each of the named countries, however. differs annually, so that there is no lasting conclusion.

The main exporters are Spain, followed by the Netherlands, Germany, and the UK.

Mercury is consumed in a broad range of products and processes.

Figure 126: EU 25 mercury consumption in 2005 (tonnes)



Source: European Commission, Mercury flows and safe storage of surplus mercury, 2006
[Note: Small-scale gold mining use of mercury in the EU appears to be restricted to French Guiana, formally part of the EU. By Prefectoral Decree of June 2004, the use of mercury for gold extraction was prohibited in French Guiana as of January 1, 2006.]

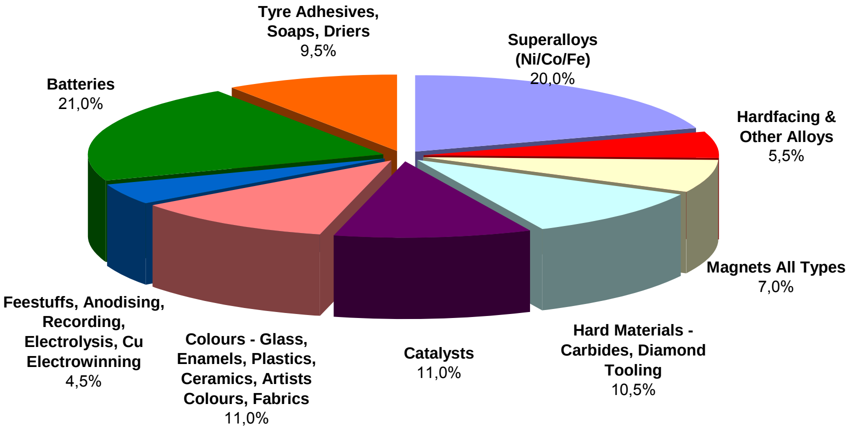
Cobalt

In 2005, according to the British Geological Survey the Democratic Republic of the Congo was the top producer of cobalt with almost 40 % of the world share followed by Canada, Zambia, Russia, Brazil, and Cuba,.

Between 1980 and the present day, world-wide refined cobalt production has more than doubled. Since 1980, several major changes in production have occurred. Production has moved from Africa to Europe and more recently to China. The European production of cobalt in 2005 came to a share of almost 31 % of the world-wide cobalt production.[99]

The major end-uses for cobalt are superalloys and batteries. As a result of the regeneration in the aerospace industry starting in 2002, superalloys represented 20 % of total consumption in 2005. Growth in the secondary battery market, particularly lithium-ion products, has caused the demand in this battery sector to rise rapidly.[100]

Figure 127: Main uses of cobalt



Source: Cobalt Development Institute (CDI)

Recycling market

<u>Nickel</u>

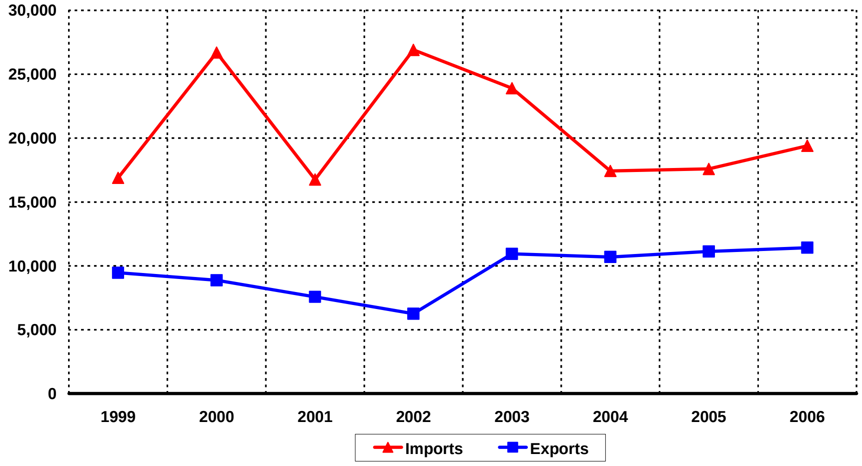
The nickel scrap processing industry consists of four or five major companies operating on an international level to ensure that nickel bearing scrap is collected on a big scale. Most of the scrap is stainless steel scrap, resulting from the demolition of obsolete factories, machinery and equipment and consumer goods.[101]

[99] The Cobalt Development Institute (CDI), Cobalt supply & demand 2005.

[100] www.roskill.com/reports/cobalt

[101] International Nickel Study Group

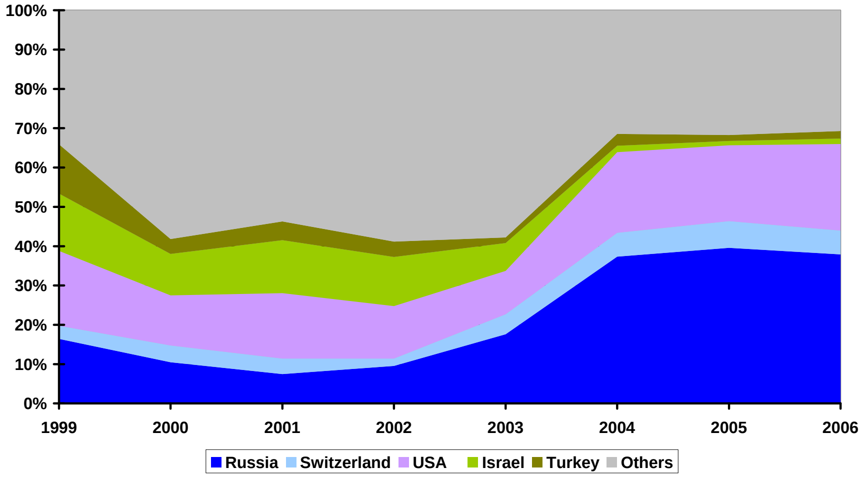
Figure 128: EU 27 nickel waste and scrap trade 1999 - 2006 (tonnes)



Source: COMEXT

Since 1999, EU 27 nickel scrap imports have been significantly exceeding exports. Over the 6 last years, imports have fluctuated with a drop of 36 % in 2001, a catch-up in 2002 followed by another drop of 36 % until today. Currently, a new increase is expected.

Figure 129: Share of EU 27 nickel waste and scrap imports 1999 - 2006 by origin

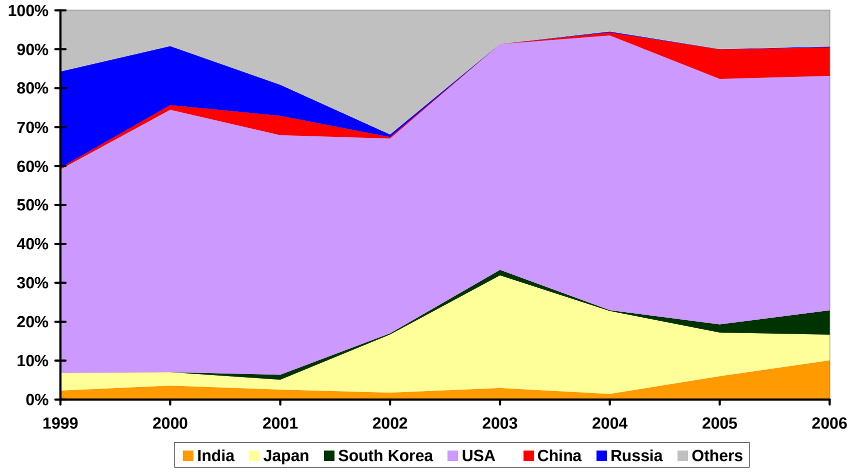


Source: COMEXT

In 1999, the two main suppliers of nickel scrap to the EU were the USA and Russia. Since then, Russia has more than doubled its exports to the EU and accounted for 38 % of total EU 27 imports in 2006.

The EU is a net importer of nickel scrap.

Figure 130: Share of EU 27 nickel waste and scrap exports 1999 - 2006 by destination



Source: COMEXT

Mercury

The small market for commodity mercury is characterized by a limited number of virgin mercury producers and a larger number of secondary mercury producers.

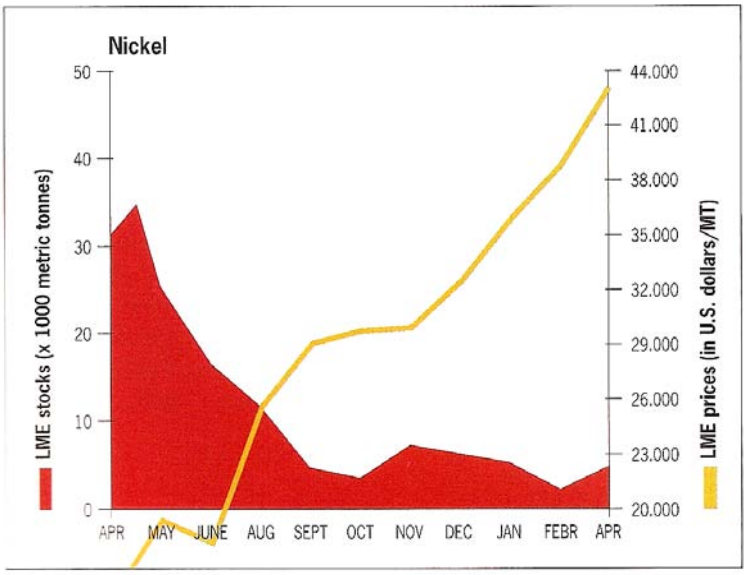
Market prices

Nickel

The price of nickel has fluctuated over the past decade. The development in Eastern Europe in the early 1990s led to substantially lower nickel demand; along with a massive de-stocking of nickel bearing materials this pushed exports to the West to an all-time high. In Europe, the nickel demand has been curbed by continuous high prices. Higher financing costs have also affected scrap companies.

The price for nickel on September 3rd, 2007, was 21,621 € per ton (London Metal Exchange).

Figure 131: Nickel price development 2004 - 2007

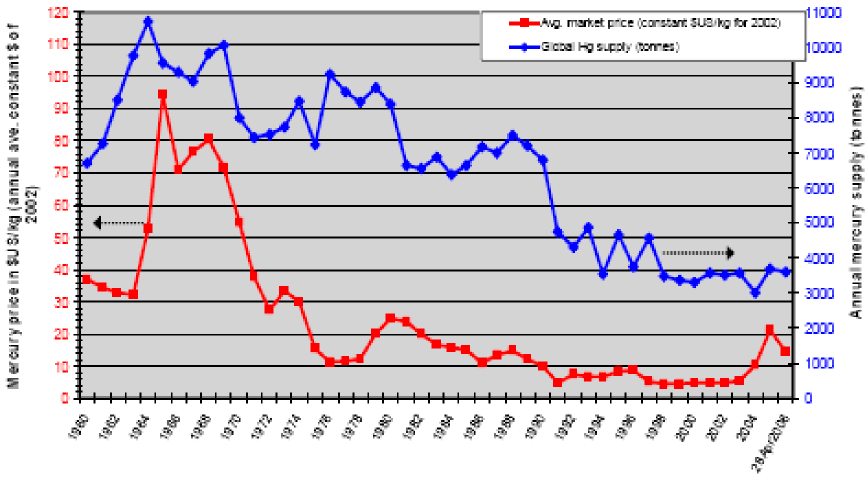


Source: Recycling International, No. 3, April 2007

<u>Mercury</u>

As the following figure shows, mercury prices have been on an overall downhill slide for most of the past 40 years. During the last 10 years they stabilized at their lowest levels before spiking up considerably from the middle of 2004.

Figure 132: Mercury supply vs. market price 1960 - 2006



Source: European Commission, Mercury flows and safe storage of surplus mercury, 2006

7.13.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream other metals. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 28: Waste sources for the waste stream other metals

*Group-ing***	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
II	160802*	spent catalysts containing dangerous transition metals or dangerous transition metal compounds	☠	**01.4**	Spent chemical catalysts	☠/⚐
	160803*	spent catalysts containing transition metals or transition metal compounds not otherwise specified				
	150104*	metallic packaging		**06.3** ****	Mixed metal wastes	☠/⚐
	020110*	waste metal				
	120103*	non-ferrous metal filings and turnings				
	120104*	non-ferrous metal filings and turnings				
	160118*	non-ferrous metal				
	170407*	mixed metals				
	170409*	metal waste contaminated with dangerous substances	☠			
	191002*	non-ferrous waste				
	191203*	non-ferrous metal				
	200140*	metals				
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
II	160602*	Ni-Cd batteries	☠	**08.4** *****	Discarded machines and equipment components	☠/⚐
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
III	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		**12.1** ******	Construction and demolition wastes	
IV	101010	flue-gas dust other than those mentioned in 10 10 09		**12.4**	Combustion wastes	

☠ Hazardous waste fraction

☠/⚐ As well as hazardous and non-hazardous fractions

* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered other metal waste amounts were estimated as described in Sources of data collection.

** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of other metal waste is necessary. The considered other metal waste amounts were estimated as described in the Introduction.

*** Allocation of waste stream sources to the sources group in the flow sheet

I Municipal solid waste (MSW) and bulky waste

II Mixed metallic packaging and other mixed metallic wastes (including separate collected fractions from MSW and separate recorded other metal waste from industry), end-of-life-vehicles, construction & demolition as well as treatment processes (as described in the table “waste sources”). For member states with EWC-6-digit-level data basis are considered only separate selected fraction 200140 and waste from treatment 191002 and 191203.

III Demolition and construction waste (including codes 170407and 170409 for member states with EWC-6-digit-level data basis)

IV Production and industrial sources (including codes 120103, 120104 and 150104 for member states with EWC-6-digit-level data basis).

V End-of-life-vehicles (including code 160118 for member states with EWC-6-digit-level data)

**** Data available only for the aggregated group “06”

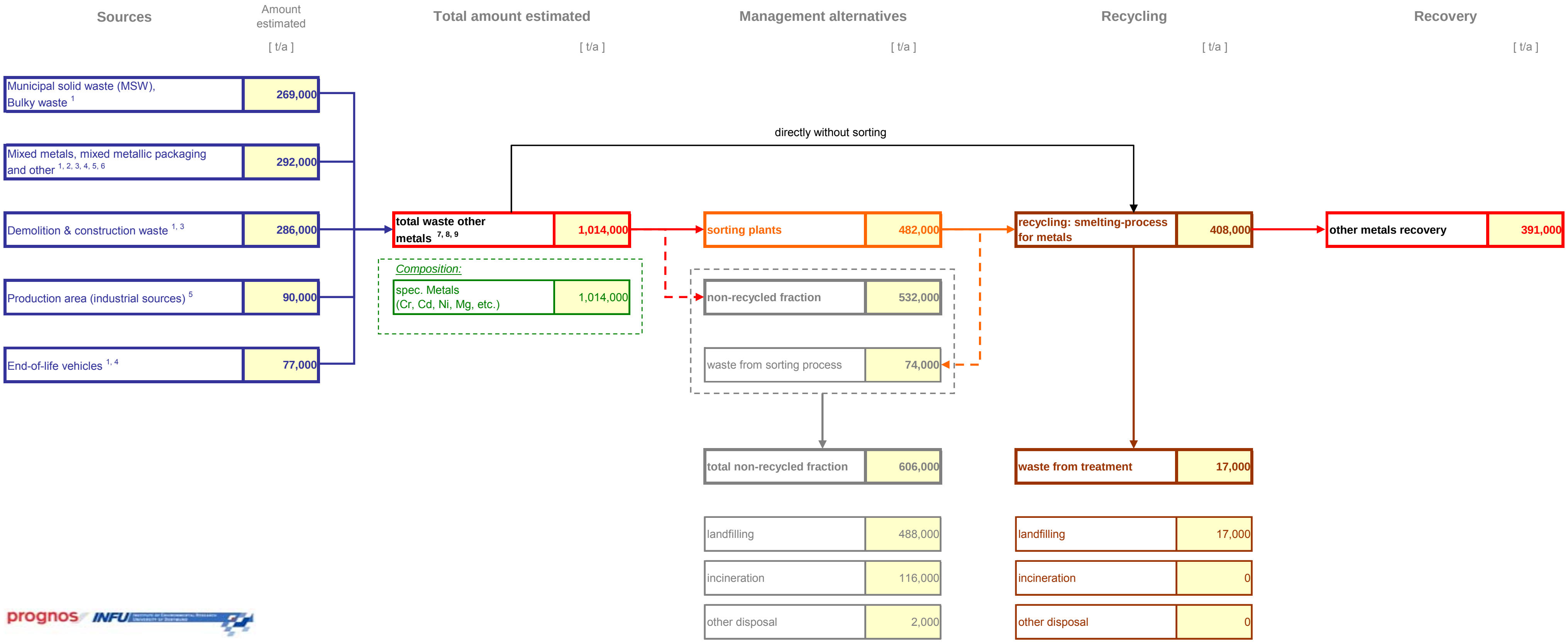
*****Data even available for the more specific group “08.41”

******Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.13.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream of other metals could be compiled.

Figure 133: Estimation of other metals waste flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "mixed metallic packaging and other mixed metallic wastes". Separate data is available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 9.0 Mt.
3. Other metal collected separately from construction & demolition waste (170407 and 170409) is included in the group "mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "construction & demolition waste".
4. Other metal recorded separately from end-of-life-vehicles (160118) is included in the group "mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "end-of-life-vehicles".
5. Other metal recorded separately from production and industry (120103, 120104 and 150104) is included in the group "mixed metallic packaging and other mixed metallic wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, it is allocated to the group "production and industrial sources". "Cycle scrap" is not included.
6. Includes also other metal waste from treatment processes, which are part of the aggregated group "mixed metallic packaging and other mixed metallic wastes". Separate data is available only for the member states with data basis on EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to approx. 5.0 Mt.
7. Data for Latvia reflects only municipal and commercial waste; no information is available for other economic sectors.
8. Data for Poland, Slovakia and Czech Republic is compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.
9. Data for Portugal is available only for MSW, all other figures are roughly estimated.

The main sources for other metal waste as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows:

Based on the use of at least two different data sources (EWC and EWC-STAT)

- Other metals waste collected separately from municipal solid waste is not reported separately, but included in the group "mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with EWC data basis.

- Other metals from construction and demolition sources cover several potentials. Separately collected fractions (170407 and 170409) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

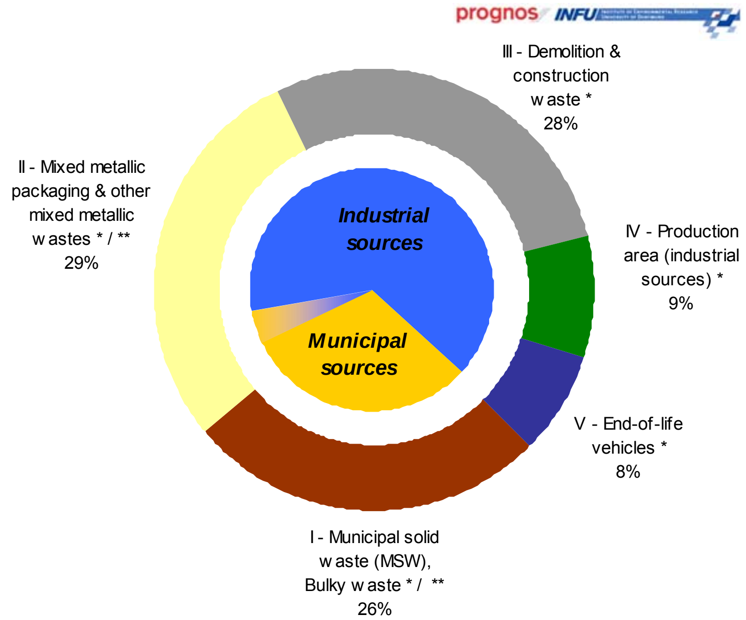
- Other metals from production and industry sources cover several potentials. Separately recorded fractions (120103, 120104 and 150104) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "mixed metallic packaging and other mixed metallic wastes", because an allocation is not possible due to the aggregated data basis.

- Other metals from end-of-life-vehicles cover several potentials. Separately collected fractions (160118) are only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "mixed metallic packaging and other mixed metallic wastes", as an allocation is not possible due to the aggregated data basis.

- Other metals from waste treatment processes is not reported separately, but also included in the group "mixed metallic packaging and other mixed metallic wastes", as separate data is only available for member states with an EWC data basis.

In total, the amount of other metal waste generated in the EU 27 was 1.0 Mt in 2004, of which 31 % -36 % is originated from MSW102.

Figure 134: Estimated other metals waste generation by sources



* please also refer to notes on

[102] No better estimates can be provided because the aggregated group "mixed metallic packaging and other mixed metallic wastes" includes other metal fractions from both MSW and from production and commercial sources.

Table 28 and Figure 133

** includes waste fractions from MSW

The amount of other metals waste collected separately or collected and then separated in sorting plants with the objective of recycling 103 was estimated at 0.48 Mt in 2004. Taking into account various losses during the sorting process, about 0.4 Mt of other metals waste were returned to manufacturing industry for recycling. Considering further losses within other metals recycling processes, the total recovery of other metals waste amounted to about 0.39 Mt in 2004.

Therefore, the estimated share of the other metal waste for recycling of the total estimated other metals waste generation (rate of recycling) was about 40 % at the level of the EU 27, also shown in

[103] Total other metals waste generated less directly disposed other metals waste fractions.

Figure 137.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 135. Sweden and Finland record the highest other metals waste recycling rate of more than 45 %.

Figure 135: Recycling potential in kg per capita (2004)

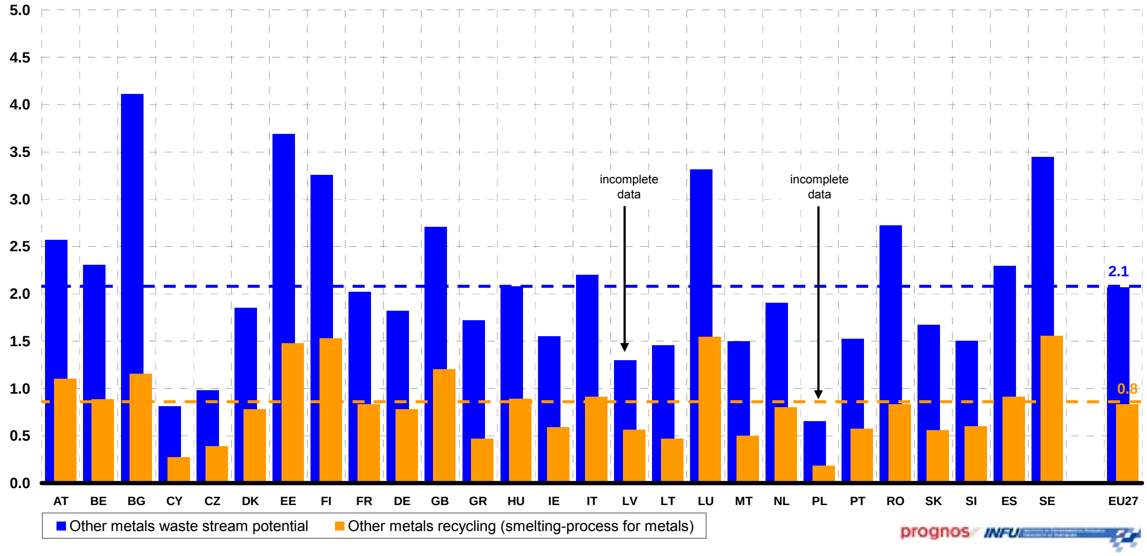


Figure 136 shows the estimated total amount of other metals waste by different waste management alternatives, and

Figure 137 presents the same but in percentage.

Figure 136: Management alternatives for other metals waste (in '000 tonnes)

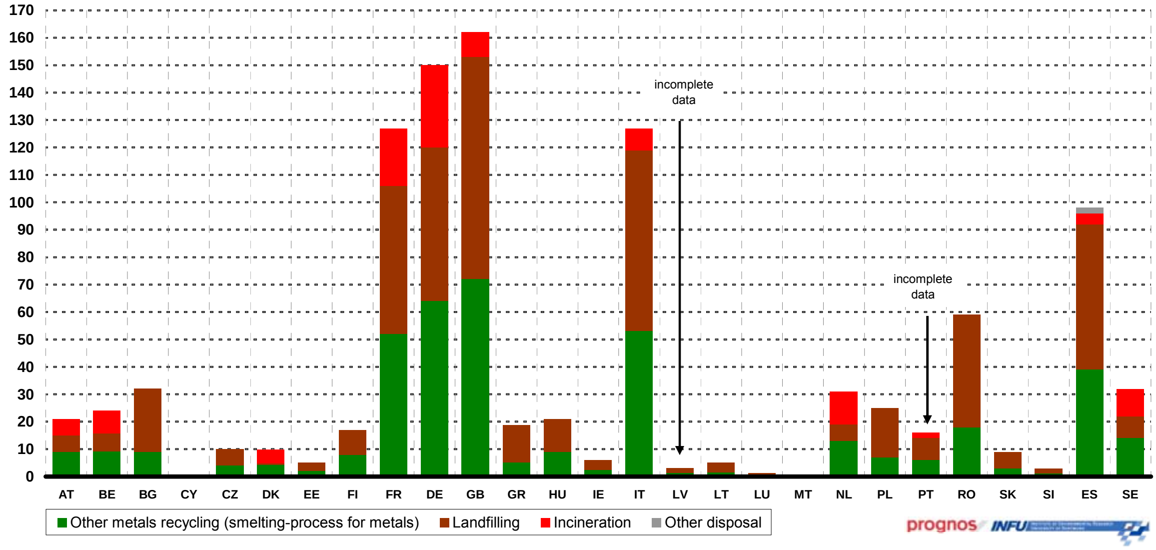
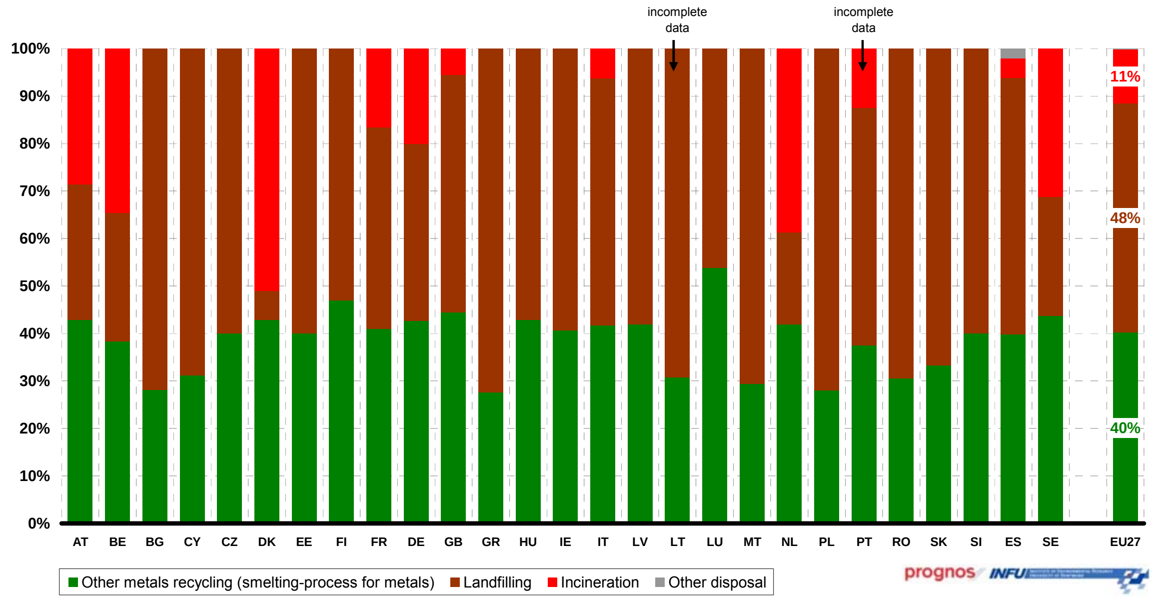


Figure 137: Estimated share of alternatives in other metals waste management (2004)



7.14 Biodegradable waste

Main findings:

- The amount of biodegradable waste generated in the EU 27 can be estimated at approx. 87.9 Mt in 2004.
- Of these, an estimated 33.8 Mt were composted or energy recovered.
- Over the past few years the recovery of biodegradable waste has become an important part of waste recovery within the EU. The management is influenced by several directives and comprehensive legislation of the EU.
- Green compost is accepted by the market all over Europe. Composted residues of fermentation can be returned into the humus and nutriment cycle.
- Alternatively, with different process technologies, electricity and heat can be produced using some of the biodegradable waste.

7.14.1 Characterisation of the waste stream

Overview

General characteristics
'Biowaste (biodegradable waste)' defines any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, paper and paperboard.[104]

Waste recovery

Collection and sorting
Collection schemes with the aim of collecting biowaste separately from other kinds of waste in order to prevent the contamination of biowaste with other polluting wastes, materials and substances are often in place.

Mixed collection schemes contain biodegradable waste of lesser quality (up to 40 to 50 % of MSW contains biodegradable waste).[105]

Pre-treatment and recovery technologies
<u>Anaerobic digestion (without oxygen):</u>

Anaerobic digesters produce conditions that encourage the natural breakdown of organic matter by bacteria in the absence of air.
Anaerobic digestion is suitable for sewage sludge, organic farm waste, municipal solid waste, green / botanical waste, organic industrial & commercial waste.

These wastes need to be pre-treated in several steps in order to achieve a suitable quality for digestion. First, different feedstock are mixed, then, after the addition of water, undesirable materials are removed and finally, particle sizes are uniformed. The applied pre-treatment-

[104] Reference: EC (2001): Working document. Biological treatment of biowaste. 2nd draft. Brussels.

[105] Marmo, L. (2002): Current management of biodegradable waste and future perspective. Bruessels, 8.-10. April 2002. http://ec.europa.eu/environment/waste/compost/presentations/marmo.pdf).

techniques are Hydropulper, manual sorting, rotating sieve drums or other type of screen to remove oversize items, and hammer mill for size reduction.

Digestion can be achieved with either a wet or a dry method. Dry digestion refers to mixtures which have a solid content of 30 % or greater, whereas wet digestion refers to mixtures of 15 % or less. No clear trend for either method is recognizable.emperature levels at which different digestion types take place are the

mesophilic digestion (with mesophile bacteria): 20-45°C, usually 35°C, and the thermophilic digestion (with thermophile bacteria): 50-65°C, usually 55°C.

Retention time for mesophilic digester is 15-30 days, for thermophilic digester: 12-14 days.

There are several technologies for sterilisation. Through athermophilic digester operation, the pre-treatment of substances at 70°C for 60min.or post-treatment of digestate at 60°C for 60min., and composting after digestate.

The Types of digestersare single stage, multi-stage and batch. The vastly appliedoperations are batch and continuous.

Batch is the simplest, with the biomass added to the reactor at the beginning and sealed for the duration of the process. In this continuous process, which is the more common type, organic matter is constantly added to the reactor and the end products are constantly removed, resulting in a much more constant production of biogas.

A standard type of digester is thesingle–stage low solid (SSLS), the single-stage high solid (SSHS),the multistage processes, batch process (single-stage system), sequential system, and up-flow anaerobic sludge blanket (UASB) reactor.

<u>Aerobic decomposition (with oxygen):</u>

Techniques:

- In the active or hot decomposition a process temperature of about 45-60°C, usually 55°C is set. A period of three or more days with temperatures higher than 55°C kills pathogens etc., faster and cleaner than anaerobic processes mostly used by industrial composting.
- In the passive or cold decomposition which is mostly used in domestic gardens, compost temperatures never reach over 30°C.There usually is a high moisture rate which enforces the risk of partially anaerobic decomposition.

Technologies:

- Windrow systems
- Windrow composting (55°C for two weeks with five turnings of the heap)
- Windrow composting (65°C for one week with two turnings of the heap)
- In-vessel composting (60°C for one week)
- Static pile systems
- Preconditions and technical limitationsSampling requirements:
- agronomic parameters
- heavy metals
- organic compounds

- Wastes separately collected and of good quality: Compost
- Wastes not separately collected and of lesser quality: stabilised biodegradable waste

Alternative management
Biodegradable waste can be incinerated in order to generate energy.

If biodegradable wastes are separately collected, they can be re-used (e.g. recovery for animal food, swill is used as forage).

Environmental and health issues related to waste management

Key issues
Measures shall be taken to minimise nuisances and hazards arising from the treatment plant through:

- emissions of dust,
- wind-blown materials,
- noise and traffic,
- birds, vermin and insects,
- formation of aerosols,
- odour and
- fires.

Biodegradable wastes contain hazardous matters such as pathogens, seeds, and transmissible spongiform encephalopathies (TSE).

The primary risk is the contamination of composts with pathogens. Therefore pre- or post-treatment like pasteurisation must be applied or the temperature-level within the pile reaches over 55°C for three or more days.

Impurities that are often to be found in composts are plastic and rubber, metal, glass and ceramic; sand and stones, and cellulosic materials.

Waste recovery process
A by-product of the composting process is a liquid (methanogenic digestate) that is rich in nutrients and can be an excellent fertilizer dependent on the quality of the material being digested. If the digested materials include low levels of toxic heavy metals or synthetic organic materials such as pesticides or PCBs, the effect of digestion is to significantly concentrate such materials in the digester liquor (further treatment is required).

Market

Biodegradable wastemarket
Biowaste treatment has been rapidly developing during the last years in nearly all European countries.

Biodegradable waste can be used as:

- compost or soil after composting,
- input material for biogas production, which can be used as fuel for electricity and heat generation, combined with the production of organic fertilisers (compost), and
- a fuel substitute (mainly bulky garden and park waste).

The main markets for compost products are:

- the agricultural sector,
- the landscaping sector,
- private gardens and homes,
- fruit and wine growing,
- nurseries and greenhouses.

Green compost is accepted by the markets all across Europe as an organic fertiliser and soil conditioner.

There is high competition between manufacturers and users of composts and producers of mineral and other fertilizer. Different quality specifications assure the quality of compost; however, these make market access difficult.

As mentioned the increasing demand of biomass for energy generation is leading to a positive market value for wood and wooden materials. Pellets or wood chips of bulky garden and park waste and comparable pellets generated from separated and dried biodegradable waste can substitute wood chips and shavings from the forest industry and shavings. These were previously used by the timber industry as well as for energy production, so that competition between the two industries was high. The introduction of biodegradable waste for energy generation thus decreases that competition to a certain extent.

Recycling market

Over the past few years the recovery of biowaste has become an important part of waste recovery within the EU. Organic fractions in the rest waste (grey bin) after separate collection is still considerable even in counties with established composting. According to the European Compost Network (ECN) it varies strongly and amounts between 20% to 30% (e.g. Sweden and Austria) and up to 40% to 50% in Belgium, The Netherlands and Germany.[106]

The management of biodegradable waste will be increasingly influenced by decisions and the legislation in Brussels, e.g.

- targets of the EU-Landfill Directive 1999/31/EC which commit all EU Member States to reduce the landfilling of biowaste, accompanied by a ban and a tax on waste to landfill and an increasing collection of separated organic materials (composting, fermentation),
- the EU-Sewage Sludge Directive 86/278/EEC that seeks to encourage the use of sewage sludge in agriculture and to regulate its use, the progressive implementation of the Urban Waste Water Treatment Directive 91/271/EEC in all Member States, that increases the quantities of sewage sludge requiring disposal, but also

[106] European Compost Network ECN/ORBIT e.V.: Status of organic waste recycling in the EU, 2006.

- the EU Directive 183/2005 laying down requirements for feed hygiene and the Soil Directive, which is expected to come into force in 2008, climate protection programmes as well as several standards and the implementation of quality assurance etc. ,
- the national and local waste planning by the municipalities and their engagement in the build up of separate collection systems

Separate collection schemes for biodegradable packaging and of food- and garden waste are already well established in Central Europe and are rapidly growing in different countries.[107]

In order to achieve the reduction targets of biodegradable municipal waste from landfilling until 2016 as defined in Art. 5 of the Landfill Directive, a combined set of measures and instruments is used, e.g.

- separate collection
- obligations for pre-treatment
- development of treatment capacity for biowaste like composting, MBT, anaerobic digestion

Disposal and treatment of bio waste will be influenced by:
- Tightening of hygienic rules for the production of animal feed as well as
- The growing promotion of bio energy production as a result of climate protection activities of several European countries.

The work of existing composting plants can be optimized by inserting fermentation at the beginning. The resulting heat and electricity can be put to further use. New composting plants focussing on biodegradable waste and waste of food preparation will spring up.

The fermentation of separately collected biodegradable waste or waste from food production is a cost-effective and efficient form of waste disposal. Composted residues of fermentation can be returned into the humus and nutriment cycle.

Simultaneously, fermentation will produce CO_2 neutral electricity and heat.

Market prices
he compost market shows several trends in Europe. Green compost is an organic fertiliser and soil conditioner accepted by the markets all over Europe. It can be produced in good quality without much technical equipment.

The compost market shows two contrary developments:

- Low price market for standard qualities

By means of the low or descreasing tipping fees, some of the composting plants try to minimise their treatment costs which mostly results in delivering the compost free of charges or very low prices to farmers (mass market). Customers are mainly organic farms, landfill cover, agriculture, wine and fruit, hobby gardens.

[107] A comprehensive evaluation of the status and application of the EU Landfill Directive on biodegradable municipal solid waste management and the reduction of these materials being landfilled is currently ongoing at EU level.

- High price market with additional specifications

On the other hand, a lot of composting plants start to add value to their compost products and produce mixtures or special products according to customer's needs and market requirements (high quality compost) with prices closely linked to the demand. They are supported by quality assurance organisations. Customers are for example sports turf, top sloil mix, landscaping, nurseries, and greenhouses.

The borderline between those two groups is evolving slowly with the development of marketing actions by compost producers, and with the increasing demand for soil organic matter.

The market for fibre fraction (anaerobic digestion) can be found in agriculture, forestry and ground rehabilitation, while the market for liquid fertiliser is dominated by agriculture.

7.14.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream biodegradable waste. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 29: Waste sources for the waste stream biodegradable waste

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
III	020102	animal-tissue waste		**09.1 ******	Waste of food preparation and products	
III	020103	plant-tissue waste		**09.1 *******	Waste of food preparation and products	
	020304	materials unsuitable for consumption or processing				
	020701	wastes from washing, cleaning and mechanical reduction of raw materials				
	020702	wastes from spirits distillation				
	020203	materials unsuitable for consumption or processing				
	020302	wastes from preserving agents				
	020501	materials unsuitable for consumption or processing				
	020601	materials unsuitable for consumption or processing				
	020704	materials unsuitable for consumption or processing				
	200108	biodegradable kitchen and canteen waste				
	200302	waste from markets				
II	200201	biodegradable waste		**09.2 *******	Green wastes	
III	020106	animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site		**09.3**	Slurry and manure	
I	200301 *	mixed municipal waste		**10.1**	Household and similar wastes	
III	020204	sludges from on-site effluent treatment		**11.1**	Waste water treatment sludges	

*Group-ing****	EWC	Waste Description	Hazar-dous	EWC-STAT**	Waste Description	Hazar-dous
	020305	sludges from on-site effluent treatment				
	020403	sludges from on-site effluent treatment				
	020502	sludges from on-site effluent treatment				
	020603	sludges from on-site effluent treatment				
	020705	sludges from on-site effluent treatment				
	030311	sludges from on-site effluent treatment other than those mentioned in 03 03 10				

* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered biodegradable waste amounts where estimated as described in Sources of data collection.

** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of biodegradable waste is necessary. The biodegradable waste amounts where estimated as described in the introduction.

*** Allocation of waste stream sources to the sources group in the flow sheet

I Municipal solid waste (MSW), (including codes 200108 and 200302 for member states with EWC-6-digit-level data basis)

II Green Wastes

III Production and industrial sources (including codes 200108 and 200302 (as described in the table “waste sources”) for member states with EWC-STAT data basis).

**** Data available separately for group “09.11”

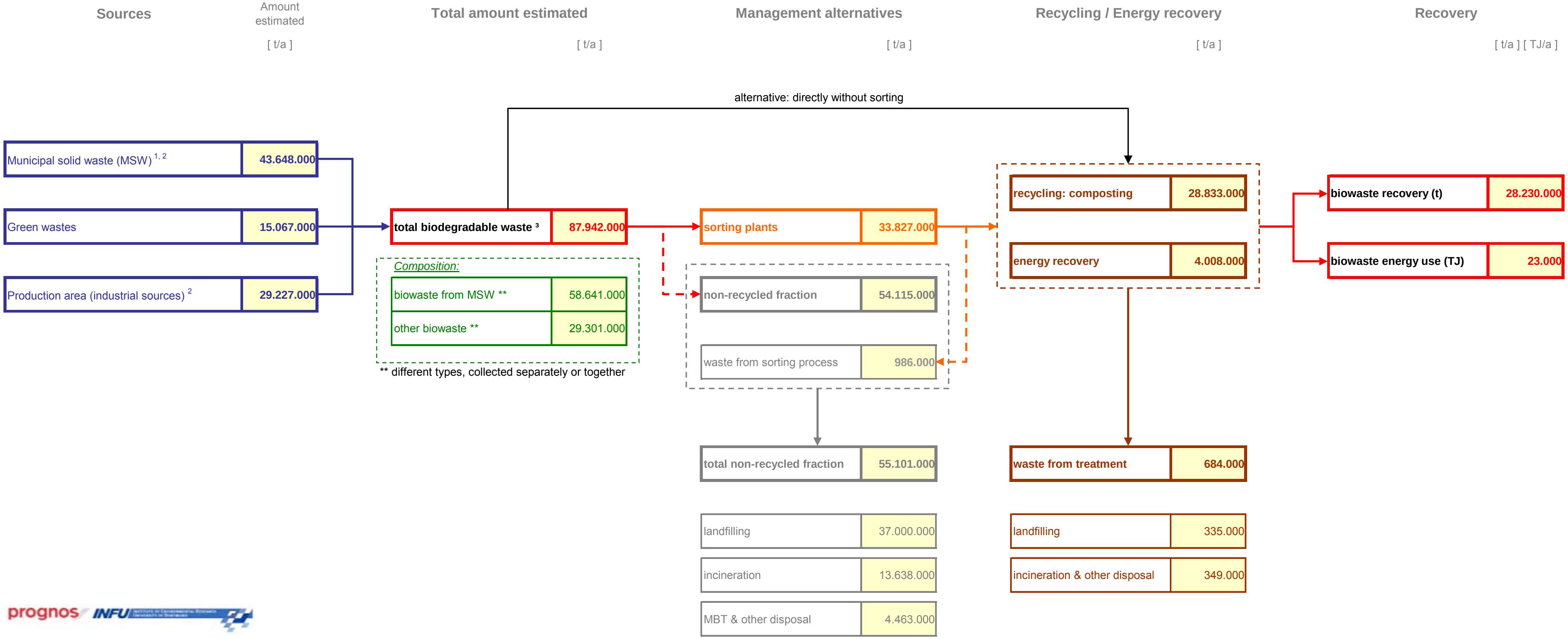
*****Data available only for the aggregated group “09 not 09.11 and 09.3”

******Data available only for the aggregated group “11 not 11.3”

7.14.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream biodegradable waste could be compiled.

Figure 138: Estimation of biodegradable waste flow (all figures rounded to thousands)

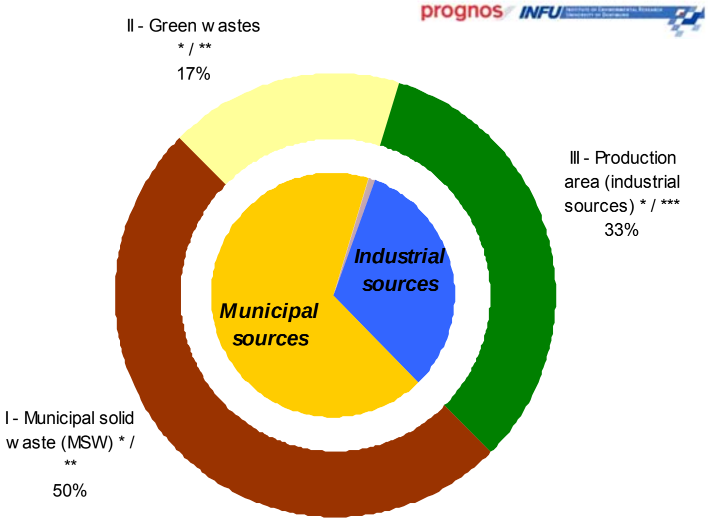


Notes related to the flow sheet:
1. Sorting or separation from these mixed wastes is necessary.
2. Biodegradable wastes recorded separately from production and industry including codes including codes 200108 and 200302, for member states with EWC-6-digit-level data basis these codes are included in MSW
3. Data for Latvia and Portugal only for municipal and commercial waste, no information available for other economic sectors.

The main sources for biodegradable waste as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation os a combined result of the collected data together with expert estimations.

In total, the amount of biodegradables (for the EU 27) was 87.9 Mt in 2004, of which 66 % - 68 % is originated from MSW.

Figure 139: Estimated biodegradable waste generation by sources



* please also refer to notes on Table 29 and Figure 138
** only waste fractions from municipal sources
*** includes waste fractions from MSW

The amount of biodegradable waste fraction collected separately or collected and then separated[108] was estimated at nearly 87.9 Mt in 2004. Taking into account various losses during the sorting process, about 32.8 Mt of biodegradable waste were returned to composting or energy recovery. Considering further losses during the biodegradable recycling processes, the total material recovery of biodegradable waste amounted to about 28.2 Mt in 2004; energy use amounted to approx. 23,000 TJ. The estimated share of biodegradable waste for recycling / energy recovery of the total biodegradable waste generation (rate of recycling) was about 37 % at the level of the EU 27, also shown in

[108] Total biodegradable waste generated less directly disposed biodegradable waste fractions.

Figure 142.

At country level the generation and rate of recycling differ from country to country as shown in

Figure 140. The Netherlands, Sweden and Germany record the highest biodegradable waste recycling rates of more than 50 %.

Figure 140: Recycling potential in kg per capita (2004)

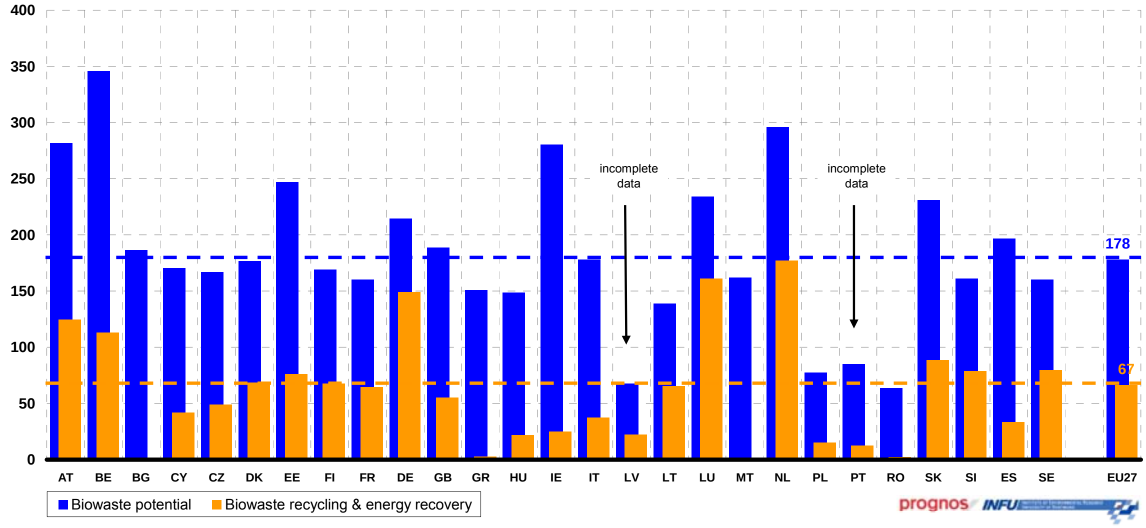


Figure 141 shows the estimated total amount of biodegradable waste potentials by different waste management alternatives, and

Figure 142 presents the same data but in percentage.

Figure 141: Management alternatives for biodegradable waste (in '000 tonnes)

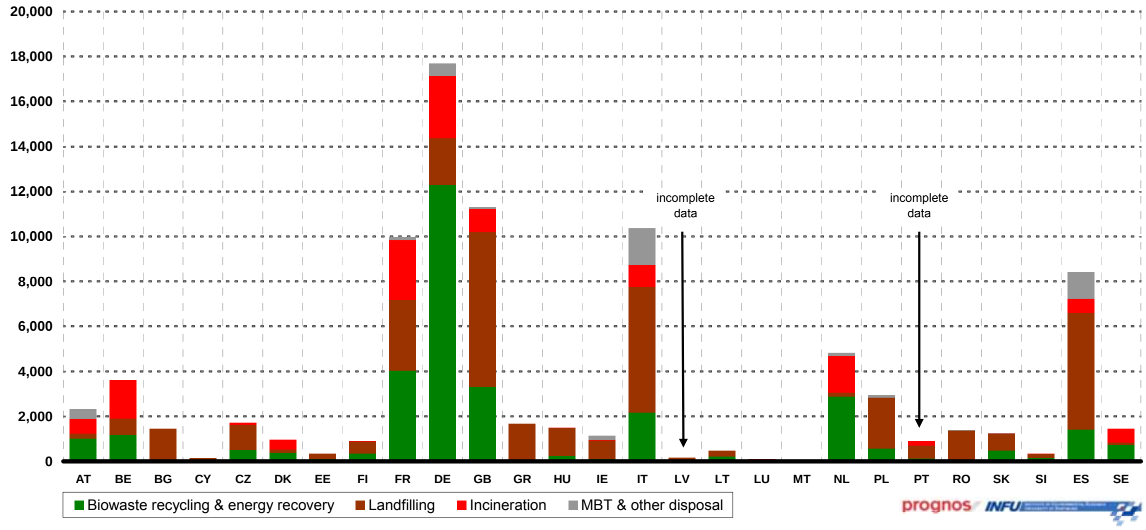
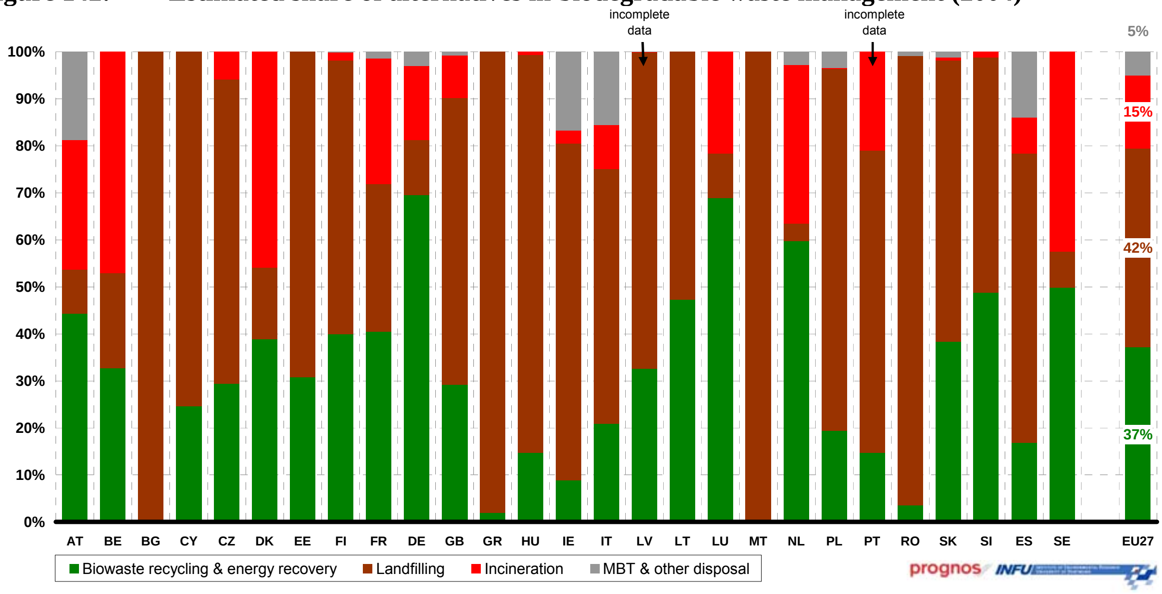


Figure 142: Estimated share of alternatives in biodegradable waste management (2004)



7.15 Solvents

Main findings:

- The amount of waste solvents generated in the EU 27 can be estimated at 1.6 Mt in 2004.
- Of these, an estimated 1.0 Mt was recycled or energy recovered (61 %).
- Solvents, solvent waste and still bottom are one of the main sources of hazardous waste.
- Prices for purified solvents are linked to world market prices for primary products (e.g. methanol). The prices are very volatile. Prices for energy recovery of solvents vary significantly depending on the calorific value and the quality of solvents in general.

7.15.1 Characterisation of the waste stream

Overview

General characteristics
Waste solvents are organic agents that are contaminated with suspended and dissolved solids, organics, water, other solvents, or any other substance not added to the solvent during its manufacture. Industrial processes that generate waste solvents include solvent refining, polymerisation processes, vegetable oil extraction, metallurgical operations, pharmaceutical manufacture, surface coating, and cleaning operations (dry cleaning and solvent degreasing). The amount of solvents recovered from these waste sources varies from about 40 to 99 %, depending on the extent and characterisation of the contamination and on the recovery process employed. The following solvents are normally recycled: aromatics (e.g. toluene, xylene), alcohols (e.g. Isopropanol, isopropyl alcohol), Ester (e.g. ethyl acetate), Ketones (e.g. Acetone), glycols (e.g. Methanol, Ethanol, MEG), organic acids and chlorinated hydrocarbons (e.g. Tetrachloroethene). Most of the solvents which are included in household products (e.g. paint thinners, cleaners) are incinerated and landfilled as household hazardous waste.

Waste recovery

Collection and sorting
At the industry sites, waste solvents are initially separated and collected through two possible processes: vapour recovery and mechanical separation. Vapour recovery entails the removal of solvent vapours by condensation, adsorption and absorption from a gas stream in preparation for further reclaiming operations. Condensation of solvent vapours is accomplished by water-cooled condensers and refrigeration units. Mechanical separation includes both removing water by decanting and removing undissolved solids by filtering, draining, settling, and / or centrifuging. A combination of initial treatment methods may be necessary to prepare waste solvents for further processing.

Pre-treatment and recovery technologies
Waste solvents are further distilled to remove dissolved impurities and to separate solvent mixtures. Separation of dissolved impurities is accomplished by thin film evaporators and

steam distillation. Mixed solvents are separated by multiple simple distillation methods, such as batch or continuous rectification. The still bottoms or residues remaining in the bottom of the still are then collected and disposed of. During purification, special additives renew the solvent. After distillation, water is removed from the solvent by decanting or drying with calcium chloride.

Preconditions and technical limitations
Wastes containing different solvents should not be mixed. For adequate recovery with condensers, a solvent vapour concentration well above 20 mg/m3 is required.

The technical feasibility of recycling waste solvents depends on their physical and chemical properties (clear solvent or blend) and on the characterisation of the contamination.

Alternative management
Most solvents are incinerated, but they can also be re-used by collecting them directly from the processes.

Environmental and health issues related to waste management

Key issues
Solvents, solvent waste and still bottom are a leading source of hazardous waste.

Waste recovery process
The recycling of solvents reduces air and water pollution and saves energy and primary material.

Explosion or fire hazard conditions have to be factored in when some materials are distilled. In combination with water, waste solvents can be corrosive.

Market

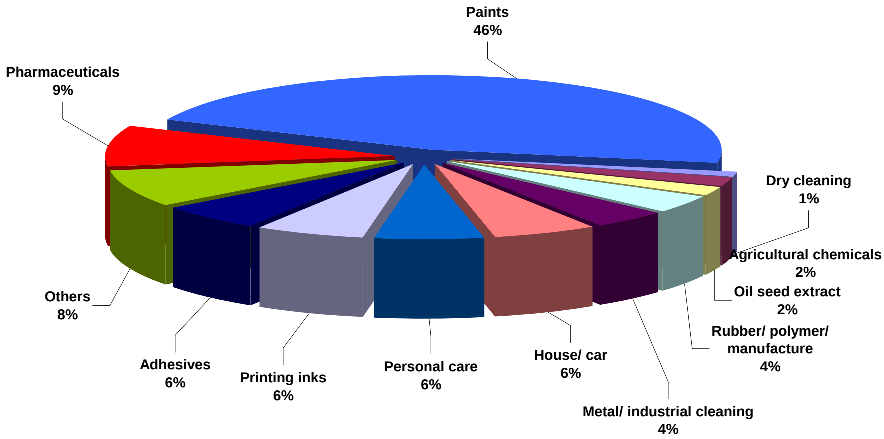
Solvents industry
Overall world demand for solvents is forecast to grow at less than 2.3 % in 2007 and approach 20 Mt. The main demand occurres in the Asia and Pacific region (32 %) followed by North America (24,8 %) and Western Europe (22,6 %)109

Solvents are used on the one hand in a wide variety of everyday applications, e.g. adhesives, printing inks, toiletries and cosmetics, and household and car care. They play a vital role in providing solutions to many of the challenges of modern life. There are many kinds of solvents with different physical and chemical properties. On the other hand important amounts of solvents are used also in the production of chemical intermediate or final products (pharmaceutical products, fine chemicals etc.). These solvents do not become part of the product and therefore are not included in the following described market segments.

[109] http://www.ceresana.com/html/losungsmittel.html

The largest demand for solvents in the user market comes from the paint and coatings industry. The pharmaceutical sector is a growing market showing a steady increase in demand year on year.

Figure 143: Uses of solvents



Source: European Solvent Industry Group (ESIG)

Recycling market

Most solvents in final products can not be recycled due to the volatilising nature of solvents. Therefore, sources of solvent waste are mainly industrial processes, where a large share of waste solvents can be purified and re-used. The remaining share will be energy recovered or treated and disposed of as hazardous waste.

Market prices

Prices for purified solvents are linked to world market prices for primary products (e.g. methanol). The prices are very volatile. The waste producer on the one hand incurs costs for the purification of solvents (including transport); on the other hand revenues for recycled solvents generate income. As a result, solvents have no positive market price. This situation may change in the near future.

Prices of solvents for energy recovery vary depending on the calorific value and the quality of solvents in general (e.g. contamination with chlorine). Prices range between 0 and 150 €/t. As opposed to that, disposal costs range considerably higher, between 150€ up to 1,000€ per tonne.

7.15.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream solvents. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 30: Waste sources for the waste stream solvents

Group -ing	EWC	Waste Description	Hazar -dous	EWC-STAT**	Waste Description	Hazar-dous
I	070103	organic halogenated solvents, washing liquids and mother liquors	☠	01.1	Spent solvents	☠
	070203	organic halogenated solvents, washing liquids and mother liquors	☠			
	070303	organic halogenated solvents, washing liquids and mother liquors	☠			
	070403	organic halogenated solvents, washing liquids and mother liquors	☠			
	070503	organic halogenated solvents, washing liquids and mother liquors	☠			
	070603	organic halogenated solvents, washing liquids and mother liquors	☠			
	070703	organic halogenated solvents, washing liquids and mother liquors	☠			
	140602	other halogenated solvents and solvent mixtures	☠			
	070104	other organic solvents, washing liquids and mother liquors	☠			
	070204	other organic solvents, washing liquids and mother liquors	☠			
	070304	other organic solvents, washing liquids and mother liquors	☠			
	070404	other organic solvents, washing liquids and mother liquors	☠			
	070504	other organic solvents, washing liquids and mother liquors	☠			
	070604	other organic solvents, washing liquids and mother liquors	☠			
	070704	other organic solvents, washing liquids and mother liquors	☠			
	140603	other solvents and solvent mixtures	☠			
	200113	solvents	☠			
II	040214	wastes from finishing containing organic solvents	☠	02.1***	Off-specification chemical wastes	☠/⚐
	040215	wastes from finishing other than those mentioned in 04 02 14				
	160113	brake fluids	☠			

☠ Hazardous waste fraction

☠/⚐ As well as hazardous and non-hazardous fractions.

* Solvents are hazardous waste, so data on EWC-6-digit-level are available also for Austria, Germany, Great Britain.

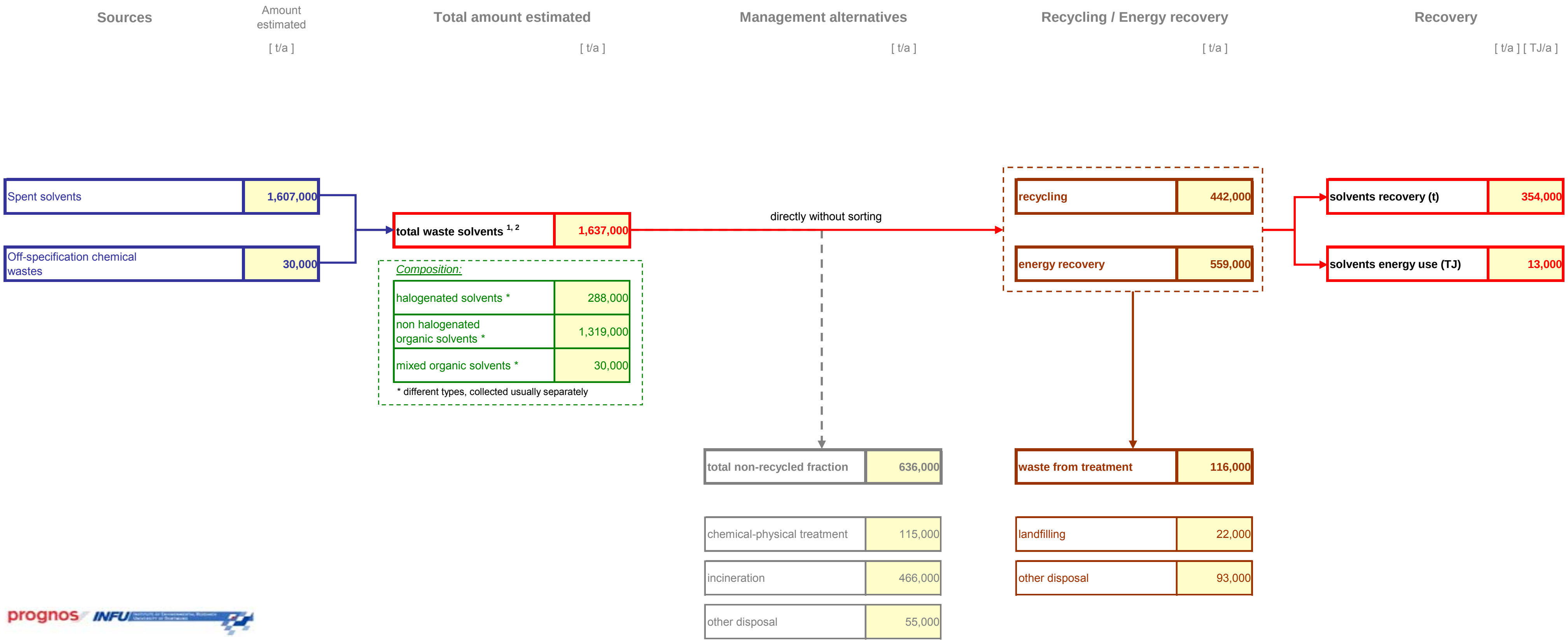
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of solvents waste is necessary. The considered solvents waste amounts were estimated as described in Sources of data collection.

*** Data available only for the aggregated group "02".

7.15.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream solvents could be compiled.

Figure 144: Estimation of solvents waste flow (all figures rounded to thousands)

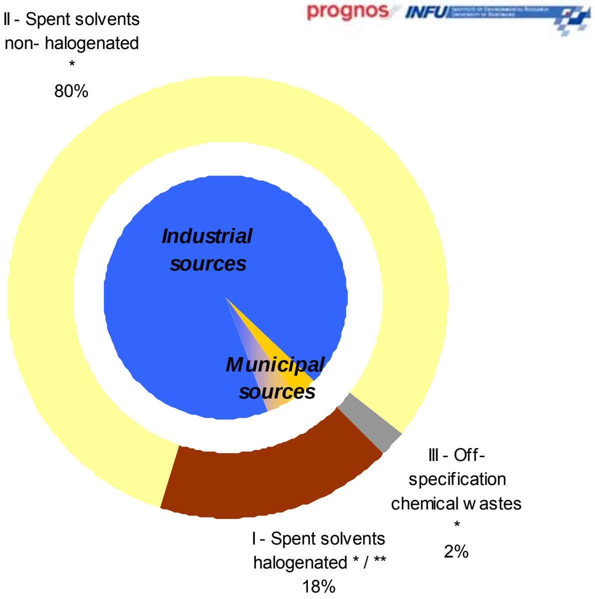


Notes related to the flow sheet:

1. As hazardous waste fraction data for solvents is available on EWC basis for CZ, HU, PL, LV, LU, SK, SI but also UK, DE, DK and EE.
2. Data for Portugal and Malta are not available. Data for Bulgaria, Greece, Latvia, Lithuania, Romania, and Slovakia is seemingly incomplete.

In total, the amount of solvents generated in the EU 27 was 1.6 Mt in 2004, of which 3 % - 7 % is originated from MSW.

Figure 145: Estimated solvents generation by sources



* please also refer to notes on Table 30 and Figure 144
** includes waste fractions from MSW

The amount of solvents collected separately or collected and then separated in sorting plants with the objective of recycling or energy recovery [110] was estimated at 1.0 Mt in 2004. Considering further losses during the solvent recycling processes or energy recovery, the total material recovery of solvents waste amounted to approx. 354,000 t in 2004; the energy use amounted to approx. 13,000 TJ. The estimated share of the waste solvents for recycling of the total estimated waste solvents generation (rate of recycling) was about 61 % at the level of the EU 27, also shown in

[110] Total solvents waste generated less directly disposed solvents waste fractions.

Figure 148.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 146. Luxembourg, Germany, Great Britain, and Denmark record the highest solvents recycling rates of more than 65 %.

Figure 146: Recycling potential in kg per capita (2004)

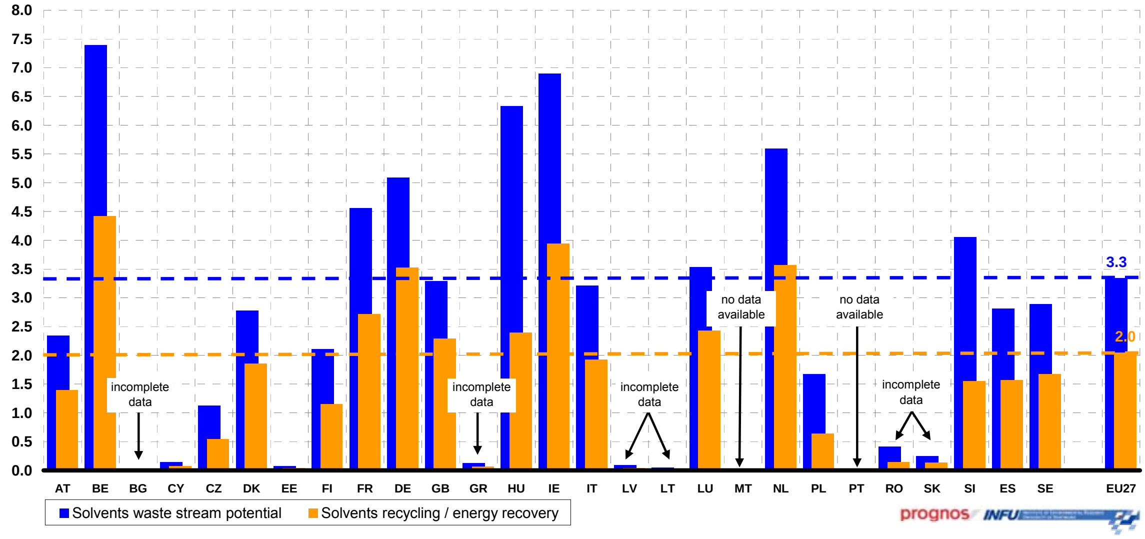


Figure 147 shows the estimated total amount of solvents waste by different waste management alternatives, and the

Figure 148 presents the same data but in percentage.

Figure 147: Management alternatives for waste solvents (in '000 tonnes)

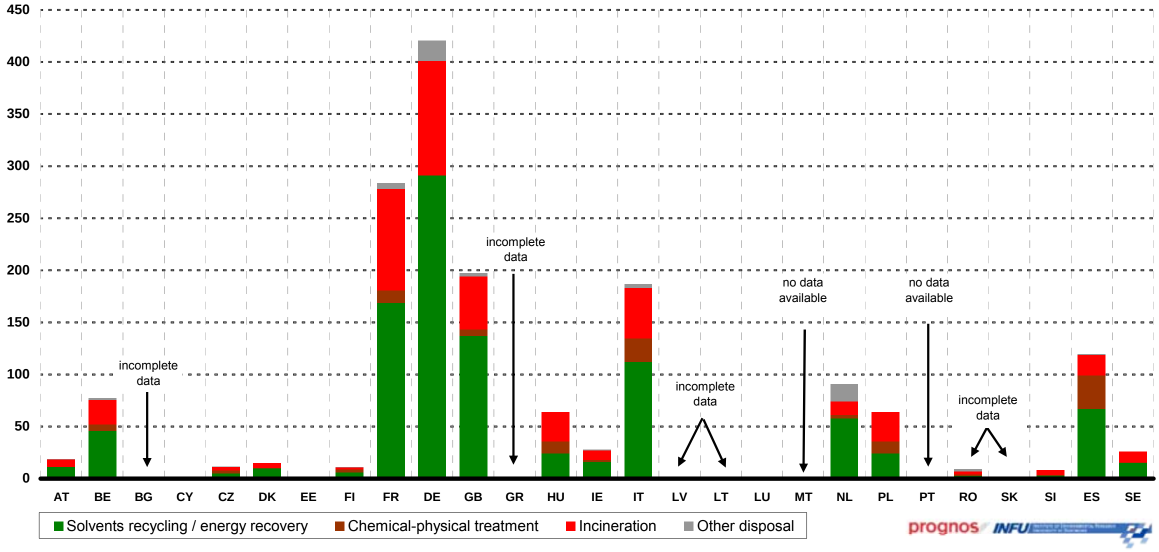
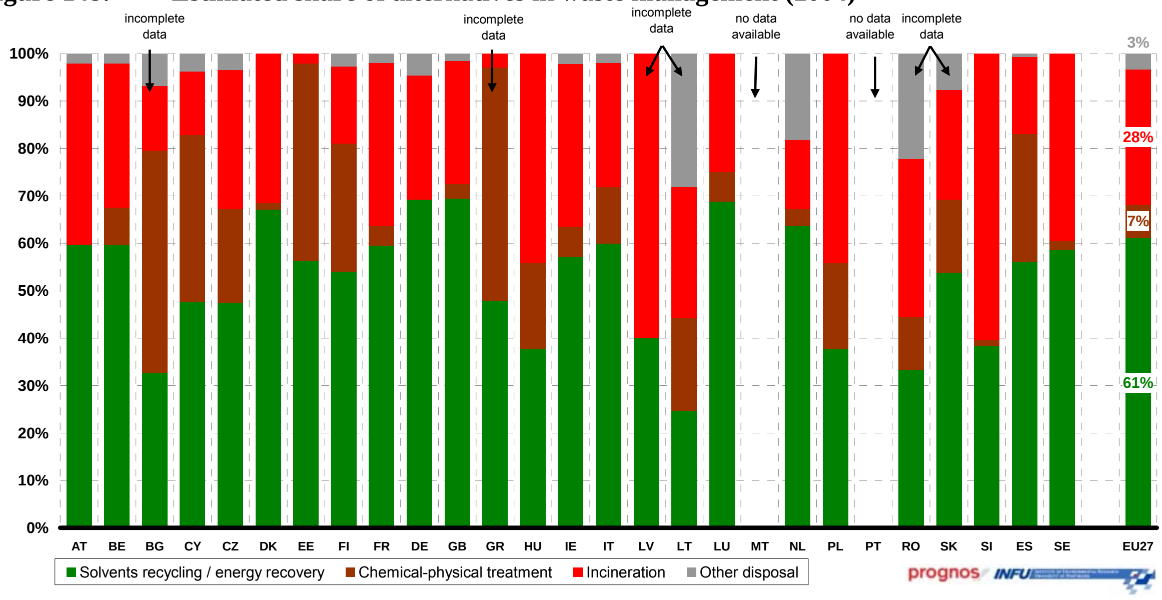


Figure 148: Estimated share of alternatives in waste management (2004)



7.16 Waste oil

Main findings:

- The amount of oil containing waste generated in the EU 27 can be estimated at 7.4Mt in 2004.
- Of these, an estimated 3 Mt were recycled or energy recovered (41 %).
- In general, used oil can be collected, recycled and used over and over again. The cost of recycling oil is relatively high, making it difficult for regenerated or laundered oil to compete with virgin oil.
- The demand for recovered fuel oil has increased and this trend is expected to continue in the next years.

7.16.1 Characterisation of the waste stream

Overview

General characteristics
Data on oil containing waste is uncertain, because there is no universally accepted definition for waste oil, such as waste lubricants and fuels (mainly hydrocarbons) or oils from the food industries (mainly animal or vegetable oil.

The categories of waste oil streams are:

- Post-use lubricating oils
- Heavy fuel oil washings unloaded from the large trans-continental ships (typically containing 30 % water) and from ferries and local traffic (typically containing 50 % water)
- Contaminated fuels (e.g. crossovers of diesel and petrol road fuels, off specification jet fuel), time-expired military fuels, e.g. custom and excise returns etc.
- Fuel tank residues and sludge (often wet)
- Wastes with a higher water content but with some oil
- Emulsions (e.g. from metal working or fire resistant hydraulic fluids)
- Oil interceptors (e.g. from run off areas or storage / processing plant)
- Food oils from domestic and industrial use

Waste recovery

Collection and sorting
Appropriate collection and disposal arrangements for waste oils (WO) from industrial or automotive origin (e.g. garages) are generally well established in Europe.

However, WO from ‘Do-It-Yourself’ oil changes are less likely to be collected so the risk of improper disposal is higher.

In Germany, waste oils have to be separated according to their composition and ability to be re-used. The aim is to supply raw material for the recycling plants. According to German experts, this requirement currently remains unmet due to different problems, mainly collection costs.

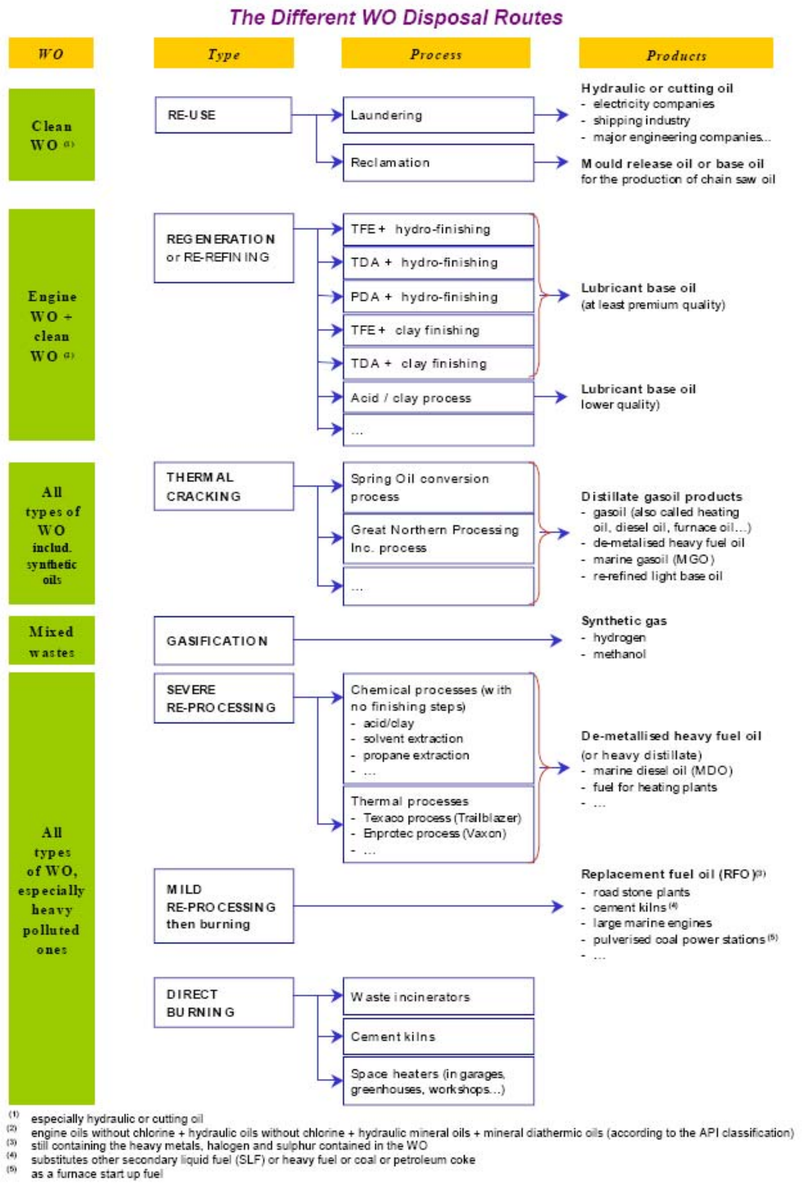
Typically, there are many small waste oil collectors, which feed a network of larger collectors and processors thus ensuring a countrywide service.

The overall tendency in Europe is that half of the lubricating oils are lost through leaks or in the flue gas emissions during use. Approximately 75 % of the waste oil generated is collected.

Pre-treatment and recovery technologies
Distillation and other processes to remove contaminants are used for the regeneration of 25 % of waste oil generated. 50 % of waste oil generated is incinerated for energy recovery.

In the EU, there are presently various types of treatment processes in use. The type of treatment depends on the composition of the waste oil. The characteristics of the final products vary according to the type of treatment used (see figure below).

Figure 149: Waste oil disposal routes



Source: Critical Review of existing Studies and Life Cycle Analysis on the Regeneration and Incineration of Waste Oils, Final Report, December 2001, European Commission DG Environment, A2- Sustainable Resources- Consumption and Waste

Preconditions and technical limitations
Waste oil needs to be sorted into its different grades of cleanliness in order to be processed further, either for re-use or for incineration.

The cost of recycling oil is relatively high, making it difficult for re-used or laundered oil to compete with virgin oil. In addition, it is not easy to market recycled lubricants because they are more poorly perceived than their virgin alternative. The majority of car firms take a neutral position on recycled oil at best, and tend to set specifications that discourage its use.

Alternative management
Probably 25 % of the waste oil generated is illegally burned or dumped in sewage or elsewhere into the environment.

Environmental and health issues related to waste management

Key issues
Most of waste oil recovery plants have very high energy needs and produce residues which are potentially hazardous to the environment and have to be disposed of (e.g. acids, sludge, and clays).

Oil is a common and highly visible form of pollution. Oil and water are immiscible, and even a small spillage can cause significant pollution. Five litres of oil can cover a small lake. Oil pollution has three main effects:

- it forms a film on the surface of water, reducing the level of oxygen in the water and hence causing eutrophication;
- it coats plants and animals that come into contact with it, and
- in large quantities it can make water sources unfit for use as drinking water.

It is an official offence to cause pollution by dumping oil illegally in every EU member state.

Waste recovery process
Used oil contains physical and chemical impurities due to physical contamination, chemical reactions and wear occurring during use. For example, the additive lead tetraethyl decomposes to lead, polycyclic aromatic hydrocarbons (PAH's) are formed by incomplete combustion of organic matter, such as oils, and heavy metal particles are introduced through wear. It is these contaminants, rather than the oil itself, which are of concern when oil is burned in particular ways or used on roads. When used oil is re-refined or re-processed, the contaminants are not destroyed, but accumulate in the waste sludge. The contaminants render this oily sludge highly toxic.[111]

Market

[111] http://www.mfe.govt.nz/publications/waste/used-oil-recovery-dec00.pdf.

Waste oil industry
The European Waste Oil regeneration industry is a global leader and plays an important role in conserving European oil resources.

The European waste oil recycling industry is constituted of about 28 plants. Between 1,000 and 1,200 people are employed in re-fining and 2,000 to 2,500 in collection of waste oil (excluding waste oil from the food industry).

Recycling market
Once oil has been used, it can be collected, recycled, and used over and over again.

One of the largest uses remains to be burning for energy recovery (for example, in boilers and asphalt plants). Nevertheless according to the Waste Oil Directive 75/469 EEC, the recycling of waste oil in Europe takes priority over all other treatment operations. As waste oils are hazardous waste, collection, transport and treatment are subject to special monitoring and to restrictions according to the Hazardous Waste Directive, the Groundwater Regulations and Water Framework Directive but also the Landfill Directive.

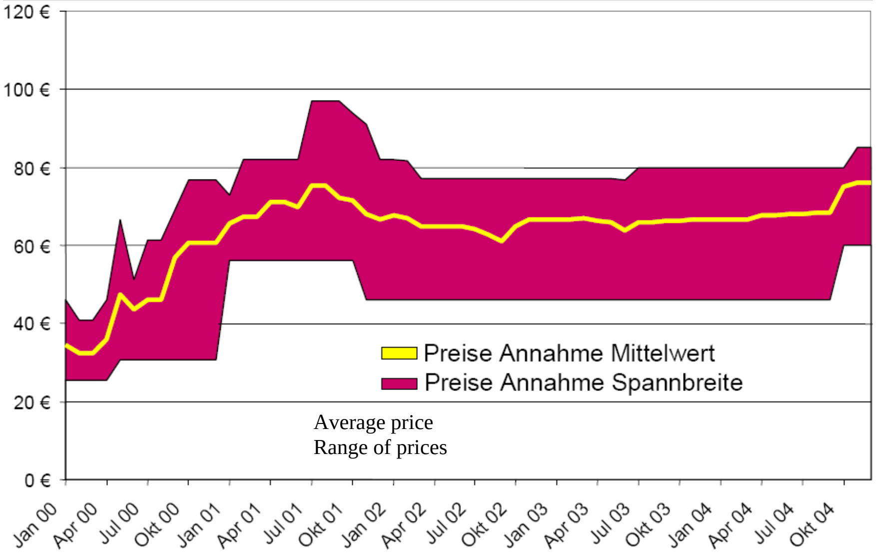
Products from the waste stream are re-supplied in a variety of uses Germany generated the most waste oil in Europe. Of the collected waste oil, approx. two-thirds were regenerated, mainly by production of lubricants and waste oil into base oil. The second largest market for oil waste is the UK, followed by France and Italy.

The demand for recovered fuel oil (RFO) increased until 2006.The quantity of waste oil is expected to decrease for several reasons:

- New technologies enable lower oil consumption.
- More and more high-performance-oils are used, so that longer periods of use are possible and also guaranteed.
- The market will change also by an increasing use of synthetic and biogenic oils, which replace the crude oils. Furthermore, the use of biologically easily degradable oils increases.

Market prices
Example:
From 2000 to 2004 the price for selling price of waste oil to secondary refineries showed a continuous increase. In the period under consideration the price for waste oil increased by 120% to nearly 80 € per ton in Germany.

Figure 150: Selling prices for waste oil to secondary refineries in Germany 2000 - 2004 (€/t)



Source: Stoffstrom- und Marktanalyse zur Sicherung der Altölentsorgung, Umweltbundesamt 2006

On the other side – the selling price for the waste oil to the cement industry (cement kilns), which in 2000 were at the same level, did not undergo a similar development. At the end of 2004, these prices were half of the prices paid to the secondary refineries.

7.16.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream oil containing waste. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 31: Waste sources for the waste stream oil containing waste

Group -ing	EWC	Waste Description	Hazar -dous	EWC-STAT **	Waste Description	Hazar-dous
I	130204	mineral-based chlorinated engine, gear and lubricating oils	☠	**01.3**	Used oils	☠
	130205	mineral-based non-chlorinated engine, gear and lubricating oils	☠			
	130206	synthetic engine, gear and lubricating oils	☠			
	130207	readily biodegradable engine, gear and lubricating oils	☠			
	130208	other engine, gear and lubricating oils	☠			
	050112	oil containing acids	☠			
	120106	mineral-based machining oils containing halogens (except emulsions and solutions)	☠			
	120107	mineral-based machining oils free of halogens (except emulsions and solutions)	☠			
	120108	machining emulsions and solutions containing halogens	☠			
	120109	machining emulsions and solutions free of halogens	☠			

Group -ing	EWC	Waste Description	Hazar -dous	EWC-STAT **	Waste Description	Hazar-dous
	120110	synthetic machining oils	☠			
	120112	spent waxes and fats	☠			
	120119	readily biodegradable machining oil	☠			
	130104	chlorinated emulsions	☠			
	130105	non-chlorinated emulsions	☠			
	130109	mineral-based chlorinated hydraulic oils	☠			
	130110	mineral based non-chlorinated hydraulic oils	☠			
	130111	synthetic hydraulic oils	☠			
	130112	readily biodegradable hydraulic oils	☠			
	130113	other hydraulic oils	☠			
	130306	mineral-based chlorinated insulating and heat transmission oils other than those mentioned in 13 03 01	☠			
	130307	mineral-based non-chlorinated insulating and heat transmission oils	☠			
	130308	synthetic insulating and heat transmission oils	☠			
	130309	readily biodegradable insulating and heat transmission oils	☠			
	130310	other insulating and heat transmission oils	☠			
	130506	oil from oil/water separators	☠			
	200126	oil and fat other than those mentioned in 20 01 25	☠			
II	050106	oily sludges from maintenance operations of the plant or equipment	☠	**03.1**	Chemical deposits and residues	☠
	130401	bilge oils from inland navigation	☠			
	130402	bilge oils from jetty sewers	☠			
	130403	bilge oils from other navigation	☠			
	130501	solids from grit chambers and oil/water separators	☠			
	130502	sludges from oil/water separators	☠			
	130503	interceptor sludges	☠			
	130507	oily water from oil/water separators	☠			
	130508	mixtures of wastes from grit chambers and oil/water separators	☠			
	130701	fuel oil and diesel	☠			
	130702	petrol	☠			
	130802	other emulsions	☠			
	190207	oil and concentrates from separation	☠			
III	100211	wastes from cooling-water treatment containing oil	☠	**03.2**	Industrial effluent sludges	☠

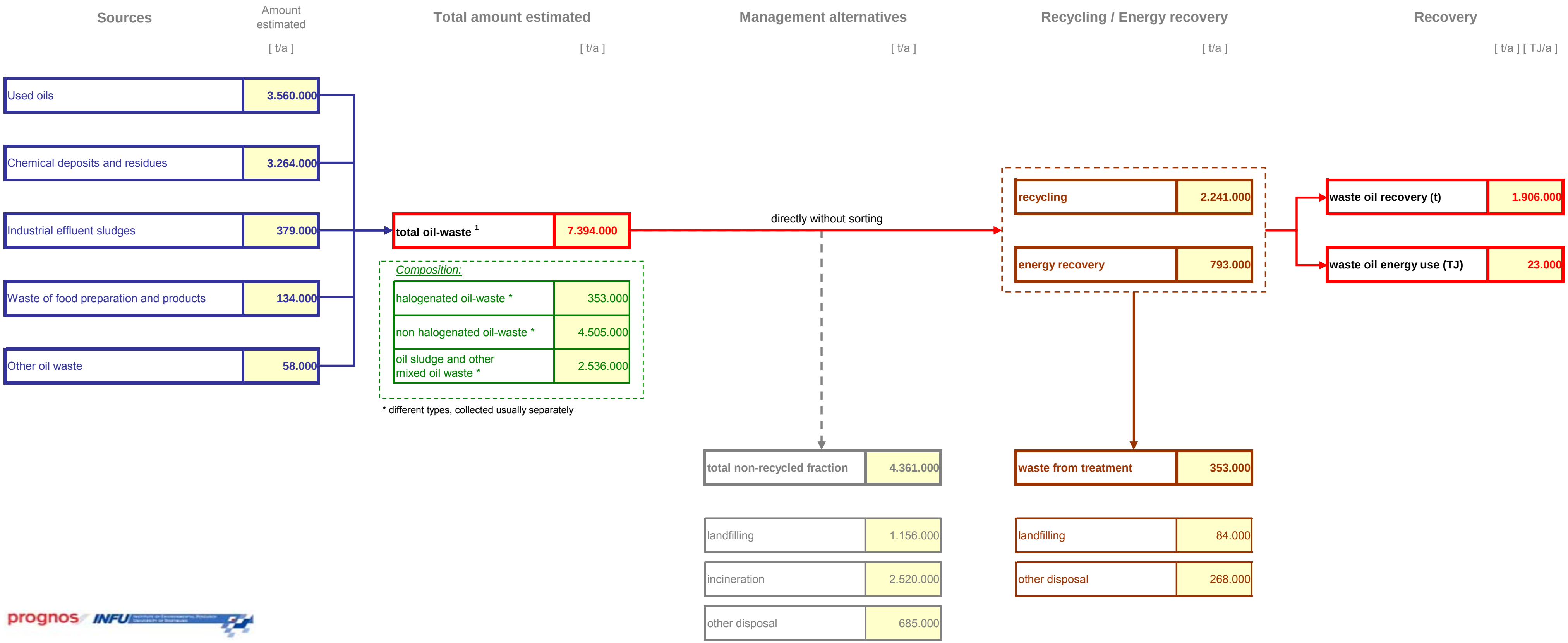
Group -ing	EWC	Waste Description	Hazar -dous	EWC-STAT **	Waste Description	Hazar-dous
	100327	wastes from cooling-water treatment containing oil	☠			
	100409	wastes from cooling-water treatment containing oil	☠			
	100508	wastes from cooling-water treatment containing oil	☠			
	100609	wastes from cooling-water treatment containing oil	☠			
	100707	wastes from cooling-water treatment containing oil	☠			
	100819	wastes from cooling-water treatment containing oil	☠			
	160708	wastes containing oil	☠			
	190810	grease and oil mixture from oil/water separation other than those mentioned in 19 08 09	☠			
V	130101	hydraulic oils, containing PCBs	☠	**07.7**	Waste containing PCB	☠
	130301	insulating or heat transmission oils containing PCBs	☠			
IV	190809	grease and oil mixture from oil/water separation containing only edible oil and fats	☠	**09.1*** ***	Waste of food preparation and products	☠/⚐
	200125	edible oil and fat				
V	050105	oil spills	☠	**12.6**	Contaminated soils and polluted dredging spoils	☠

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions.
* Waste oils are hazardous waste; as a result, data on EWC-6-digit-level are available also for Austria, Germany, Great Britain.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of waste oils waste is necessary. The considered waste oils waste amounts were estimated as described in Sources of data collection.
*** Data available only for the aggregated group "09 without 09.11".

7.16.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream oil containing waste could be compiled.

Figure 151: Estimation of oil containing waste flow (all figures rounded to thousands)



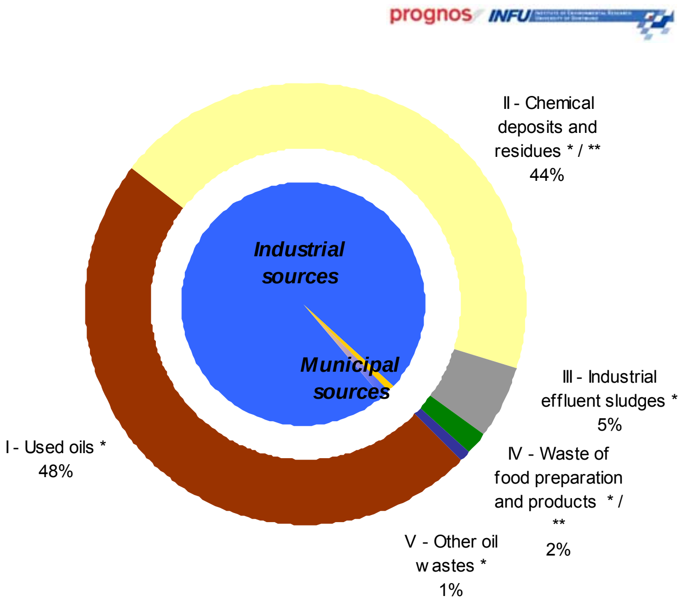
Notes related to the flow sheet:

1. As hazardous waste fraction data for waste oil are available on EWC basis for CZ, HU, PL, LV, LU, SK, SI but also UK, DE, DK and EE.
2. Data for Portugal is not available. Data for Bulgaria, Greece, Latvia, Lithuania, Romania and Slovakia is seemingly incomplete

The main sources for oil containing waste as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations.

In total, the amount of oil containing waste generated in the EU 27 was 7.4 Mt in 2004, of which a minimum of 1 % - 2 % is originated from MSW. The share of oil containing waste potentials from MSW refers to edible oil and fat. This fraction is not well recorded separately.

Figure 152: Estimated oil containing waste generation by sources



* please also refer to notes on Table 31 and Figure 151
** includes waste fractions from MSW

The amount of oil containing waste collected with the objective of recycling or energy recovery [112] was estimated at 3.0 Mt in 2004. Considering further losses during oil containing waste recycling processes or energy recovery, the total material recovery of oil containing waste amounted to approx. 1.9 Mt in 2004; the energy use amounted to approx. 23,000 TJ. The estimated share of the oil containing waste for recycling or energy recovery of the total estimated oil containing waste generation (rate of recycling) was about 41 % at the level of the EU 27, also shown in

[112] Total waste-oil waste generated minus directly disposed waste-oil waste fractions.

Figure 155.

At country level the generation and rate of recycling differ from country to country, as shown in

Figure 153. Belgium, Denmark, Finland and Germany record the highest waste oils recycling or energy recovery

Figure 153: Recycling potential in kg per capita (2004)

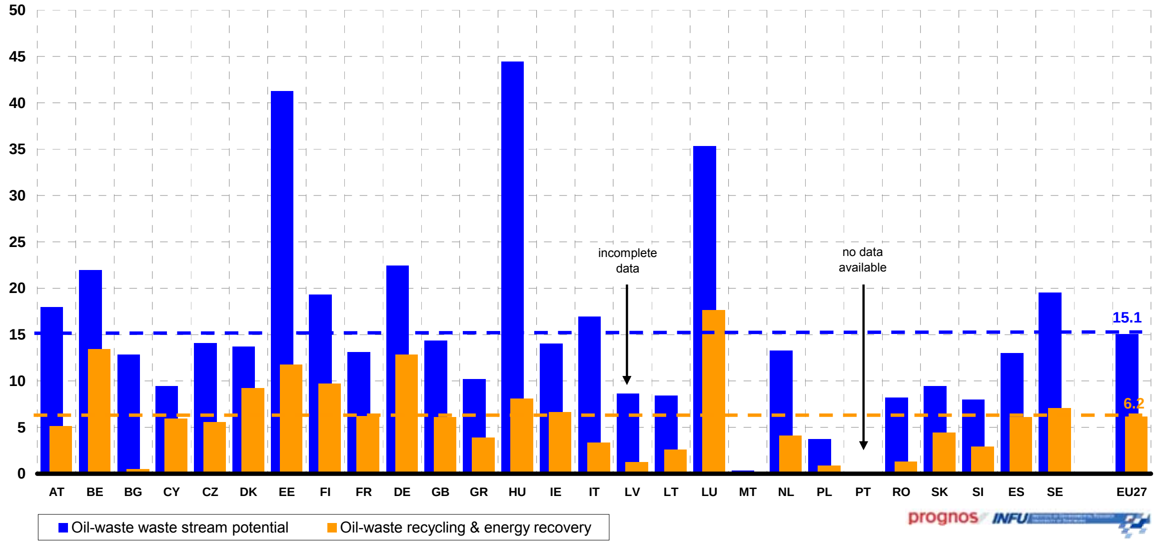


Figure 154 shows the estimated total amount of waste oil by different waste management alternatives, and the

Figure 155 presents the same data but in percentage.

Figure 154: Management alternatives for oil containing waste (in '000 tonnes)

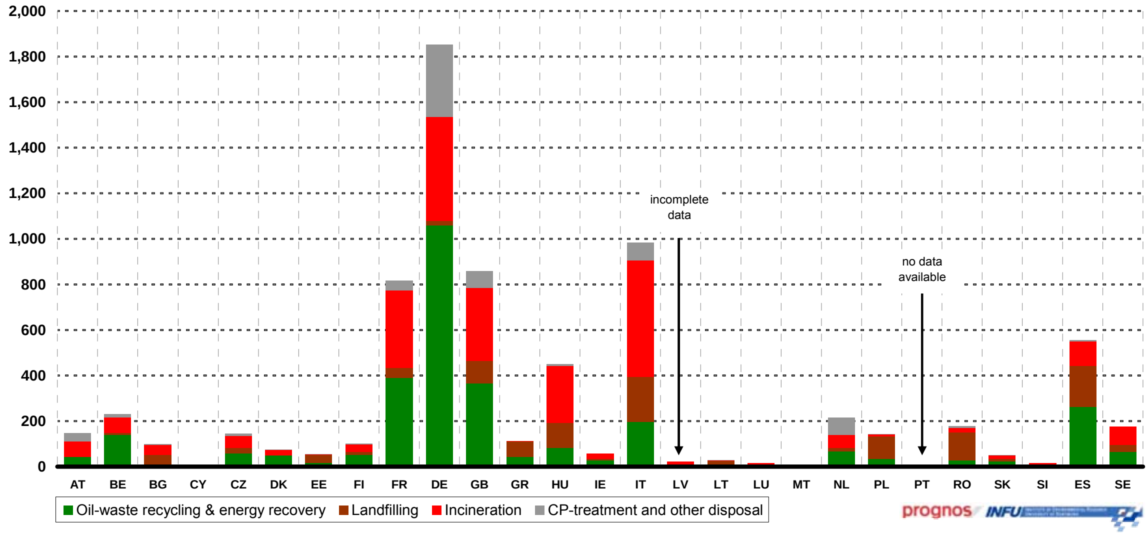
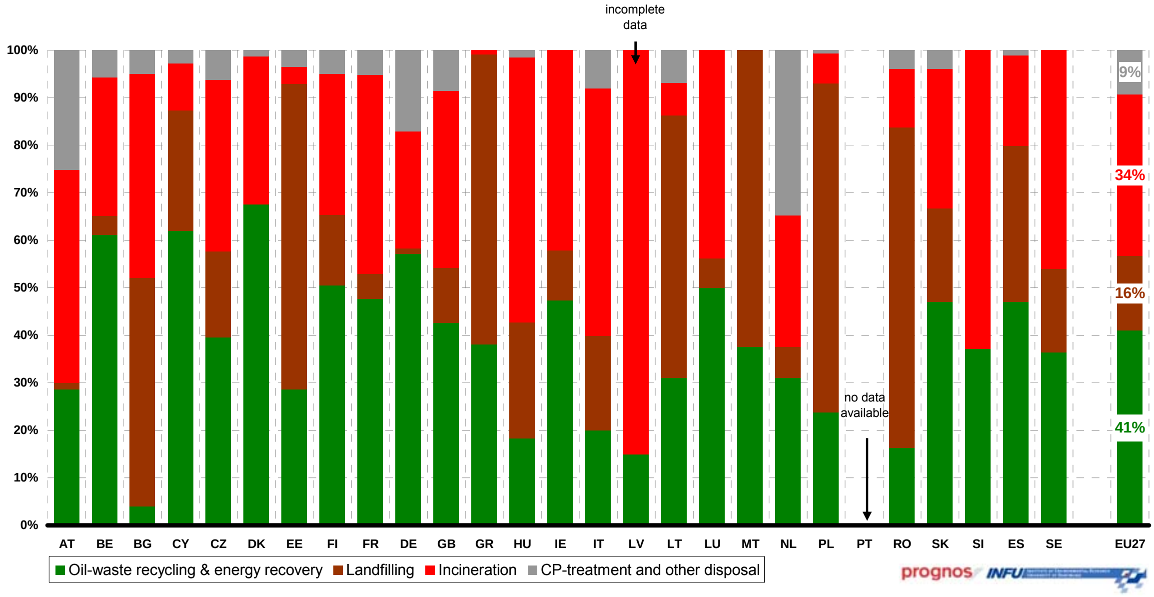


Figure 155: Estimated share of alternatives in oil containing waste management (2004)



7.17 Solid fuels

Main findings:

- Solid fuels potential in the EU 27 can be estimated at 70 Mt in 2004.
- Of these, an estimated 15.1 Mt were energy recovered (22 %).
- In general, an increasing tendency of using fuels recovered from solid waste is visible. The development of European Standards is seen as a major driver to expand the market for this type of fuels.
- The predominantly domestic market will become more international. Increasing trade should assist in stabilising prices.

7.17.1 Characterisation of the waste stream

Overview

General characteristics
Refuse derived fuels (RDFs) cover a wide range of waste materials which have been processed according to guideline, regulatory or industry specification mainly to achieve a high calorific value. Waste derived fuels include residues from MSW recycling, sewage sludge, and variety of industrial waste, which include: plastics and paper / cardboard from commercial and industrial activities (i.e. packaging waste or rejects from manufacturing), waste tyres, biomass waste, waste textiles, residues from car dismantling operations and hazardous industrial wastes such as waste oils, industrial sludge and impregnated sawdust.

Waste recovery

Collection and sorting
In residential areas, RDFs are collected as part of the municipal waste by local companies and separated afterwards in mechanical biological pre-treatment plants.

RDFs from commercial and industrial sources are directly transferred to the incineration plants (with R 1 – status).

Pre-treatment and recovery technologies
Solid waste fuels are treated according to their source. For plastics, paper and cardboard, biodegradable wastes, waste oils, used wood, and textiles please refer to the according waste stream tables.

Generally, wastes accrued in their pure forms (such as wood, textiles, paper and also tyres) can be incinerated without prior processing.

Wastes mixed with other materials (sewage sludges, hazardous industrial wastes, etc.) have to be processed prior to combustion. One of the less expensive and well-established technologies in the recovery process of RDFs from MSW is mechanical biological pre-treatment (MBT). An MBT plant separates out metals and inert materials, screens out organic fractions (for stabilisation using composting processes, either with or without a digestion phase), and separates out high-calorific fractions. RDFs can also result from a ‘dry stabilisation process’ in which residual waste (after separating out metals and inert materials) is dried through a composting process leaving the residual mass with a higher calorific value.

RDF production from MSW is most active in Member States with high levels of MSW source separation and recycling (i.e. Austria, Germany, the Netherlands), as more non-recyclable high calorific residues suitable for RDFs are generated. The capacity for RDF production from MSW is increasing in Austria, Belgium, Finland, Italy, and the Netherlands with new MBT plants being built.

Co-incineration (incineration of RDF in existing power plants and / or energy recovery facilities) of RDFs from MSW in Europe is rather limited. RDFs from processed MSW are reportedly incinerated in fluidised bed incinerators in the UK for energy generation, in multi-fuel district heating plants and paper-mill boilers in Finland and in a few cement kilns in several EU member states. If it is not possible to secure an outlet for RDF's, excess quantities have to be stored. The total quantity of co-incinerated RDFs has been estimated at up to 70 % of the quantities produced. The quantities of RDFs burnt are expected to increase mainly in Germany, Belgium, Italy, France, Spain and in the UK in the future. There are also plans for using RDFs from MSW in other non-combustion processes such as gasification and pyrolysis.

RDFs from industrial wastes are also co-incinerated in industrial processes as secondary fuels. Secondary fuels processed from industrial waste are commonly co-incinerated in cement kilns across Europe.

District heating plants and the power industry are other sectors using industrial RDFs in their coal-fired power plants. They mainly co-combust non-hazardous secondary fuels such as waste wood, straw and dried sewage sludge. The co-firing of biomass waste in coal-fired power plants is likely to increase following the implementation of the EC Directive on Renewable Energy as it is recognised towards the renewable obligations.

The paper industry also co-incinerates large quantities of waste mainly originating from its production process (i.e. bark, paper, sludge, spent liquor).

After pre-treatment, the RDFs are often sent to designated incineration facilities for energy recovery.

Preconditions and technical limitations

These pre-treated wastes need to have a high calorific value consistant quality. Moreover, the production must be economically viable, i.e. the cost of RDFs recovery needs to be compatible to alternative fuels. From the customer side, RDFs have to fulfil several requirements such as long-term availability, assured quality in relation to chemical and physical properties, economy etc.

Alternative management

Solid fuel waste is also landfilled with major environmental consequences (please refer to different waste stream tables for wood, paper, textiles, waste oils, biodegradable waste and plastics). Additionally, the energy that could otherwise be recovered from this waste remains unused.

Environmental and health issues related to waste management

Key issues
Due to both environmental and economic reasons of waste disposal, and to the GHG emissions of fossil fuel, the use of RDFs as fuel substitution can be very beneficial, although it also presents environmental problems. The general emission of toxins is smaller and land-filling would be even more hazardous.

Mercury from co-incineration in the environment can interact with various organic compounds to produce very toxic organo-mercury compounds.

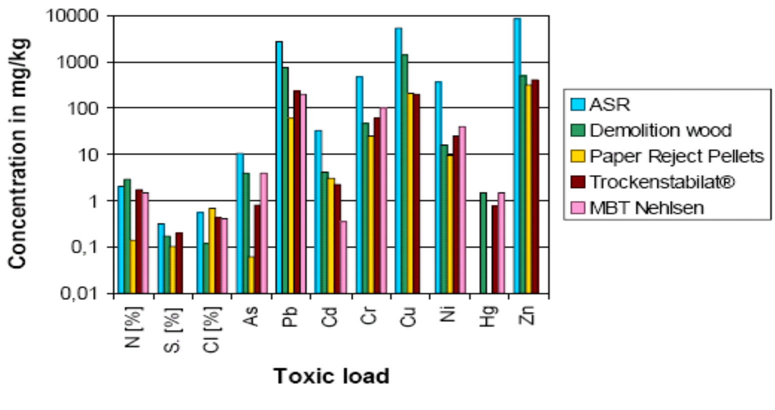
Heavy metal toxicity can result in damaged or reduced mental and central nervous functions, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer.

Waste recovery process
Mercury emissions might be problematic when RDFs are co-incinerated in industrial processes, and there are no special emission control measures developed yet.

There also is a need to study the increase of heavy metals in cement and other by-products from co-incineration facilities to investigate the possible environmental consequences those by-products may cause.

Volatile fumes can also arise from the combustion of RDFs.

Figure 156: Toxic load of selected secondary fuels



Source: European Commission - Directorate General Environment, Refuse derived fuel, current practice and perspectives (B4-3040/2000/306517/MAR/E3), Final Report July 2003.

Market

Solid fuels industry
For more than 10 years there has been an increasing demand in waste derived fuel from the cement, lime, steel and energy industry and the trend is expect to continue.

This development is driven by several factors, mainly:

- the EU Landfill Directive, which requires diversion of biodegradable waste from landfill. This led several states to implement a complete ban for organic waste in landfill,
- the Waste Incineration Directive 2000/76/EC,
- the Renewable Energy Sources (RES) Directive 2001/77/EC,
- the Emission Trading Directive,
- rising energy costs and the consequent interest to substitute expensive primary fuels, and
- the development of European Standards.

RDFs can be used in a variety of ways to produce electricity or heat. It is often used alone or together with traditional sources of fuel in the following industries:

- power plants for energy generation
- industrial power plants
- cement kilns
- incineration plants (R1 –status)
- pyrolysis plants
- steel mills, etc.

The main outlets of RDFs are found in the cement industry as well as paper manufacturing.

Countries where RDFs production is already well established are Germany but also Austria, Finland, Italy, the Netherlands, and Sweden. Countries where RDFs production and energy recovery is currently being developed are Belgium and the United Kingdom. In various countries several RDFs are produced as different forms of appearance (fluff, pellets, chips, powder). They enter the market under different product names.

Market prices
The prices for RDFs are unstable. The price development is influenced by:

- the technology development and cost of RDFs production,
- competition among users,
- the development of waste incineration plant capacities,
- the classification of waste incineration either as disposal or treatment plant,
- the quality requirements, and
- energy process (heat and power).

The predominantly domestic market will become more international, though constrained by transport costs. Increasing competition and increasing trade is expected to stabilise prices for solid recovered fuels at acceptable levels.

7.17.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream solid fuels. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 32: Waste sources for the waste stream solid fuels

*Group - ing****	EWC	Waste Description	Hazar- dous	EWC- Stat**	Waste Description	Hazar- dous
IV	190209	solid combustible wastes containing dangerous substances	☠	**02.3 ******	Mixed chemical wastes	☠
	150110	packaging containing residues of or contaminated by dangerous substances	☠			
	100125	wastes from fuel storage and preparation of coal-fired power plants		**03.1**	Chemical deposits and residues	☠/⚐
	100318	carbon-containing wastes from anode manufacture other than those mentioned in 10 03 17				
	150202	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	☠			
	150203	absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02				
II	200101	paper and cardboard		**07.2**	Paper and cardboard wastes	
	150102	plastic packaging		**07.4**	Plastic wastes	
	160119	plastic				
	170203	plastic				
	200139	plastics				
	200137	wood containing dangerous substances	☠	**07.5**	Wood waste	☠/⚐
	200138	wood other than that mentioned in 20 01 37				
	200111	Textiles		**07.6**	Textiles wastes	
V	160104*	end-of-life vehicles	☠	**08.1**	Discarded vehicles	☠/⚐
	160106*	end-of-life vehicles, containing neither liquids nor other hazardous components				
I	200301*	mixed municipal waste		**10.1**	Household and similar wastes	
	200307*	bulky waste				
IV	150105	composite packaging		**10.2**	Mixed and undifferentiated materials	
	150106	mixed packaging				
	190210	combustible wastes other than those mentioned in 19 02 08 and 19 02 09				
VI	191003	fluff-light fraction and dust containing dangerous substances	☠	**10.3**	Sorting residues	☠/⚐
	191004	luff-light fraction and dust other than those mentioned in 19 10 03				
	191005	other fractions containing dangerous substances	☠			

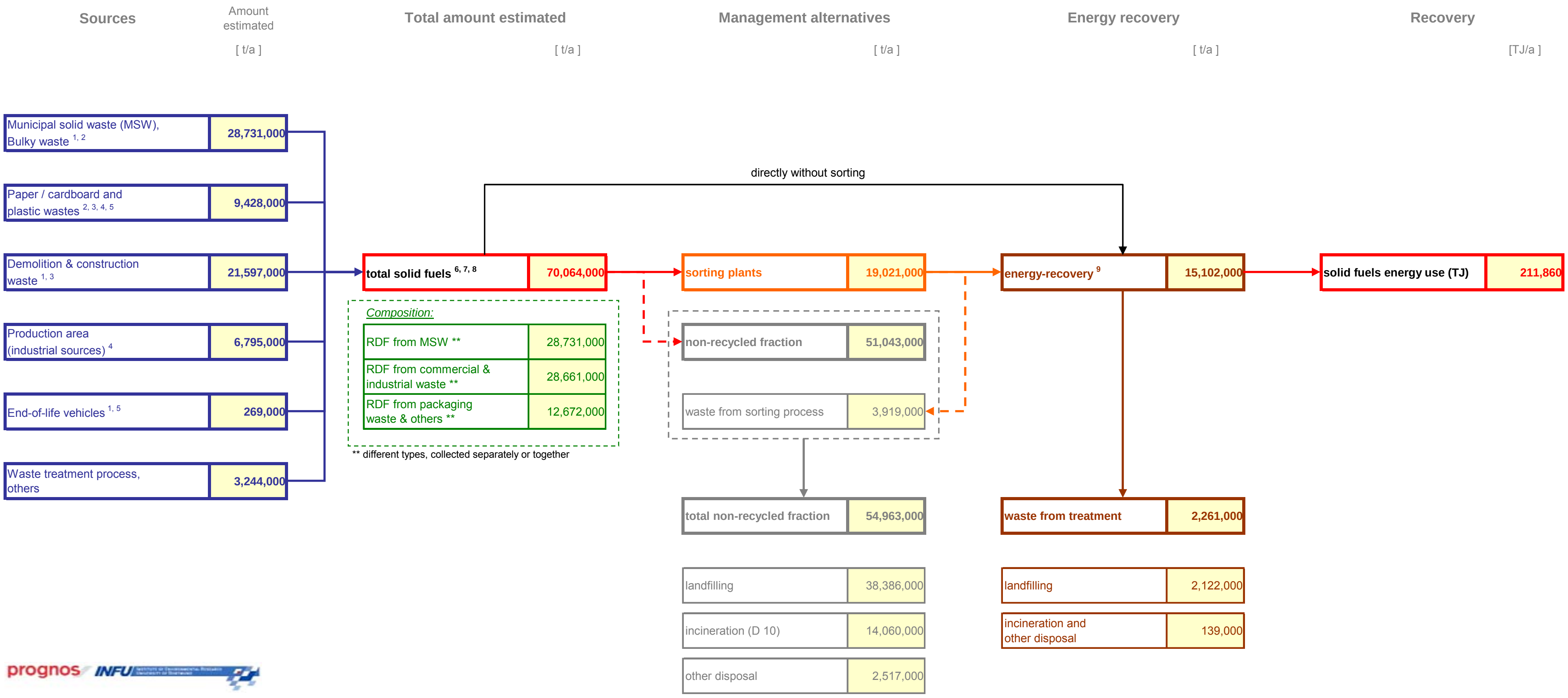
*Group-ing****	**EWC**	**Waste Description**	**Hazar-dous**	**EWC-Stat****	**Waste Description**	**Hazar-dous**
	191006	other fractions other than those mentioned in 19 10 05				
	191210	combustible waste (refuse derived fuel)				
III	170301	bituminous mixtures containing coal tar	☠	**12.1 *******	Construction and demolition wastes	☠/⚐
	170302	bituminous mixtures other than those mentioned in 17 03 01				
	170303	coal tar and tarred products	☠			
	170904*	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03				

☠ Hazardous waste fraction
☠/⚐ As well as hazardous and non-hazardous fractions
* The marked waste fractions are mixed fractions, sorting or separation is necessary. The considered waste amounts for solid fuels were estimated as described in the Introduction.
** All named waste groups consist of several single waste fractions so that an estimation of the relevant share of waste for solid fuels is necessary. The considered waste for solid fuels were estimated as described in Sources of data collection.
*** Allocation of waste stream sources to the sources group in the flow sheet
I Mixed municipal solid waste (MSW) and bulky waste
II Paper, plastic, textiles and wood waste for solid fuels (mainly separate collected fractions from MSW and separate recorded waste from industry), end-of-life-vehicles and construction & demolition (as described in the table “waste sources”). For member states with EWC-6-digit-level data basis are considered only separate selected fractions 200101, 200111, 200137, 200138 and 200139.
III Demolition and construction waste (including code 170203 for member states with EWC-6-digit-level data basis)
IV Production and industrial sources (including code 150102 for member states with EWC-6-digit-level data basis
V End-of-life-vehicles (including code 160119 for member states with EWC-6-digit-level data basis).
**** Data available only for the aggregated group “02”
*****Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.17.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream solid fuels could be compiled.

Figure 157: Estimation of solid fuels flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Sorting or separation from these mixed wastes is necessary.
2. Includes also separately collected fractions from municipal solid waste, which are part of the aggregated group "plastic and paper wastes". Separate data available only for the member states with data basis on an EWC-6-digit-level (CZ, HU, LV, LU, PL, SK, SI). Their share amounts to 0.5 Mt.
3. Solid fuels sources recorded separately from construction & demolition waste (170203) are included in the group "plastic and paper wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, they are allocated to the group "construction & demolition waste".
4. Solid fuels sources recorded separately from production and industry (150102) are included in the group "plastic and paper wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, they are allocated to the group "production and industrial sources".
5. Solid fuels sources recorded separately from end-of-life-vehicles (160119) are included in the group "plastic and paper wastes" for member states on an EWC-STAT basis; for member states with EWC-6-digit-level data base, they are allocated to the group "end-of-life-vehicles".
6. Data for Latvia reflects only municipal and commercial waste; no information is available for other economic sectors.
7. Data for Poland, Slovakia and Czech Republic is compiled from several other sources due to missing or fragmentary EWC-6-digit-data for MSW or C&D.
8. Data for Portugal is available only for MSW, all other figures are roughly estimated.
9. Energy recovery means without incineration in Municipal Solid Waste Incineration Plants.

The main sources for solid fuels as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations, which are detailed as follows.

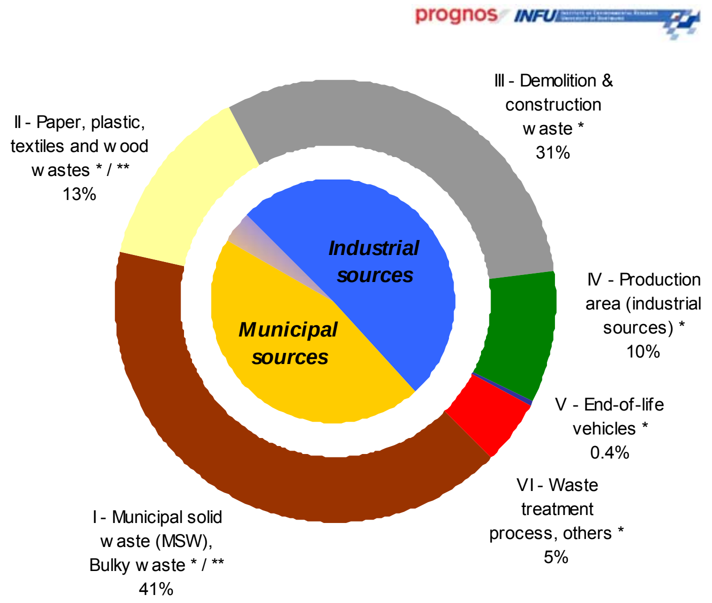
Based on the use of at least two different data sources (EWC and EWC-STAT) Solid fuels from municipal solid waste are not reported separately, but included in the group "paper and plastic wastes", as separate data is only available for member states with EWC data basis.

Solid fuels from construction and demolition sources cover several potentials. The separately recorded fraction (170203) is only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "paper and plastic wastes", because an allocation is not possible due to the aggregated data basis.

Solid fuels from production and industry sources cover several potentials. Separately recorded fraction (150102) is only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis, these amounts are included in the group "paper and plastic wastes", because an allocation is not possible due to the aggregated data basis.
Solid fuels from end-of-life-vehicles and electronic equipment covers potentials from several sources. Separately recorded fraction (160119) is only included for member states with EWC-data-basis. For all member states with EWC-STAT data basis these amounts are included in the group "paper and plastic wastes", as an allocation is not possible due to the aggregated data basis.

In total, the amount of solid fuels generated in the EU 27 was 70 Mt in 2004, of which 45 % - 49 % is originated from MSW.

Figure 158: Estimated solid fuels generation by sources



* please also refer to notes on Table 32 and Figure 157
** includes waste fractions from MSW

The amount of solid fuels source fractions collected separately or collected and then separated in sorting plants with the objective of energy recovery[113] was estimated at 19 Mt in 2004. Taking into account various losses during the sorting process, about 15.1 Mt of solid fuels sources were energy recovered. Considering further losses within energy recovery, the total energy use amounted to about 211,860 TJ in 2004. The estimated share of the solid fuels sources for energy recovery of the total estimated solid fuels generation (rate of recycling) was about 22 % at the level of the EU 27, also shown in

[113] Total solid fuels potential less directly disposed solid fuels fractions. Energy recovery means without incineration in Municipal Solid Waste Incineration Plants.

Figure 161.

At country level the generation and rate of recycling differ from country to country, as shown in Figure 159. Austria, Denmark, Italy, and Sweden record the highest solid fuels energy recovery rate of more than 25 % in 2004.

Figure 159: Energy recovery potential in kg per capita (2004)

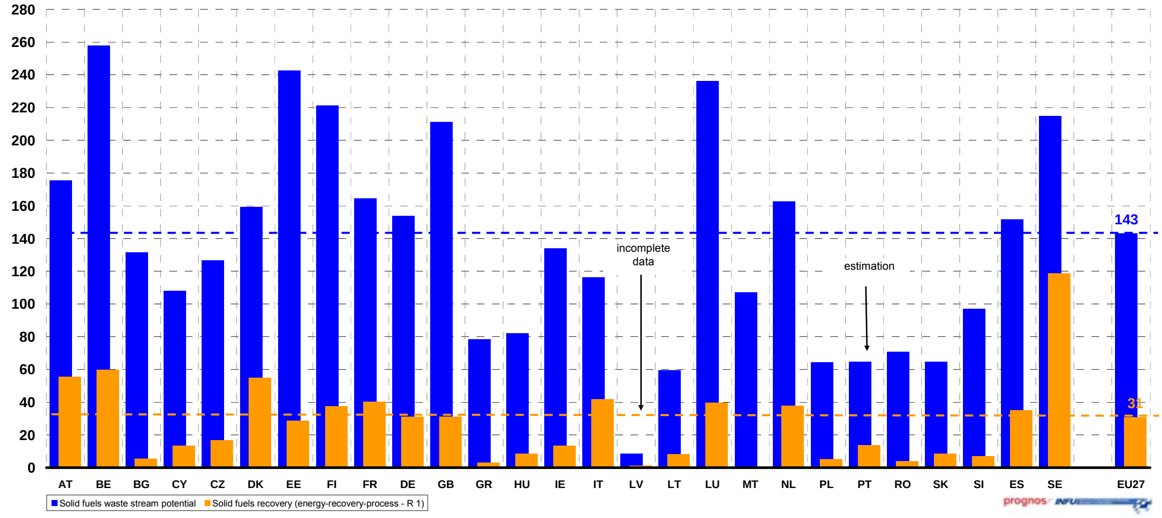


Figure 160 shows the estimated total amount of solid fuels sources by different waste management alternatives, and the

Figure 161 presents the same data but in percentage.

Figure 160: Management alternatives for solid fuels sources (in '000 tonnes)

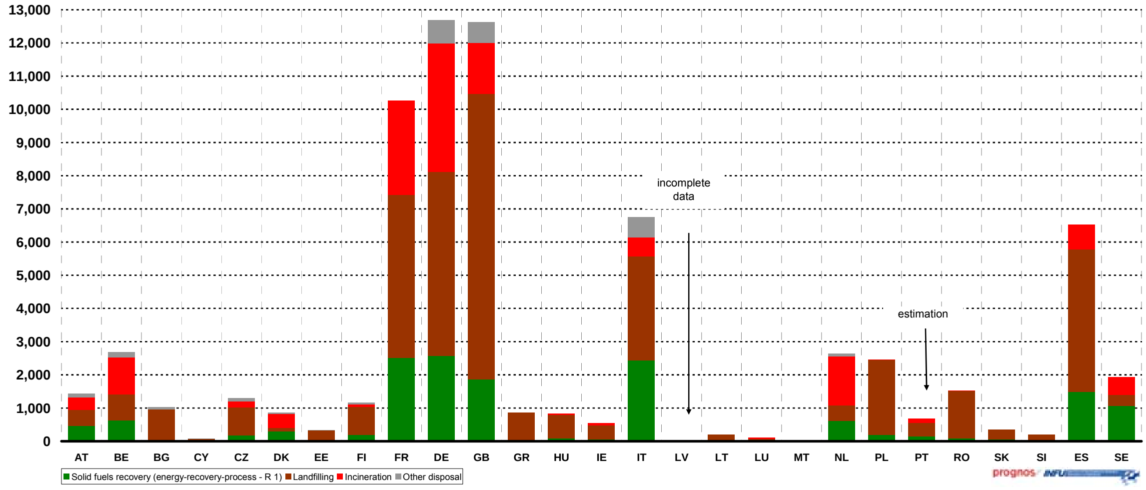
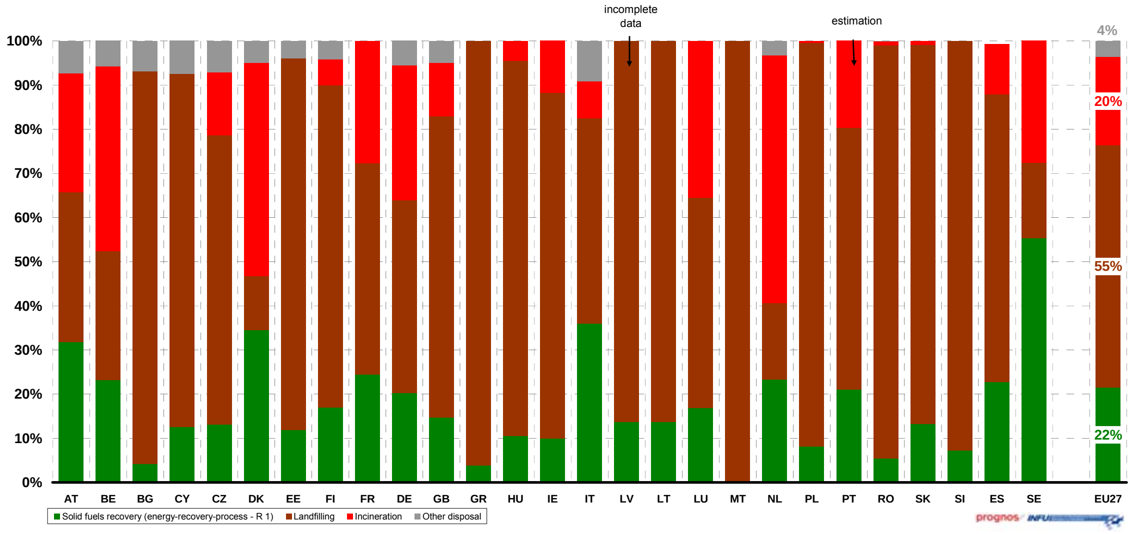


Figure 161: Estimated share of alternatives in solid fuels sources management (2004)



7.18 Ashes & slags

Main findings:

- The amount of ashes & slag generated in the EU 27 can be estimated at 131.4 Mt in 2004.
- Of these, an estimated 83 Mt were recycled (63 %).
- Ashes and slag have a wide range of applications, from cement production to aggregates use in road construction. The demand is increasing.

7.18.1 Characterisation of the waste stream

Overview

General characteristics
Slag from the ferrous and non-ferrous metal production

Internal residual materials and wastes from the iron and steel industry are:
- Slag from furnaces, oxygen converters, electric arc furnaces, secondary metallurgy,
- Sludge from wastewater treatment plants, packed scrubbers, rolling mills,
- Dust from flue-gas cleaning systems,
- Oil-containing scale from rolling mills,
- Internal scrap from ironworks or steel works.

Per ton of crude steel, integrated ironworks produce about 450 to 500 kg residual materials and wastes, of which about 375 kg/t represent slag and about 60 to 65 kg/t represent dust, sludges, and scale.

Typical residues and wastes from the non-ferrous metal industry copper and lead production are slag, flue-gas dust, and dross. In the case of the aluminium industry, salt slags are generated. Residues and wastes from refractory metal production (titanium, zirconium, vanadium, chromium, molybdenum, tungsten, etc.) include flue-gas dust, slag, and dross.

Ashes from combustion / incineration processes

Ashes / slags are the mineral content of the fuel used in combustion processes. The following origins can be differentiated:
- Ashes from incineration
- Ashes from co-incineration in combustion plants
- Ashes from electricity production

Incinerating of wastes leads to about 20 % (w/w) slag.
Ashes from combustion / incineration processes consist of calcium- and iron oxides, alumosilicate compounds.

Waste recovery

Collection and sorting

Fly ash is generated from flue gas cleaning of combustion / incineration processes. The fly ash is separated from the flue gas by means of electrostatic precipitators or baghouse filters - depending on its properties and the sought degree of purity of the resulting gas. The particle size of separated fly ashes ranges from 10 to 100 µm.

Other types of residue generated in the combustion / incineration process are bottom ash and boiler slag, depending on the type of combustion technology used This is the coarser fraction of ash produced during the combustion which remains at the bottom of the boiler. Typically, the material is removed form the furnace bottom by jets of water.

Slags from ferrous and non-ferrous metal production are tapped from the metal in a molten stage and are cooled down. The cooling down depends on the slag type and the final use of the material.

Pre-treatment and recovery technologies

<u>Ashes from incineration</u>

The waste incineration generates bottom / ash. The resulting bottom has to be removed and cooled in water for about one hour. During this time, calcium reactions lead to an increase in pH, which mobilizes some metal ions (e.g. Pb, Al).

Given these constraints, ashes from waste incineration are predominantly disposed of at landfills or underground sites.

Several processes have already been developed and tested for treating ashes and the derivative compound mixes. These include:

- Washing techniques,
- Mixing with water to produce a slurry, reacting injected calcium oxide or calcium hydroxide with the ammonium sulfate within the ashes to produce a slurry containing gypsum and ammonia, which can be processed for producing building materials.
- Low-temperature processes (e.g. catalytic processes) and
- Melting processes (plasma, glas, electro melting processes).

Optimal control of the incineration process is essential to control safe disposal and effective recycling, this includes:

- Optimal burnout of the carbon compounds,
- Transforming heavy metals into the gaseous phase and making them accumulate in the ashes,

in the case of fluidised bed combustion:

- Separation of small ash particles (40–100 µm) in cyclones
- Separation of very small ash particles (< 40 µm), which carry dioxins / furans and heavy metals

Treatment is often restricted to the removal of interfering substances, such as plastic, non-ferrous metals, etc. Separating glass (10 to 25 %) is possible, but the resulting glass fraction is heavily contaminated.

For the treatment of residues, the BREF “waste incineration” identifies the following (combination of) processes as best available technology:

- Combining processes appropriately to reach a preferably complete burnout (The TOC in ash should be smaller than 3 %; it typically ranges from 1 % to 2 %),
- Treating flue-gas dust and coarse ashes as well as other residues from flue-gas cleaning separately to avoid the contamination of coarse ashes and to increase its potential for recycling,

For residues from fluidised bed combustion:

- checking the potential of each waste stream for recycling
- Determining whether flue-gas dust from pre-dust removal (if existing) can be re-used (possibly after treatment), or whether it should be landfilled.

Treating the coarse ashes by an adequate combination of techniques (dry, wet, thermal, physical) so that the necessary requirements can be met

Treating residues from flue-gas cleaning so that the criteria for the respective preferred treatment option can be met.

<u>Ashes from electricity production</u>

Electricity production from fossil fuels in particular, or coal used as fuel, generates a significant amount of ashes. The composition of the ashes depends strongly on the type of fuel used and the combustion conditions. The ashes can be collected in the flue gas cleaning equipment (fly ash) or in the case of coarser and heavier particles at the bottom of the furnace (bottom ash or boiler slag). The fly ash does not need to be further processed. Boiler slag and bottom ash may need to be further treated depending on the recycling / disposal option envisaged.

<u>Slag from the ferrous and non-ferrous metal production</u>

To promote recycling of residues and wastes from the iron and steel industry, the following measures would be desirable:

- Selective separation of dust and sludges into a Fe-rich fraction and a Zn/Pb-rich fraction, and
- Oil removal from scale with an oil concentration > 1 % to 2 %

If residues and wastes are treated in one of these ways, they can be re-used in existing primary processes of the iron and steel industry.

In particular for blast furnace slags, from pig iron production the cooling can be done in several ways depending on the final use of the material. The material can be cooled down rapidly with high-pressure water sprays forming a glassy granular material with specific properties enabling its use in cement and concrete.

In other cases, the material is air cooled, crushed and sieved to enable its use in the construction sector. Slags from the iron and steel have a long tradition of being used in the construction sector and the cement industry.

For steel slags the material might pass a separation process after the cooling to recover ferrous particles, which can be internally recovered.

For slags from aluminium production, recycling salt slags usually involves 5 steps:

- mechanical crushing, sieving, and dry separation of slag
- dissolving, degassing, creation of a suspension
- separation of unwanted gases
- concentration, filtration, extraction of residue
- crystallisation to recover the sodium and potassium chlorides that can be re-used as flux in the melting furnaces

This process allows the waste reduction and recovery of salt for re-use. Worldwide, several other techniques are available for processing salt slag on a large scale.

Preconditions and technical limitations

Central problems with wastes from the iron and steel industry have to do with the accumulation of heavy metals (in particular zinc and lead) and with the oil concentration of the mill scale. High recycling quotas for internal residues and wastes – such as dust, scale, sludges – as well as for external wastes – such as scrap – lead to unwanted accumulation of accompanying elements (Zn, Pb). Another problem is the oil concentration in scale. Recycling scale for metallurgical processes requires drying and backwashing.

Potential recycling of wastes and residues from metal production is possible by means of proper selection of raw material and process control. So far, the flue gas dusts from the metal industry are mainly landfilled.

Steel slags may present volume stability problems due to the lime contact which expands in contact with moisture. Depending on the type of application of the material, this can be a constraint.

Using ash / from waste incineration as additive for concrete production does not appear to have potential in the future as reactions of water and embodied ashes & slag lead to instable concrete and lower quality.

Ashes / slags from coal-fired power stations can be used in cement, concrete and road construction; only a small fraction is landfilled.

Alternative management

Wastes generated in the metal industry which are not recycled internally have to be disposed of at landfill sites.

Ashes / slags which cannot be recycled have to be disposed of at landfill sites.

Flue-gas dust that contains harmful substances and solid wastes from flue-gas cleaning are predominantly disposed of underground. In many EU member countries, landfilling usually on hazardous waste sites – is the norm.

Environmental and health issues related to waste management

Key issues
The release of dangerous substances from the material to the environment; heavy metals, oxyanions and inorganic salts.

Waste recovery process
Slag from the ferrous and non-ferrous metal production

High recycling quotas within the iron and steel industry for internal residues and wastes such as dust, scale, sludges as well as for external wastes such as scrap have negative effects and lead to unwanted accumulation of accompanying elements (Zn, Pb). The zinc input into an integrated iron or steel works amounts to about 0,4 kg per ton crude steel. The main source is zinced scrap. If the zinc concentration is too high, the quality of the products (pig iron, steel) and by-products (slag) decreases, while reject and specific wastes increase.

When the slag is cooled down with water, water emission might be expected for the residual water. When recycling the material into construction material, the slag is crushed and sieved. This may create dust problems in the slag processing.

Ashes from combustion / incineration processes

One has to assume the composition of the waste influences the composition of the incineration residues. To prevent the presence of contaminants in the waste, quality checks on the waste composition and the ash have to be done regularly, thereby increasing the costs.

To cope with the problem of heavy metals in the bottom ash / boiler slag and fly ash the material can be vitrified. In this process, the solid residues are heated to at least 1300°C. After cooling, the heavy metals are bound in the silicate matrix. Such cooling can be done separately from the actual waste incineration. Modern techniques, however, operate in a way that the vitrification is integrated into incineration. The high energy input and the disputed bonding quality of the contaminants in the glass matrix have repeatedly led to controversies between disposers and legislators.

Measures for decreasing the contaminant load of ashes / from waste incineration can be applied in the consumer phase. Products with heavy metal loads (electronic waste, batteries) have to be replaced by less problematic products. In some areas (cadmium in batteries), this goal could already be achieved, whereas in others (lead batteries) special collection systems may reduce the problem.

Market

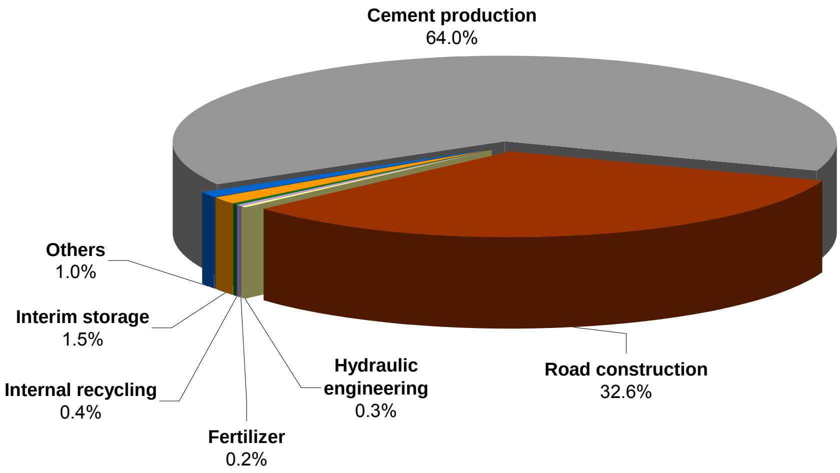
Slag from the iron and steel industry

According to the European Slag Association (EUROSLAG) in 2004 the European iron and steel industry generated about 40 Mt of slag resulting from iron and steel making. Of these, generated blast furnace slag amounted to about 25 Mt and steel slag to about 15 Mt.

Most of the generated slag from the iron and steel industry is used for road construction (45 % of steel slag and nearly 33 % of blast furnace slag in 2004). While about 64 % of blast furnace slag is used in cement production, the share for steel slag amounts to only 1 %. In general the recovery for steel slag is lower than for blast furnace slag. [114]

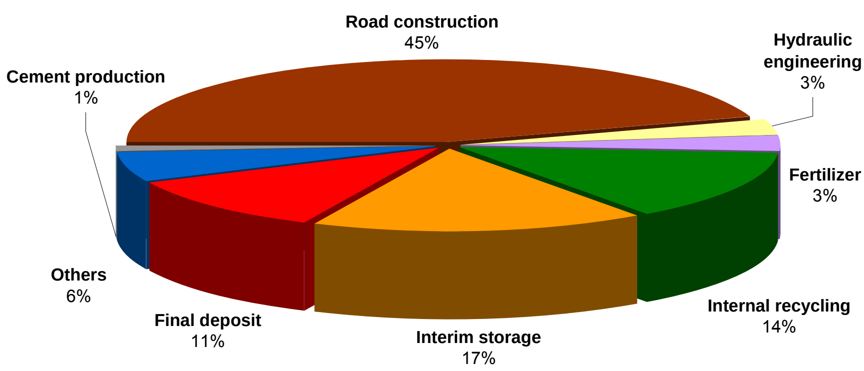
Recovery possibilities vary from country to country and depend e.g. on the quality of slag. In several countries the recovery rate is higher than 90 %.

Figure 162: Use of blast furnace slag in 2004 (total use 2004: 27.2 Mt)



Source: European Slag Association 2006

Figure 163: Use of steel slag in Europe 2004 (total amount 2004: 15 Mt)



[114] Legal Status of slag – Position Paper, The European Slag association, 2006.

Source: European Slag Association 2006

France, Italy, Japan, Turkey ,and Germany are the major exporting nations of granulated blast furnace slag.

Bottom ash from waste incineration plants

Bottom ash is the most significant by-product from municipal solid waste incineration. It accounts for 85-95 % of the solid product resulting from MSW combustion.

The bottom ash contains significant levels of heavy metals. If these are mineralized, it may be used as an aggregate in :

- road construction and
- concrete.

Ashes and slag from power plants

In 2005, the EU 15 produced about 65 Mt of coal combustion products (CCP). These are produced in coal-fired power stations which burn either hard or brown coal.

Fly ash represents the greatest proportion of total CCP production (around 43 Mt) at nearly 70 %. Bottom ash amounted to about 6 Mt (9.6 %).

The estimated total production of CCP for the EU 27 reaches about 95 Mt.[115] In the majority of cases CCPs are used as a replacement for naturally occurring resources. Within the EU approx. 48 % of fly ash and 45 % of bottom ash is used in the construction industry.

The recycling of bottom ash is specifically regulated in Wallonia, France, Germany and The Netherlands.

Market prices

Slag from metal industry

Blast furnace slag, which is used as construction materials in road construction, hydraulic engineering and railway construction (ballast), has a positive market value comparable to minerals. A constant demand for this application exists, which exceeds the supply in some cases. In comparison to the natural minerals, prices for ground granulated blast furnace slag, which is used as a base material in the cement industry are on the same level.[116]

Bottom ash from waste incineration plants

The example of the Hanseatisches Schlackenkontor (HSK) has shown that rehashed slag from waste incineration plants can have a positive market value. In the last years the HSK always brought 100 % of the produced and rehashed slag to the market.

Ashes and slag from power plants

[115] ECOBA European Coal Combustion Products Association

[116] MUNLV Ministerium für Umwelt und Naturschutz, Landwirtschaft und Verbraucherschutz des Landes Nordrhein-Westfalen: Vereinbarung über die rechtliche Behandlung von Hüttensand und Hochofenschlacke der Firma ThyssenKrupp Stahl AG, Düsseldorf 2006.

Bottom ash produced in coal-fired power stations has a glazed structure and can be used like a mineral. Similar to bottom ash, fly ash from hard coal fired power plants has a positive market price.

7.18.2 Waste sources

On the basis of the European Waste Catalogue (C (2000) 1147), the following waste fractions have been selected as relevant sources for the waste stream ashes & slag. As different statistical data sources were used, the equivalent waste groups on an EWC-STAT-basis were identified according to the official equivalence table.

Table 33: Waste sources for the waste stream ashes & slag

EWC	Waste Description	Hazar-dous	EWC-STAT *	Waste Description	Hazar-dous
100118	wastes from gas cleaning containing dangerous substances	☠	**12.4**	Combustion wastes	☠/⚐
100119	wastes from gas cleaning other than those mentioned in 10 01 05, 10 01 07 and 10 01 18				
100815	flue-gas dust containing dangerous substances	☠			
100816	flue-gas dust other than those mentioned in 10 08 15				
190107	solid wastes from gas treatment	☠			
190402	fly ash and other flue-gas treatment wastes	☠			
100101	bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)				
100102	coal fly ash	☠			
100103	fly ash from peat and untreated wood				
100104	oil fly ash and -boiler dust	☠			
100113	fly ash from emulsified hydrocarbons used as fuel	☠			
100114	bottom ash, slag and boiler dust from co-incineration containing dangerous substances	☠			
100115	bottom ash, slag and boiler dust from co-incineration other than those mentioned in 10 01 14				
100116	fly ash from co-incineration containing dangerous substances	☠			
100117	fly ash from co-incineration other than those mentioned in 10 01 16				
100201	wastes from the processing of slag				
100202	unprocessed slag				
100911	other particulates containing dangerous substances	☠			
100912	other particulates other than those mentioned in 10 09 11				
101003	furnace slag				
190111	bottom ash and slag containing dangerous substances	☠			
190112	bottom ash and slag other than those mentioned in 19 01 11				
190113	fly ash containing dangerous substances	☠			
190114	fly ash other than those mentioned in 19 01 13				

EWC	Waste Description	Hazar-dous	EWC-STAT *	Waste Description	Hazar-dous
190115	boiler dust containing dangerous substances	☠			
190116	boiler dust other than those mentioned in 19 01 15				
190117	pyrolysis wastes containing dangerous substances	☠			
190118	pyrolysis wastes other than those mentioned in 19 01 17				
190119	sands from fluidised beds				
101306	particulates and dust (except 10 13 12 and 10 13 13)		**12.5 ****	Various mineral wastes	
190401	vitrified waste		**13.2**	Vitrified wastes	

☠ Hazardous waste fraction

☠/⚐ As well as hazardous and non-hazardous fractions

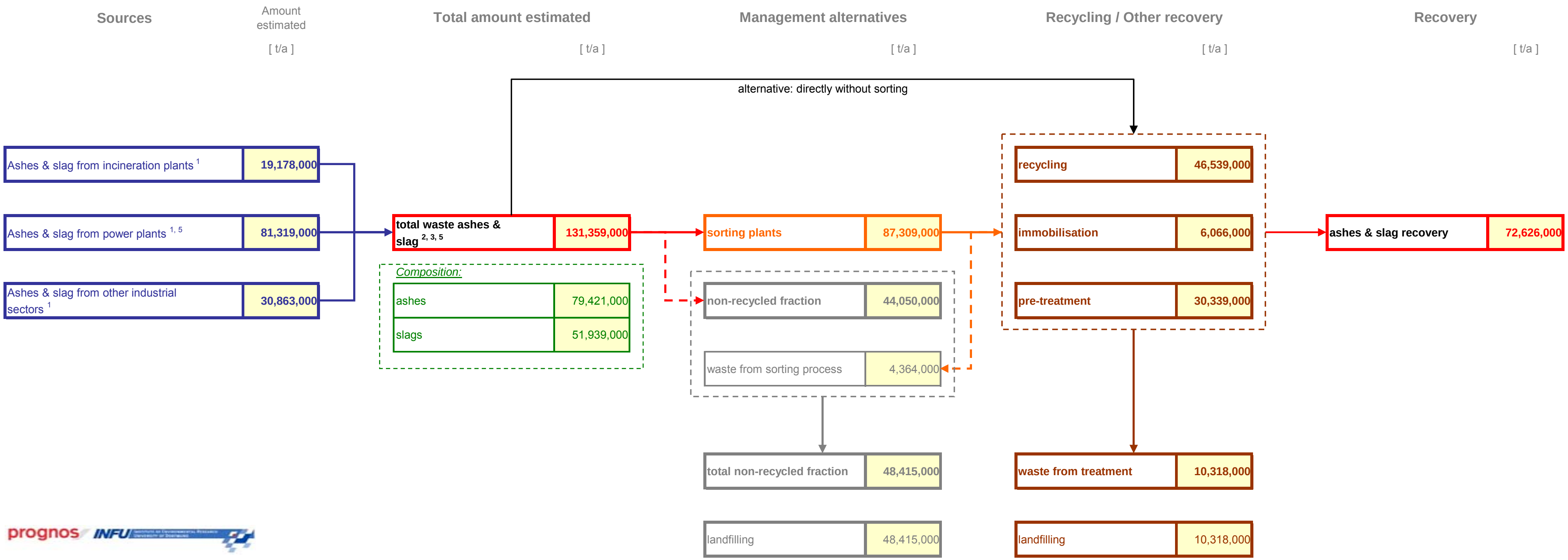
* All named waste groups consist of several single waste fractions so that an estimation of the relevant share of ashes & slag is necessary. The considered ashes & slag amounts were estimated as described in Sources of data collection. Further estimations were made for the allocation to ashes & slag from incineration, from power plants or from other industry sectors.

** Data available only for the aggregated group “12.1 to 12.5 not 12.4”

7.18.3 Key figures

As a result of adjusting the available data basis, the following flow sheet for the waste stream ashes & slag could be compiled.

Figure 164: Estimation of ashes & slag flow (all figures rounded to thousands)



Notes related to the flow sheet:

1. Estimations were made for the allocation to ashes & slag from incineration, from power plants or from other industry sectors.
2. Data for Latvia reflects only municipal and commercial waste, no information is available for other economic sectors.
3. There is only incomplete data for Lithuania.
4. No data for Portugal is available; estimations were made on the basis of treatment information for incineration plants.
5. Estimations were made for the allocation to ashes & slag from power plants for Poland and Greece due to the inconsistent data basis for branches within the EWC-STAT group 12.4

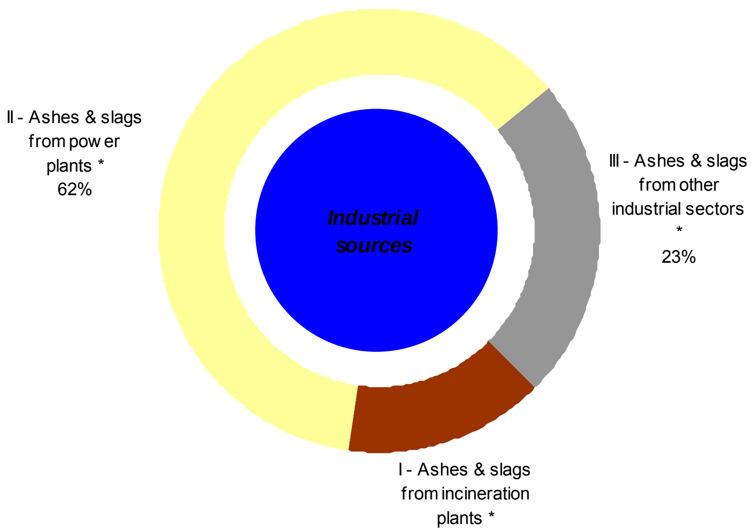
The main sources for ashes & slag as the starting point of the waste flow sheet are displayed on the left side of the above figure, and their quantitative estimation is a combined result of the collected data together with expert estimations.

The total ashes & slag potential can be split into three main groups:

- Ashes & slag from incineration plants
- Ashes & slag from power plants
- Ashes & slag from other industrial sectors

Due to missing differentiated data, the distribution between these three groups was estimated on the basis of additional information sources.

Figure 165: Estimated ashes & slag generation by sources



* please take into consideration also notes referring to Table 33 and Figure 164

The amount of ashes & slag collected separately or collected and then separated in sorting plants with the objective of recycling [117] can be estimated at 87.3 Mt in 2004. Taking into account various losses during the sorting process, about 83 Mt of ashes & slag waste were treated / recycled. Considering further losses within ashes & slag treatment / recycling the total recovery of ashes & slag amounted to about 72.6 Mt in 2004. The estimated share of the ashes & slag for recycling of the total estimated ashes & slag generation (rate of recycling) was about 63 % at the level of the EU 27, also shown in

[117] Total ashes & slag potential less directly disposed ashes & slag fractions.

Figure 168.

Figure 166: Recycling potential in kg per capita (2004)

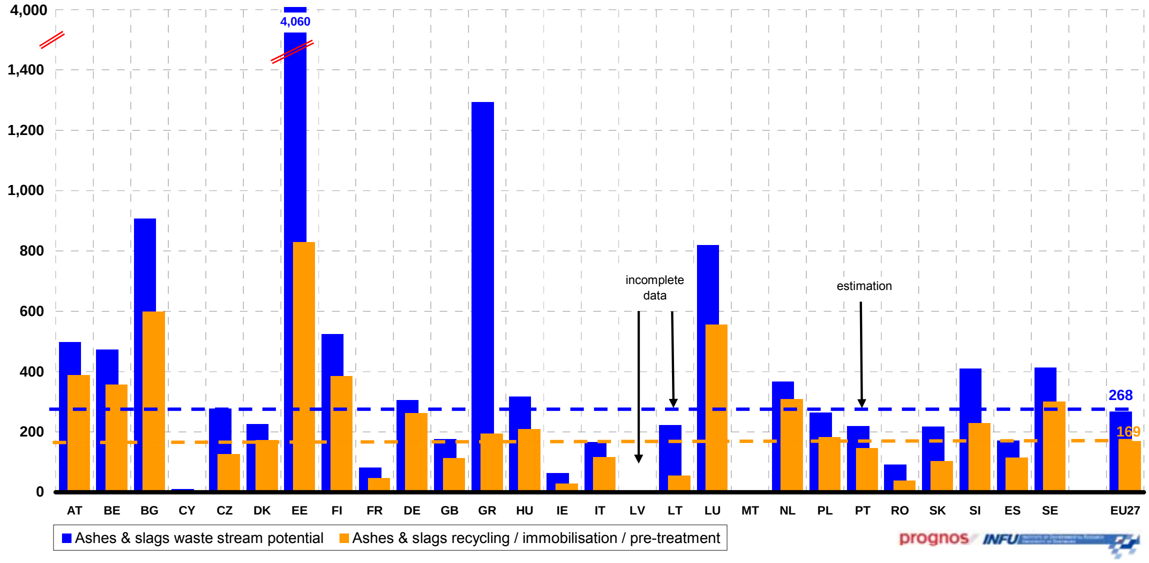


Figure 167 shows the estimated total amount of ashes & slag by different waste management alternatives, and the

Figure 168 presents the same data but in percentage.

Figure 167: Management alternatives for ashes & slag (in '000 tonnes)

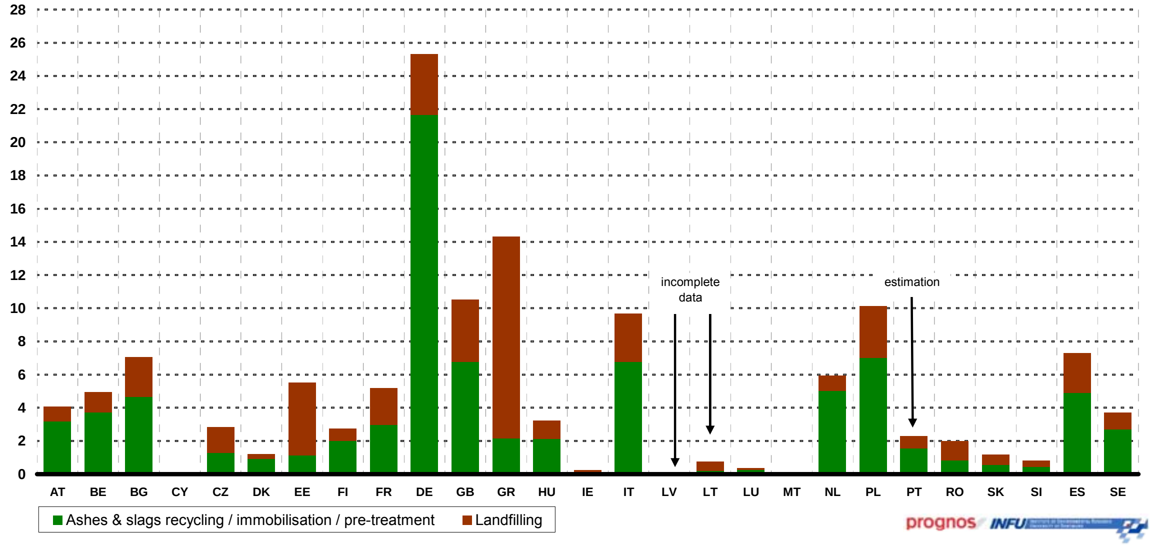
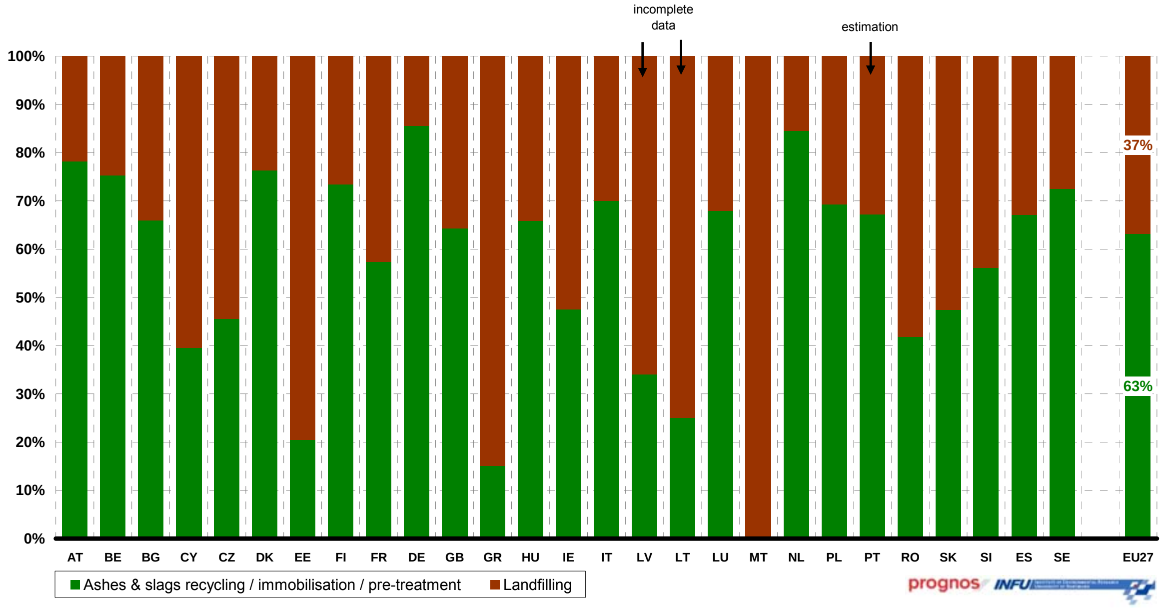


Figure 168: Estimated share of alternatives in ashes & slag management (2004)



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- Umweltbundesamt Österreich: Abfallvermeidung und –verwertung – Aschen, Schlacken und Stäube in Österreich, Wien 2005.
- www.ecoba.org (European Coal Combustion Products Association)
- www.euroslag.org (European Slag Association)
- www.flyash.info
- www.schlackenkontor.de (Hamburger Schlackenkontor)

8 ANNEX II - DATA SOURCES FOR THE IDENTIFIED WASTE STREAMS

Several of the EU member countries have published waste statistics based on the EWC (referred to as EWC data in this report) and can be used in this study fairly straightforward; however for majority of the member countries, EUROSTAT is the main source of information. Waste data from EUROSTAT (referred to as EWC STAT data in this report) is gathered according to Waste Statistic Regulation, which categorise all the waste fractions by their nature, making it easier to be linked to the recycled secondary material, although need to be analysed for the linking to the source of origin. Therefore, in order to use both data sources, both categorisation of waste are analysed and compared to ensure the correctness and consistency of each waste stream flow. The disaggregating and re-aggregating of data is a time consuming and complicated process. Moreover, due to the details of data collection and methodology of data reporting are not often available; assumptions and expert judgements are necessarily made, mostly in a case-by-case base.

An example, glass, is shown in Figure AII.1. The main sources of waste glasses are listed on the left side of the figure and are identified at EWC 2-digit level, which can be further identified by fractions at the 6-digit level. The waste fractions at the EWC 6-digit level can be used directly to recognised the different status of separation that are already undergone and the "cleanness" of the waste fraction. For instance, separated collected glasses from municipal waste (200102) is expected fairly clean and could be directly sent to glass manufacture after cleaning and metal and plastic separation; however, glasses in mixed municipal waste should be separated before return to glass manufacture or, as often in reality, they are as bulky waste directly being incinerated, composted or landfilled. This example means different waste fractions under one waste stream possess different quality which determines the management choices and the destination of the recycled materials.

The right column of the Figure lists the categories under the waste stream "glass" according to EWC STAT, which needs to be compared to the EWC and disaggregated to the EWC 6-digit level. Continuously using "glass" as an example, the waste groups listed on the right side considered potential sources for waste glass. While the group "construction and demolition waste", which could contain glass, can be directly identified with EWC 170204 and 09, the group "glass waste", on the other hand, is a mix of several EWC 2-digits and need to be broken down to glass from packaging, end of life vehicles, construction and demolition, etc.

Again various assumption have to be made for this exercise, and furthermore, information at national level are often incomplete and estimations have to be made based on information from other countries or expert judgement. The following is a summary of the situation on data quality and the important assumptions for data estimation:

- Municipal waste is a traditional domain in waste management and the data is relatively more available and reliable. Apart from incompletion of data, the following summarise several observations on the EWC STAT data:

- Data on waste generation was collected in a different manner. Municipal waste is considered as a result of consumption while the rest (non hazardous and hazardous) is supposed to be waste from production. However, in some countries, data on waste is based on the disposed waste volumes as input to the waste treatment plants. Therefore, the discrepancies in data collection are of methodological nature. Furthermore, import and export of waste are not differentiated, since they were either not considered or not clearly indicated in the collected data and information.

- In several member states the quantitative listing of waste – especially when land filled – is estimated on the basis of truck volumes (m^3) and converted into tonnes, due to mainly the lack of weighing bridges.

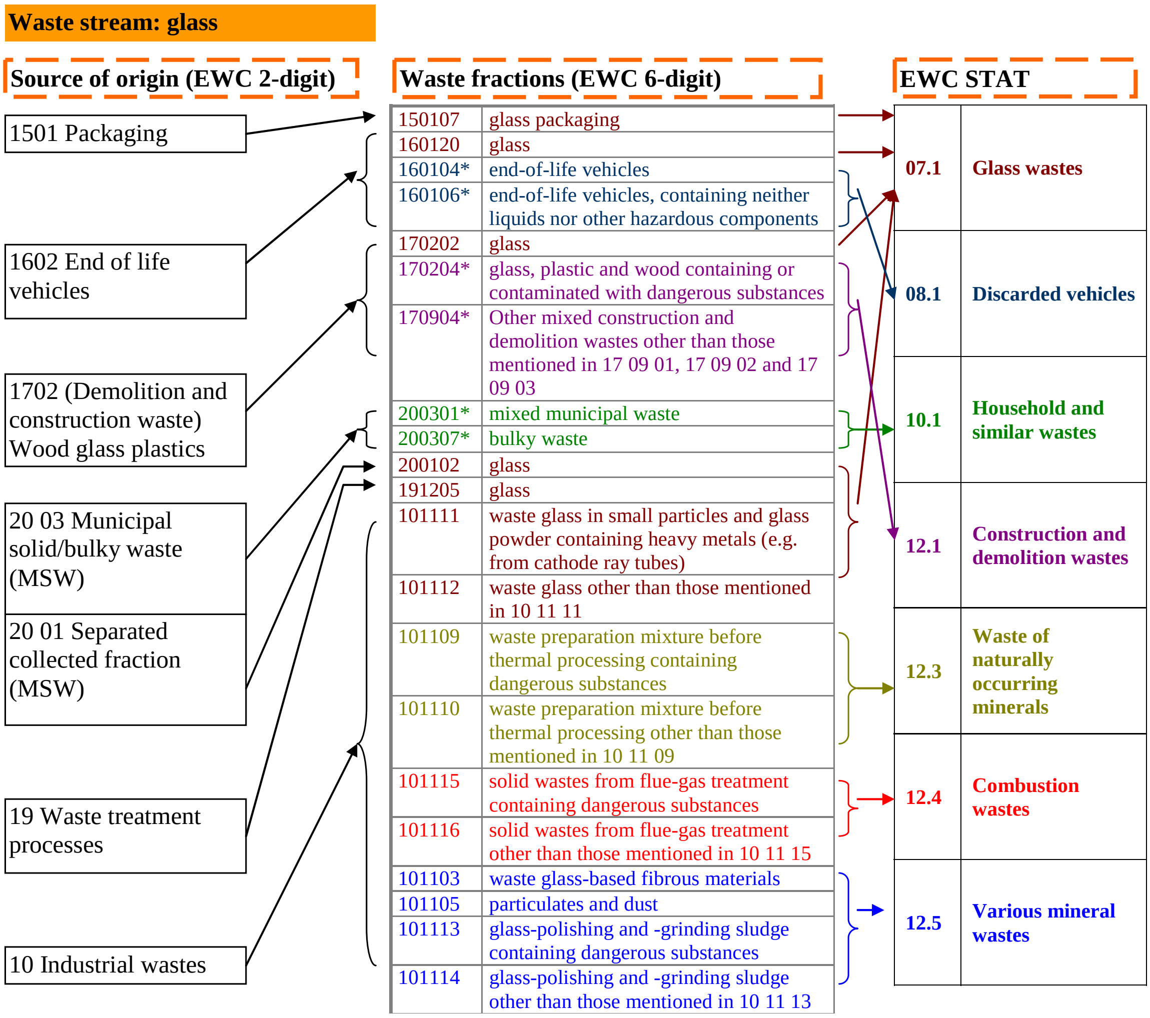
- Reporting obligations for waste generation or handling exist in several countries only for licensed companies. Therefore, the amount of waste published is either for licensed companies only or extrapolated based on the report of these companies.

- In the current study, several waste streams, such as paper, glass, etc., within the mixed municipal waste were estimated by using the following assumptions:

- The shares of different waste steams within the mixed municipal waste (as EWC 200301) were estimated on the basis of available sorting analysis for the respective member states. It is to be mentioned that the sorting analysis should be done for the total amount of municipal waste generated, which means it should include waste streams reported as "collected separately" for recycling or recovery, which are categorised with different EWC codes. The share of the respective waste stream in the mixed municipal waste is estimated on the basis of sorting analysis and adjusted with data and information reported on the separate collection of the waste stream.

- Under the EWC STAT, data on the mixed municipal waste are available and categorised as the group 10.1 (Household and similar wastes). The group 10.1 also includes bulky waste, street cleansing waste and others. Therefore, it is necessary to estimate the share of mixed municipal and bulky waste within this group before carrying out the sorting analysis for each waste streams.

Figure AII.1. Waste stream identification, example: glass



- For several member states, no complete sorting analyses are available because of missing data on certain waste streams, for instance data on the share of wood and single metals. In these cases estimations for the share of these waste streams are made on the basis of data from similar countries. The grouping of similar countries is done by examine several indicators, such as regional characteristic, economic indicators, and patterns of waste generation and management.

- The waste streams reported under the mixed construction waste is estimated in a similar way as that for the mixed municipal waste. As well, in the mixed packaging waste, the share of the respective waste stream (paper, plastics, aluminium etc.) was estimated in the similar method.

- Furthermore, additional information and data are gathered through internet research. An overview of information sources are provided in the following Table AII.1.

Table AII.1 Overview of information source by country

Country	Used data basis	Additional information*
Austria (AT)	EWC-STAT / ÖNORM	Data submitted to EUROSTAT was compiled from different administrative sources, questionnaires, indirect determinations, studies and mass balances. ÖNORM is a specific Austrian national codification, a special conversion key to EWC was developed. *ÖNORM*

Country	Used data basis	Additional information*
		data were used for verification purposes only No consistent data management on national level. Waste generation is indirectly determined through waste collection and treatment. Data to EUROSTAT was submitted with derogations for agriculture, hunting and forestry, fisheries and services activities (only on the basis of estimations). Exported waste (green list) is not included in waste generation.
Belgium (BE)	EWC-STAT	Data submitted to EUROSTAT were extrapolated on the data basis of Flanders. *Verification of EUROSTAT data were made by national publications and data for Flanders submitted by the Statistical office.*
Bulgaria (BG)	EWC-STAT	Data submitted to EUROSTAT was compiled through estimations based on sampling results and pilot studies. For several waste fractions no single data is available due to confidentiality
Cyprus (CY)	EWC-STAT	Data submitted to EUROSTAT was extrapolated on the basis of several samples and estimations. Data was submitted with derogations for agriculture, hunting + forestry, fisheries and services activities. Cyprus offers no history in data collection (2004 data collection was provided for the first time, for household waste data has been collected since 2002). Waste amounts for household waste are compiled on the basis of collection; treatment amounts only for licensed companies (without internal treatment).
Czech Republic (CZ)	EWC	Data is available to the public on 6-digit-level (source: National Statistical office - NSO), *for the amounts of the EWC waste group 20 we used also data available to the public by the Waste management research-Centre - VÚT . Both sources (NSO and VÚT) differ by ± 2 million tonnes, mainly due to the fact, that data of the EWC waste group 20 published by the NSO don't include waste from households, but only household-like waste from the commercial sector.* Annual statistical surveys are provided, unavailable results are estimated at approx. 5% of waste volumes.
Denmark (DK)	EWC-STAT (partly EWC for hazardous waste fractions)	Existing long-term web-based data basis, but codification according to EWC is at early stage. Annual statistics were produced. Data collection is based on information given by treatment plants. Some of the data is unavailable either because of difference in registration methods (difference between ISAG and NACE codes) or because data on the specific waste categories are not available. Additional statistical information and publications were evaluated.
Estonia (EE)	EWC-STAT (partly EWC for	Data submitted to EUROSTAT were formed for the first time. They are based on questionnaires, surveys and

Country	Used data basis	Additional information*
	hazardous waste fractions)	various other methods. Estimation factors were used and data were extrapolated to reach a full cover. Waste internally treated in households is not considered. Treatment information is mandatory only for facilities with waste permits. No data is available for enterprises with less than 10 employees.
Finland (FI)	EWC-STAT	Data submitted to EUROSTAT is based on several studies, surveys and administration sources. Sampling methods were not used. The Quality report refers to several provisions regarding reliability of data Detailed data for some waste fractions could not be provided due to confidentiality.
France (FR)	EWC-STAT	Data submitted to EUROSTAT was compiled through questionnaires, surveys and the evaluation of administrative sources. Hazardous wastes > 50 t/a have to be declared annually since 2003; since 2005 >10 t/a. Household waste generation was estimated by projection. The amounts for waste treatment are only fragmentary.
Germany (DE)	EWC	Data on 6-digit-level are available for selected waste fractions as input streams into treatment plants. Data collection is under the responsibility of the Federal states. Some data is not published due to confidentiality. Data collection errors are possible due to different demarcations between waste treatment and product.
Great Britain (GB)	EWC-STAT (partly EWC for hazardous waste fractions)	Data is compiled from a number of different sources using a variety of methodologies, like sample surveys, assumptions etc. For the regions England, Wales, Scotland and Northern Ireland there exist different regional data collection systems.
Greece (GR)	EWC-STAT	Data for EUROSTAT is collected by several institutions or associations Derogations exist for the submission of selected data. There is an annual report from the municipal treatment facilities, covering approx. 60% of the population. Another 16 % of population of municipal cities are being reported on by unorganised sites which give rough figures of their wastes. The remaining 24 % of the population is being covered by random data.
Hungary (HU)	EWC	A full scale survey is provided for enterprises with > 10 employees, data for waste generation by enterprises < 10 employees compiled only by attribution.
Ireland (IE)	EWC-STAT	Data submitted to EUROSTAT was composed from several sources (questionnaires, surveys, studies etc.). Information for single fractions like tyres, food packaging etc. is missing. Industrial waste generation was assessed by estimations. Municipal solid waste includes an estimation of non-

Country	Used data basis	Additional information*
		collected fractions.
Italy (IT)	EWC-STAT	Data is based on several questionnaires, targeted surveys and sector specific studies. Several assessment methods were used. The waste volumes generated by industrial branches were estimated on the basis of waste production per member of staff. Calculation of total waste sent for recovery excluded waste treated in certain specific types of facility and, in particular, waste sent to mechanical-biological treatment facilities and facilities for the destruction of end-of-life vehicles.
Latvia (LV)	EWC	Data is available only for municipal and commercial waste. Estimations for industrial and construction sources were not feasible. For single waste fractions the data situation is very unclear, e.g. for waste oils, metal waste and paper & cardboard. Generated and treated wood is not reported.
Lithuania (LT)	EWC-STAT	Data for EUROSTAT was composed by surveys and pilot studies. Several derogations exist for data submission, therefore data basis partly exists only on the basis of estimations. Reporting obligations are only for waste treatment companies, these obligation was widened to waste generators > 12 t/a or > 0.6 t/a hazardous waste. A large part of waste is not weighed due to missing weighbridges, the volumes are only estimated.
Luxembourg (LU)	EWC	Reliable data basis exists for 2004 for EWC codes. The classification is made according to the NACE-code. Reporting obligations exist for all municipalities, waste transporting companies and waste treatment facilities. Double counting of waste quantities (waste transported and waste treated) is still a problem. Possibility of double counting due to high exports could not be excluded.
Malta (MT)	EWC-STAT	The data basis is still not consistent and comparable. Data are available only for engineered landfills. The whole waste generation is not covered. Also hazardous waste data is incomplete. The classification of waste fractions differs between treatment and disposal plants. Existing confidentiality restrictions for publicity (when waste amounts can be attributed to identifiable persons or enterprises)
Netherlands (NL)	EWC-STAT	Definition of national data differs from that of the Waste Statistics Regulation. Therefore data is compiled by many sources using multiple methods; no data is available for EWC code. Web-based data is available at StatLine.
Poland (PL)	EWC	Data was submitted with derogations for agriculture, hunting & forestry, fisheries and services activities.

Country	Used data basis	Additional information*
		Waste holders are obliged to keep records according to EWC-codes. Estimations were made also for households on the basis of collection (not all landfills are equipped with scales, therefore estimations and density factors for conversion from m³ into tonnes were necessary). *Implausibility for selected waste fractions, therefore also other national sources was used for plausibility.*
Portugal (PT)	EWC-STAT	The data basis for waste is fragmentary, *no further sources or information were submitted by the statistical office.*
Romania (RO)	EWC-STAT	Data submitted to EUROSTAT was compiled through estimations based on sampling results and pilot studies.
Slovakia (SK)	EWC	A detailed web-based data basis exists on EWC-code.
Slovenia (SI)	EWC	Data are based on a sample survey, extrapolation and estimations. Collected data is coded on national level according to EWC classification. There is no method for calculating missing data to reach 100% coverage, so data is incomplete. Confidentiality restrictions (if waste amounts can be attributed to identifiable persons or enterprises) exist.
Spain (ES)	EWC-STAT	Several annual surveys were provided with model-based estimations.
Sweden (SE)	EWC-STAT	The statistics on generation, recovery and disposal of waste are based on a comprehensive inventory of waste flows. A variety of methods have been used: questionnaire surveys, waste factors, calculation models and expert assessments. Data were submitted with the exception of certain parts of the service sector, the agriculture, hunting and forestry sector and fishing. Confidentiality restrictions (if waste amounts can be attributed to identifiable persons or enterprises) exist.

* Assessment based also on the evaluation of the Quality Reports for 2004, available at http://circa.europa.eu/Public/irc/dsis/pip/library?l=/wastesstatisticssregulat/data_transmission/quality_statistics&vm=detailed&sb=Title

List of Wastes (formerly *European Waste Catalogue*)

The European Waste Catalogue (EWC) (Commission Decision 94/3/EC) was to be a “reference nomenclature providing a common terminology throughout the Community with the purpose to improve the efficiency of waste management activities”. The EWC according to Decision 94/3/EC was replaced by the European list of waste (LoW) by Commission Decision 2000/532/EC last amended by Council Decision 2001/573/EC. It serves as a common encoding of waste characteristics in a broad variety of purposes like transport of waste, installation permits, decisions about recycling effectiveness
of the waste or as a basis for waste statistics.

Main Reference:

COMMISSION DECISION of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (notified under document number C(2000) 1147) (2000/532/EC)

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:226:0003:0024:EN:PDF

In order to simplify and modernise European waste legislation the Commission has launched a study on the review of the European Waste List (LoW)(1) performed by Ökopol GmbH and ARGUS GmbH. Its objective is

- informing the discussion about the further development of the LoW;
- proposing amendments of the LoW; and
- assessing the impacts of those amendments.

A number of workshops and consultations are planned as part of this project. More information about the project and current activities are available at http://low.oekopol.de .

Table AII.2: The two-digit entry categories of the List of Wastes

01 Wastes resulting from exploration, mining, dressing and further treatment of minerals and quarry
02 Wastes from agricultural, horticultural, hunting, fishing and aquacultural primary production, food preparation and processing
03 Wastes from wood processing and the production of paper, cardboard, pulp, panels and furniture
04 Wastes from the leather, fur and textile industries
05 Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal
06 Wastes from inorganic chemical processes
07 Wastes from organic chemical processes
08 Wastes from the manufacture, formulation, supply and use (MFSU) of coatings (paints, varnishes and vitreous enamels), adhesives, sealants and printing inks
09 Wastes from the photographic industry
10 Inorganic wastes from thermal processes
11 Inorganic metal-containing wastes from metal treatment and the coating of metals, and non-ferrous hydrometallurgy
12 Wastes from shaping and surface treatment of metals and plastics
13 Oil wastes (except edible oils, 05 and 12)
14 Wastes from organic substances used as solvents (except 07 and 08)
15 Waste packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified
16 Wastes not otherwise specified in the list
17 Construction and demolition wastes (including road construction)
18 Wastes from human or animal health care and/or related research (except kitchen and restaurant wastes not arising from immediate health care)
19 Wastes from waste treatment facilities, off-site waste water treatment plants and the water industry
20 Municipal wastes and similar commercial, industrial and institutional wastes including separately collected fractions

9 ANNEX III - BACKGROUND INFORMATION ON END-OF-LIFE TYRES

Source: ETRMA(2007): http://www.etrma.org, (accessed April 2008)

End of life tyres management in Europe

Each year, more than 3.2 million tons of used tyres are generated in Europe. Since 1992 the trends of the different recycling and recovery options have significantly evolved:

- **Material recycling** considerably expanded its share from 5 to more than 34 % in 2006;
- **Energy recovery** has increased from 14 to up to 31.6 %;
- **Retreading** has remained at around 12 %;

The EU total recovery rate rose from 32% to 87 % in 2006.

Table AIII.1 ELTs management in EU27 (aggregate) in 2006

	Arisings	Reuse	Export	Retreading	Material	Energy recovery	Landfill & Unknown
Ktonnes	3.238	110	185	380	1.105	1.023	425
%	100	3,4	5,7	11,7	34,1	31,6	13

Source: ETRMA, July 2007

Table AIII.2. Composition of mixed used tyres – material composition by weight

	Composition of new tyres (BLIC, 2001) (%)	Estimated composition of used tyres (%)
Synthetic rubber	25	22
Natural rubber	17	15
Carbon black	19	15.5
Silica	10	9
Sulphur	1.3	1.5
Zinc oxide (vulcanisation agent)	1.6	1.2
Aromatic oils	6	3.8
Steel wires	11.4	18
Textile fabrics	4.7	14
Other	4	-

ETRMA (2006) indicates heating values for scrap tyres in the range 27-30 MJ/kg, indicating that it is close to that of good-quality coal (coal has higher heating values in the range 25-30 MJ/kg, depending on quality).

Table AIII.3 Breakdown (by country) of ELTs management in EU27 in 2006

http://www.etrma.org/pdf/Used_tyres_recovery_in_Europe_in_2006_ETRMA_national_figures_July_07.pdf

UT/Part Worn Tyres/ELT's Europe - Volumes Situation 2006

Ktonnes (Estimates)		UT	Part-worn tyres			ELT Recovery		Landfill & Unknown	UT Treated %
		Arising	Reuse	Export	Retreading	Material	Energy		
EU15	Austria (e)	55	-	3	3	21	28	-	100%
EU15	Belgium	64		2	5	28	29	-	100%
EU15	Denmark	46	-	3	4	40	-	-	100%
EU15	Finland (e)	44	-	-	2	30	-	-	100%
EU15	France	372	13	13	50	189	107	-	100%
EU15	Germany	585	15	51	59	139	321	-	100%
EU15	Greece	51	1	1	4	37	4	5	92%
EU15	Italy	393	30	35	55	105	145	23	94%
EU15	NL (PC only)	47	8	-	4	27	8	-	100%
EU15	Portugal	89	1	-	23	43	22	-	100%
EU15	Spain	321	1	11	40	60	35	174	46%
EU15	Sweden	88	-	4	16	34	34	-	100%
EU15	UK (e)	486	33	35	57	254	74	33	93%
EU15	Ireland (e)	51	5	1	3	-	-	42	18%
	Norway	43	-	2	-	28	13	-	100%
	Switzerland	54	-	14	7	-	25	8	85%
Subtotal		2.789	107	175	332	1.034	845	285	89%
		100%	4%	6%	12%	37%	30%	10%	

Ktonnes (Estimates)		UT	Part-worn tyres			ELT Recovery		Landfill & Unknown	UT Treated %
		Arising	Reuse	Export	Retreading	Material	Energy		
EU12	Bulgaria (e)	21	-	-	-	-	-	21	0%
EU12	Cyprus (e)	7	-	-	-	-	-	7	0%
EU12	Czech Rep (e)	61	-	-	12	-	19	30	51%
EU12	Estonia (e)	13	-	-	2	-	8	3	77%
EU12	Hungary	42	-	-	-	19	23	-	100%
EU12	Latvia (e)	13	-	-	2	-	8	3	77%
EU12	Lithuania (e)	13	-	-	2	-	8	3	77%
EU12	Malta (e)	1	-	-	-	-	-	1	0%
EU12	Poland	160	-	-	22	24	88	26	84%
EU12	Romania	48	4	0	1	7	22	14	71%
EU12	Slovak Rep	35	-	10	2	21	2	-	100%
EU12	Slovenia (e)	18	-	-	4	-	-	14	22%
EU12	Croatia (e)	18	-	-	-	-	-	18	0%
Total EU12		450	4	10	47	71	178	140	69%
		100%	1%	2%	10%	16%	40%	31%	
Total EU27		3.238	110	185	380	1.105	1.023	425	87%
		100%	3,4%	5,7%	11,7%	34,1%	31,6%	13,1%	

(e) estimate
11 July 2007

Sources: ETRMA

10 ANNEX IV - EXAMPLES OF WASTE EXCHANGES

There are hundreds of organised exchange networks of industrial and municipal waste in Europe. Some of these waste exchanges are organised by non-profit organisations, government, or commerce chambers and it is free or inexpensive for companies to use them, others are run by specialised companies and are financed by a fee for announcement, or are consultancy providers which provide advice to waste producers on potential applications of their waste streams. Some are local, some regional or national, and some international. Some are open to any waste stream, and others are specialised on e.g. metals, food waste, biofuels, electronic and electric waste, or plastics.

With the development of Internet, most waste exchanges are organised as websites where it is possible to post an offer or demand announcement. Waste and product/by-product categories are in most exchanges organised and classified in groups. The economic agreements and demands of details are typically not posted on the website, but agreed among the parties who offer and demand the waste stream.

The following are a few examples of European waste exchanges:

EU	Wastechange	http://www.wastechange.com/
EU	Euro recycle net	http://euro.recycle.net/
CH	Abfallboerse Schwiez	http://abfallboerse.ch/
SE	KMI Kemimäklarna International	http://www.kemimaklarna.com/
DE	EUWID Recyclingbörse	http://www.euwid-recycling.de/recyclingboerse.html
DE	IHK-Recyclingbörse	http://recy.ihk.de/
DE	Rohstoff- und Recyclingbörse	http://www.stutensee.com/rwr/recyclingboerse/
AT	Bundes abfall- und Recyclingbörse	http://portal.wko.at/wk/startseite_th.wk?SbId=1164&DstId=7067
AT	Altwaren Markt	https://www.wien.gv.at/webflohmarkt/internet/
DK	Green Networks Genbrugskatalog	http://www.greennetwork.dk/custom/genkat/index.htm
UK	DETR Material Information Exchange	http://www.salvomie.co.uk/
Worldwide	Recycler's exchange	http://www.recycle.net/
UK	Waste Exchange Service	http://www.thewesgroup.co.uk/
NL	Dutch Waste Exchange	http://www.reststoffenbeurs.nl/
DE	Plasticker	http://plasticker.de/
DK	Affaldsbørsen	http://www.affaldsboers.dk
ES	Bolsa de subproductos	http://www.subproductes.com/
FR	Bourse des dechets	http://www.bourse-des-dechets.fr/
IT	Borsa rifiuti	http://www.borsarifiuti.com/
DK	Combineering	http://www.combineering.dk/
NL-EU	Biomass trading floor	http://www.bioxchange.com
ES	Bolsa de residuos	http://www.camaras.org/bolsa/

NOTE: Websites last accessed June 2008

11 ANNEX V – ESTIMATION OF C&D WASTE AMOUNTS

Own estimations based on Boehmer (2008)

Member State / Region	Year	Arising (Million tons)	% Re-used or recycled	Mt	% Incinerated or landfilled	Mt	Un known	Population	Generation per capita	
United Kingdom – England	2005	89,60	80	71,7	20	18	0	59699828	1,682	
United Kingdom- Scotland	2003	10,80	96	10,4	4	0	0			
Germany	2002	73,00	91	66,4	9	7	0	82531671	0,885	
France	2004	47,90	25	12,0	75	36	0	62251817	0,769	
Italy	2004	46,50	60	27,9	40	19	0	57888245	0,803	
Spain	2005	35,00	15	5,3	85	30	0	42345342	0,827	
Netherlands	2005	25,80	95	24,5	3	1	2	16258032	1,587	
Sweden	2006	11,00	85	9,4	15	2	0	8975670	1,226	
Belgium-Flanders/total	2006	9,00	92	8,3	8	1	0	10396421	1,183	
Belgium Wallonia	1995	2,10	74	1,6	17	0	9			
Belgium-Brussels	2000	1,20	59	0,7	22	0	19			
Czech Republic	2006	8,40	30	2,5	70	6	0	10211455	0,823	
Luxembourg	2005	7,80	46	3,6	54	4	0	454960	17,144	
Austria	2004	6,60	76	5,0	16	1	8	8140122	0,811	
Denmark	2003	3,80	93	3,5	7	0	0	5397640	0,704	
Portugal	1999	3,00	5	0,2	95	3	0	10474685	0,286	
Estonia	2006	2,40	73	1,8	27	1	0	1351069	1,776	
Ireland	2005	2,30	43	1,0	57	1	0	4027732	0,571	
Poland	2000	2,20	75	1,7	14	0	11	38190608	0,058	
Greece	1999	2,00	5	0,1	95	2	0	11040650	0,181	
Finland	2004	1,60	54	0,9	46	1	0	5219732	0,307	
Slovenia	2005	1,10	53	0,6	47	1	0	1996433	0,551	
Lithuania	2006	0,60	73	0,4	27	0	0	3445857	0,174	% assumed like in EE
Bulgaria	estimate	6,42	30	1,9	70	4	0	7801273	0,823	% and generation assumed like in CZ
Cyprus	estimate	0,13	5	0,0	95	0	0	730367	0,181	% and generation assumed like in GR
Hungary	estimate	8,32	30	2,5	70	6	0	10116742	0,823	% and generation assumed like in CZ
Latvia	estimate	2,26	73	1,7	27	1	0	2319203	0,975	% and generation assumed like in EE and LT
Malta	estimate	0,07	5	0,0	95	0	0	399867	0,181	% and generation assumed like in GR
Romania	estimate	17,86	30	5,4	70	13	0	21711252	0,823	% and generation assumed like in CZ
Slovak Republic	estimate	4,43	30	1,3	70	3	0	5380053	0,823	% and generation assumed like in CZ
TOTAL (Mt)		433		272		160				

12 ANNEX VI – UNITARY ENVIRONMENTAL SAVINGS OF RECYCLING AND ENERGY RECOVERY

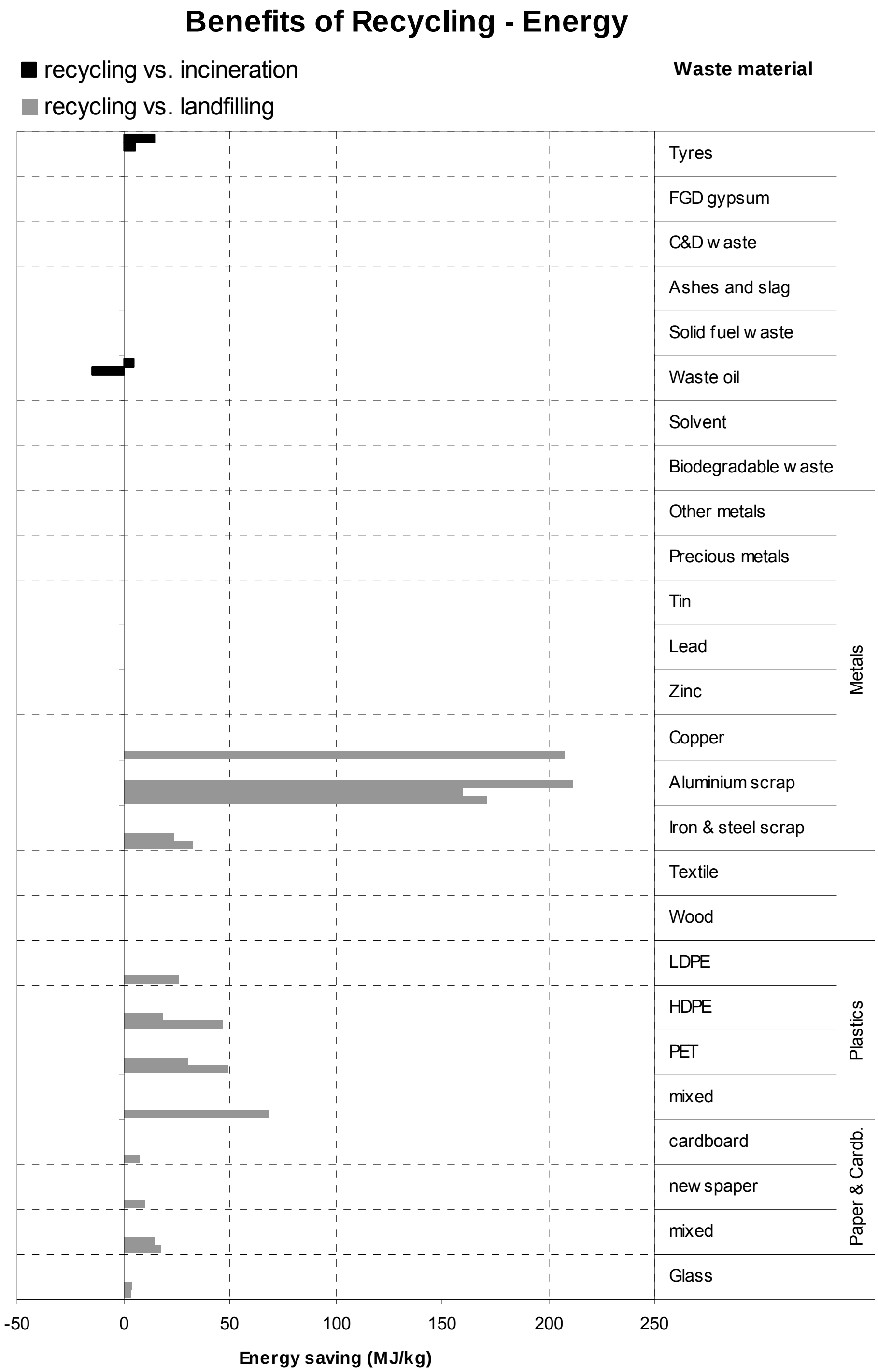


Figure 169. Results of the energy indicator in LCA studies that compare material recycling vs. energy recovery(black) or recycling vs. landfilling (grey). Positive figures in the x-axis mean the comparison is in favour of recycling.

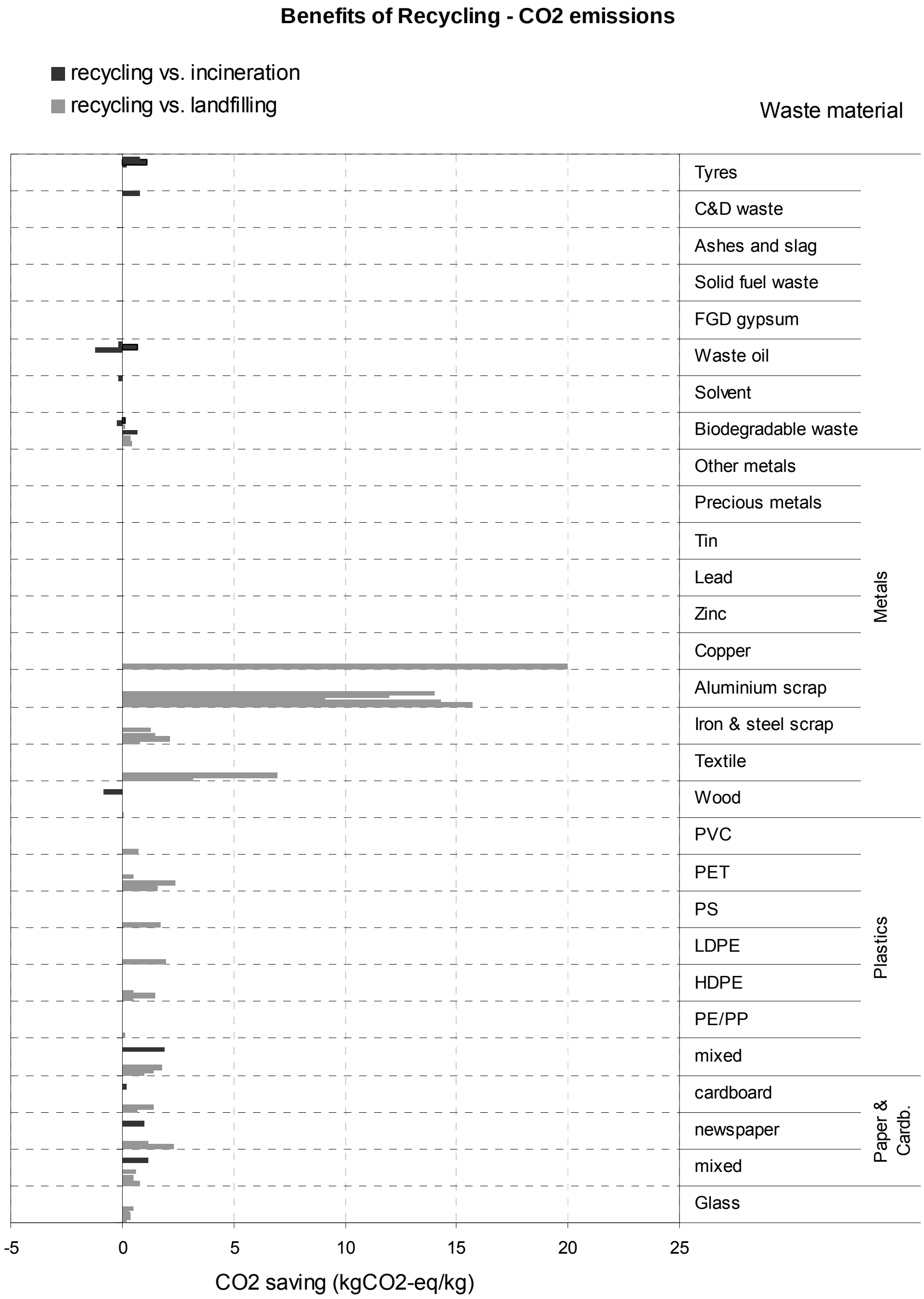


Figure 170. Results of the GHG indicator in LCA studies that compare material recycling vs. energy recovery (black) or recycling vs. landfilling (grey). Positive figures in the x-axis mean the comparison is in favour of recycling.

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Abstract

The revised Waste Framework Directive (2008/98/EC) introduces the possibility that certain waste streams that have undergone a recovery operation can cease to be waste, if they fulfil certain criteria - so-called End-of-waste (EoW) criteria. These criteria have to be developed, and they are to ensure that the waste streams fulfil a number of conditions spelled out in teh Directive, including existence of a commonly used specific applications, existence of a market or a demand, fulfilment of technical requirements for the specific applications, meeting existing legislation and standards applicable to the products the waste streams substitute, and absence of any overall adverse environmental or human health impacts.

This report is a contribution to the development and implementation of the concept of End-of-waste (EoW) in EU legislation. The report presents a list of waste streams currently traded in the EU27 that are suitable candidates for a detailed assessment of EoW criteria. Suitability has been evaluated against a number of operational and transparent, mainly quantitative selection criteria, which have been developed to reflect to the extent possible the fulfilment of the conditions of market, specific applications, legislation and standard compliance and environment required by the Waste Framework Directive.

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