JRC Scientific and Technical Reports

End-of-Waste Criteria

Final Report

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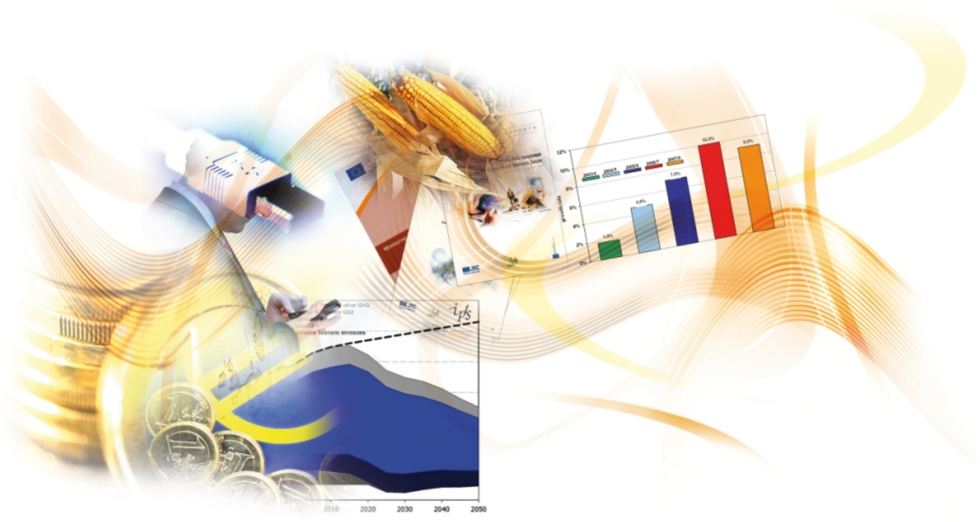

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PREFACE

This report is a contribution to the development and implementation of the concept of end-of-waste. The concept was introduced by the Thematic Strategy on the prevention and recycling of waste, adopted by the European Commission on 21 December 2005, proposing that the revision of the Waste Framework Directive to clarify under which conditions, at European Union level, waste could cease to be waste and could be regarded as a non-waste material to be freely traded as such on the open market.

The revised Waste Framework Directive adopted by the European Parliament and the Council of the European Union on 20 October 2008, contains provisions to define end-of-waste criteria that provide a high level of environmental protection and an economic benefit. Specifications and requirements should be developed in accordance with certain conditions described in the directive to check if specific waste streams have reached an end-of-waste status after a recovery operation.

In this context, on request from the European Commission’s Directorate-General for the Environment, IPTS has developed a general methodology analysing the principles according to which the criteria should be set up and providing the related analytical and impact assessment frameworks required to determine end-of-waste criteria.

The development of general methodology has been a parallel process together with the development of potential end-of-waste criteria for three pilot case studies, aggregates, compost, and aluminium and steel scrap. Its refinement is based on the work developed to determine a set of potential end-of-waste criteria for these three materials. These three materials are significantly different in terms of market and environmental risks associated. The general methodology encompasses these different aspects in a general way, in order to enable its future application to any kind of waste stream candidate for end-of-waste criteria.

The criteria proposed within the pilot case exercises do not prejudge under any circumstance future work which could be undertaken to develop end-of-waste criteria in the context of the implementation of the provisions of the Waste Framework Directive. The case studies have been conducted solely with the purpose of facilitating and illustrating the development of the general methodology.

The findings presented in this report are the result of different types of research and approaches. A literature review and assessment was done in order to understand the current practices in the EU. Numerous contacts and six workshops with experts and stakeholders as well as site visits helped to identify the different views on the end-of-waste concept. Two external contracts have been launched to gather quantitative data on the waste stream situation and generation potential on aggregates and compost. The results of the external studies conducted by the Austrian Umweltbundesamt for the case study on aggregates and by the Organic Recovery & Biological Treatment Association together with the European Compost Network (ECN) for compost are accessible on the JRC-IPTS website.

IPTS has, in the same context, carried out a complementary study to propose waste streams suitable for end-of-waste criteria based on operational selection criteria according to the principles of the Thematic Strategy on the prevention and recycling of waste as well as the revised Waste Framework Directive. For the waste stream selection, specific research on candidate waste streams was done relating to arisings on a European level, processing techniques and associated environmental issues to each waste stream. The gathering of this data was outsourced by means of an external contract to the Institut für Umweltforschung of Dortmund University and Prognos AG (Berlin). Based on this work and on the application of operational selection criteria, a list of the waste streams suitable for end-of-waste criteria has been elaborated. The outcome of this study is presented in a separate report.

This report is divided into four chapters. The first chapter presents the general methodology for determining end-of-waste criteria. The three following chapters concern respectively the findings of the compost, aggregates and scrap case studies.

The case studies have been conducted solely with the purpose of illustrating and facilitating the development of the general methodology. The development of the case studies took on different types of research. A desk research and literature review was done in order to identify the current practices on EU level. Numerous contacts with the industry, site visits and six workshops helped to identify different views on the concept of end-of-waste. Two external contracts were launched to gather quantitative data and the generation potential on recycled and secondary aggregates and compost.

EXECUTIVE SUMMARY

Background

The Thematic Strategy on the prevention and recycling of waste, adopted in 2005 by the European Commission, proposed to clarify when a waste ceases to be a waste and could be dealt as a recovered material. The Waste Framework Directive, adopted in 2008, contains a provision to define, at an EU level, end-of-waste criteria under which waste could cease to be waste, and could be regarded as a material freely traded in the open market.

The purpose of defining end-of-waste criteria is to facilitate and promote recycling, while ensuring a high level of environmental protection, reducing the consumption of natural resources and the amount of waste sent for disposal. Currently, the recycling of certain wastes is sometimes hampered by several factors that could be overcome by determining when a waste ceases to be a waste and becomes a secondary product.

The lack of harmonisation creates legal uncertainty for waste management decisions and for the different actors dealing with specific waste streams, including producers and users of the recycled material. Some Member States have developed different, and not always compatible, frameworks for regulating the recovery and reuse of secondary materials. In some cases, materials generated in one country are not considered to be wastes; however, if transported to countries with different regulatory approaches, they might be considered wastes and require waste management control, hampering the functioning of the internal market. Consequently, producers and users tend to restrict themselves to national markets avoiding administrative and judicial costs or risks of an unclear waste status of the materials.

The legal uncertainty also affects the investment decisions on new treatment capacities for the management of waste. Such uncertainty comes at a cost when it hinders the development of the recycling sector where, in fact, conditions would exist for a waste to cease to be waste.

The waste legislation imposes controls on the reuse of secondary materials, in order to protect human health and the environment in their collection, transport, treatment, storage and tipping. These administrative burdens in some cases might not be necessary where little risk is involved and the certainty of use is guaranteed. Removing the administrative burdens, by changing the waste status of the material when it is not necessary, may be an economic incentive encouraging the recycling and reusing of wastes.

For certain wastes, end-of-waste criteria can promote the production of higher quality secondary products by defining technical and environmental minimum requirements to be fulfilled by the materials. Information on the product characteristics facilitates their comparison and may enhance the final quality of the final product leading to an increase in their demand and a positive on the recycling rates.

The use of waste in replacement of primary materials, in particular if used by final consumers, is often prevented by the waste status of the material. Waste is associated with discarding and users may fear to use waste instead of primary materials with a predicted quality. End-of-waste may help to alleviate any user prejudice, to increase the confidence of the users on quality standards and to encourage the use of secondary materials.

Objectives

The objective of this report is to provide a general methodology that structures the task of defining criteria for when a waste ceases to be a waste. The general methodology can then be applied on specific waste streams, resulting in end-of-waste stream specific criteria.

In order to develop a robust and coherent methodology applicable on waste streams, its development has been carried out in parallel with the development of three pilot case studies, focusing on three different waste streams, significantly different concerning the environmental risks and market issues. The objective of the three pilot case studies was to define end-of-waste criteria for each of the waste streams, based on technical and scientific analysis.

The concept of end-of-waste

The revised Waste Framework Directive ([1]) establishes certain conditions that have to be complied with by the end-of-waste requirements. A given waste may only cease to be a waste if:

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

Compliance with the two first conditions ensures that the material or substance is more likely to be put to a useful purpose and less likely to be discarded. These two conditions prevent the definition of end-of-waste criteria for materials for which demand and market are not yet developed. The third condition requires that a substance or object can only cease to be waste if it is fit for lawful use. Once it ceases to be waste, it would be covered by the legislation applicable to products; therefore end-of-waste would only apply if the use of the material is lawful. The fourth condition means that the use of the materials or object does not merit the application of the waste legislation. A comparison between the environmental impact of using the substance or material under the waste legislation and its use under the non-waste product legislation should be done to assess the overall impact of the end-of-waste criteria.

End-of-waste criteria are all the requirements that have to be fulfilled by a material derived from waste, and which ensure that the quality of the material is such that that material will not be discarded and its use is not detrimental for human health and the environment.

The concept of end-of-waste criteria implies that the waste material has reached a stage of processing whereby it has an intrinsic value, so it is unlike to be discarded (the very definition of waste) and has been processed to a point at which its use does not represent a risk to the environment.

([1]) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste.

End-of-waste criteria will not be applicable to all wastes but only to specific waste streams for which end-of-waste criteria can be developed, agreed and adopted within the provisions of the Waste Framework Directive.

End-of-waste criteria do not intend to address decisions concerning strategic waste management options. The objective is to define technical criteria for determining when a waste ceases to be a waste, without endangering the environment. End-of-waste criteria are a tool to help improve recycling by determining when a waste ceases to be a waste, independently from the waste management option chosen.

The end-of-waste criteria do not exclude materials from being recycled. If a material does not meet the end-of-waste requirements, this does not imply that the material cannot be recycled and needs to be disposed. Materials not fulfilling the end-of-waste requirements can be recycled and reused under the waste regime.

Guidelines for the analysis of waste stream

In order to have a sufficient judgement basis for proposing end-of-waste for a certain waste stream, a large amount of detailed information needs to be analysed. For any given material, it is fundamental to identify all relevant material flows, current and potential uses of secondary materials, processes applied, relevant national and international legislation in place, standards and user specifications. It is also important to present the market situation and estimations for its evolution. The information needs to also include the economic and technical viability of producing secondary materials fulfilling end-of-waste requirements, the competing materials in the market, and non-waste legislation related to the use and the management of the material. The data should demonstrate compliance with the fundamental principles of end-of-waste, and to draw conclusions on suitable end-of-waste criteria.

The elements of end-of-waste

The conditions set out in the Waste Framework Directive, the rationale for the establishment of end-of-waste criteria and the detailed data collected are the basis for the elaboration of the operational end-of-waste criteria through a number of steps. The main target of the criteria is to ensure the fulfilment of product quality requirements; however, in some cases it may prove to be more effective in technical and economic terms to define requirements on the quality of the source materials or on the treatment process. The end-of-waste criteria may be defined at one or more stages of the recovery chain. The level of detail and complexity of the assessment on each element of the chain will vary from waste stream to waste stream.

Input material

Some waste types, especially post-consumer waste, are of heterogeneous composition and may contain contaminants bearing a potential risk of contamination should these be released to the environment. In some cases, end-of-waste criteria may include requirements or limitations at the source of the waste. In general, it is necessary to identify hazardous substances associated with each waste stream. It must be determined if the hazard associated with the particular waste stream can be adequately controlled in the processing, or substances need to be excluded at source. If so, the end-of-waste criteria have to include requirements to the input material, which can ultimately influence product quality.

Processes and techniques

The processing and the techniques can be used as part of end-of-waste requirements, as they influence the product quality. Process control parameters (e.g. temperature, residence times, pH) necessary to guarantee that a specified material quality is achieved may be used as part of end-of-waste requirements. In some cases, processing control parameters may not be required where the product quality can be guaranteed by source control and/or by defining product quality requirements.

Product quality

In order to compete on specific markets, the processed material will have to meet quality standards and often the material will need to be tested to demonstrate compliance with the applicable quality standards.

It is also necessary to assess how non-waste (i.e. product) legislation deals with the environmental risks associated with secondary materials, and to compare it with the environmental protection provided by waste legislation. Arising from this analysis, additional product quality requirements, such as pollutant limit values or maximum content of impurities may be part of the end-of-waste requirements, to ensure that risks are reduced or minimised.

Potential applications

End-of-waste criteria cannot regulate or control the use of the materials. The inclusion in end-of-waste requirements of conditions for use would contradict the goal of reducing administrative barriers by imposing a regulatory burden similar or even greater than under the waste legislation regime.

However, an analysis of potential uses is required in order to conclude on a potential market or demand and to assess the environmental risks associated with such uses. If returned to a manufacturing process, the material is most likely covered by other community legislation such as the Integrated Pollution Prevention and Control (IPPC) Directive. In other cases, the material is used directly in contact with the environment e.g. compost or aggregates. The use of these materials is covered by non-waste legislation that must be fulfilled as part of end-of-waste requirements. The producer must label the material indicating its suitability for specific uses described in standards, and if appropriate, its unsuitability for other purposes.

Quality control procedures

If conditions on source control, processing parameters and product quality standards are defined as part of end-of-waste requirements, these should be under acknowledged quality control procedures in order to guarantee the actual fulfilment of end-of-waste product quality requirements.

Guidelines for the impact assessment

A part of the general methodology is to assess the potential impacts associated with the end-of-waste criteria, to guarantee that the prerequisite principles for defining end-of-waste are met. The impact assessment analysis should compare an ‘end-of-waste scenario’ to a ‘no action scenario’.

Environmental and health impact

The assessment should use life cycle thinking covering all environmental and health impacts, through all environmental media. As far as possible state-of-the-art impact assessment methods should be used, applying as appropriate pressure, midpoint or end point impact categories.

The assessment should focus on the direct and indirect effects associated with criteria once the substances or material cease to be waste. Direct effects associated with the criteria are the introduction of pollution concentration limits and other criteria influencing the product quality, as well as change in the regulatory controls and the product market situation. Indirect effects associated with the criteria are changes in process-related emissions due to product quality requirements which might lead to an increase in emissions of pollutants,

The approach of the assessment is to calculate the differential between an ‘end-of-waste scenario’ and a ‘no action scenario’, meaning it will often not be necessary to calculate absolute indicator values for environmental impacts. The overall balance of the differential must not be negative, and preferably be clearly positive, otherwise the proposed end-of-waste criteria would need to be revised or rejected.

Economic impact

The direct costs and benefits should be analysed and compared both for a case where materials comply with the end-of-waste criteria and for a case where materials of the same type do not comply with the criteria, remaining as wastes until the ultimate use.

The fulfilment of end-of-waste conditions has additional costs associated which will have an impact on the final price of the non-waste product. However, by fulfilling the criteria the material is no longer a waste; it is a product with an increased value favouring consumer’s acceptance. Changes in costs and benefits throughout the recovery chain due to end-of-waste requirements will influence the price of the final product, and this should be quantified as far as possible.

Market impact

The market impact assessment analyses how supply and demand would change as a consequence of introducing end-of-waste criteria to the material streams in the EU. The market impact assessment should cover both materials that comply with the end-of-waste criteria and materials of the same type that do not comply. The assessment should also identify possible winners and losers as the result of introducing the criteria, and how the market for alternative materials would be affected.

Legislative impact

With the end-of-waste criteria, the material or substance is no longer under the waste legislation. The legislative analysis should cover two different aspects: (a) legislation or regulations not applicable to waste that will apply once the material ceases to be a waste, and (b) legislation associated with products, and will apply regardless of the material being a waste or not. In certain Member States, and for certain waste streams, there exists specific national legislation defining end-of-waste criteria. It can be foreseen that such legislation would have to be adapted once the EU end-of-waste criteria are introduced.

Other socioeconomic impacts

With the introduction of end-of-waste, at least two main socioeconomic impacts can be expected. One regards source separation and separate collection of waste that may require additional involvement and collaboration with the waste producer. The other concerns product acceptance because, with the end-of-waste criteria, it can be expected that perception of the consumer will change; the material or substances no longer being labelled waste, having passed stringent product quality requirements to replace the use of primary materials.

Operational procedure

As part of the methodology, this report includes a description of the operational procedure to gather and analyse all the needed background information. This procedure should include an initial investigation to identify relevant waste streams, treatment processes, potential uses and applicable standards and legislation. Based on this it should be possible to conclude if there is a basic need for developing end-of-waste criteria. If so, the next step is a detailed impact assessment, including the main environmental and human health risks, economic, social and legislative impacts, and market issues associated with the change of status. This analysis should identify key elements potentially affected by the change. An expert group consultation should provide feedback and test the initial findings, or require the provision of additional information. Ideally, the expert group should be composed of experts from industry, academia and Member States authorities, bringing the necessary information, knowledge and manifold insights to the end-of-waste discussion. Based on the conclusions and feedback from the expert group consultation, it should be possible to draft an end-of-waste proposal and potential impacts. The expert group should comment on it and a final version should be prepared. It is important to bear in mind that the results of any such study could only become effective after formal adoption process following the regulatory procedure foreseen in the revised Waste Framework Directive.

Case studies

The three pilot cases are research-based projects that have been undertaken with the purpose of helping the development of the general methodology. The main findings served as input for the development of the general methodology. The waste streams selected do not take precedence in the decision of which waste will undergo end-of-waste criteria definition.
The work carried out in these three pilot cases does not predetermine the shape of any future end-of-waste criteria definition on these streams, which has to follow the provisions described in the Waste Framework Directive.

The case studies provide the necessary reference information to propose a set of end-of-waste criteria. The level of information required varies significantly depending on the case study under consideration. The background information addresses the different aspects of the generation, processing and marketing of the three waste streams and the resulting secondary materials. The cases also provide a description of technical aspects of the recovery processes, and the alternative treatment options. Moreover, it identifies different potential uses, the environmental and health impact of production and use, and the relevant legal framework and standards.

The central part of the case studies is the analysis of the rationale for end-of-waste criteria, i.e. the advantages it may deliver compared to the current situation. The cases analyse if and how the basic general conditions for the criteria can be fulfilled and propose a possible set-up of compost end-of-waste criteria accordingly.

The last part of the case studies is an assessment of the impacts of the proposed end-of-waste criteria compared to a ‘no action scenario’. The assessment covers the environment and health impacts, the economic impact, the market impact and the legislative impact.

CHAPTER 1 Methodology for determining end-of-waste criteria

1.1 Introduction

The Thematic Strategy on the prevention and recycling of waste was adopted by the European Commission on 21 December 2005. Notwithstanding the continuing priority to prevent the generation of waste where possible, one element of the proposals within the thematic strategy is a revision of the Waste Framework Directive including clarification of certain conditions under which, at EU level, waste could cease to be waste and could be regarded as a non-waste material to be freely traded as such on the open market. Through this approach, the intention is to promote more recycling and use of waste materials as resources, reduce consumption of natural resources and reduce the amount of waste sent for disposal. The principal definition of waste remains as something which is discarded is intended to be discarded or is required to be discarded.

EU waste legislation exists to protect the environment and human health from harm caused by the improper management and disposal of waste. Powers exist to regulate the processing, storage, transport and use or disposal of waste material.

Over recent decades there have been many efforts by authorities and companies to improve and promote waste reutilisation and today such activities are a principal activity of the waste management industry. Increasingly, various waste streams are now produced, managed and/or treated to produce a material fit for further use and acceptable by one or more users. Markets have been established and some standards developed for such material which can be a waste used as waste in accordance with waste legislation, or a waste that, after fulfilling certain requirements, is used as a non-waste material outside of waste legislation.

As a general principle, end-of-waste criteria would reflect that a waste material has reached a stage of processing whereby it has intrinsic value, so that it is unlikely to be discarded as a waste and it has been processed to a point at which its use does not represent a risk to the environment which would otherwise merit regulating the material as a waste. Compliance with formally adopted end-of-waste criteria would deem the material non-waste across the EU and would preclude the case-by-case classification of the material as a waste unless, at some point, it again meets the principal definition of waste. It is important to note that end-of-waste criteria will not be applicable to all wastes but only to specific waste streams for which end-of-waste criteria can be developed, agreed and adopted within the provisions of the Waste Framework Directive.

Potential users of a material which satisfies a set of end-of-waste criteria should be able to have increased confidence on the quality standards of the material and this may also help to alleviate any user prejudice against material simply because it is derived from waste.

End-of-waste as a concept already exists in some Member States. It has been observed that some Member States have effectively introduced schemes under which waste ceases to be waste and is then used outwith the waste legislation. Such change of status is generally on the basis that the wastes fulfil certain criteria including a test of quality and fitness for purpose. It is also observed that some Member States allow the utilisation of similar material in specific applications but it retains its waste status until the point of use and is subject to waste legislation until that point.

To varying extents, depending on the waste streams in question, existing national schemes require knowledge and control over the waste source, specific processing parameters and ultimate compliance with some technical requirements of one or more users. However, such national schemes have created legal issues where the product material is moved or traded between different administrative regions. There are reported cases where a material is produced at one location and not considered to be waste; consequently, the holder is free to sell and transport the material without waste management controls. Subsequently, the authorities at a border or at the destination of the material do not share the view that the material is not waste; they demand waste related documents and controls over the material and effectively block its movement and reutilisation.

One objective of EU wide end-of-waste criteria is to facilitate movement and trading of suitable material without the risk of its classification as waste on a case-by-case basis within the EU. It is recognised that both products and wastes can have inherent hazardous properties which pose a threat to human health and the environment but in many cases there are alternative environmental protection measures to applying waste legislation.

The methodology and guidelines presented below consist of five parts. Firstly, an analysis of the concept of end-of-waste, of the principles according to which waste may cease to be waste and of the rationale for the determination of end-of-waste criteria. Secondly, a framework for the waste stream analysis including data and information requirements for conducting the entire end-of-waste criteria analysis. Thirdly, guidance on how a set of end-of-waste criteria can be developed in a way that ensures that each of these principles is respected. Then the relevant impact assessments that need to be considered and how these impact assessments should be carried out are discussed. Finally, since it is envisaged that the development of the end-of-waste criteria would be a process involving different stakeholders at various stages, an operational procedure is proposed.

It is important to note that this methodology does not address strategic waste management issues in the sense of comparing or promoting various options for recycling, use or disposal of any waste stream. The basic aim of the methodology is simply developing criteria for the removal of the classification of a material as waste in order that it is thereafter treated as a non-waste product. Any comparison of options is therefore limited to use of a material as waste compared to the use of a material as a non-waste product.

The methodology here proposed is not an instruction that can be strictly applied for the analysis of different waste streams and for the definition of the end-of-waste criteria for each candidate material. This will not be possible given the large differences in properties and application options of waste flows currently observed in the EU. Rather, this methodology is designed, and should be used, as a guideline, its core being a set of elements considered necessary for defining end-of-waste criteria, but which application in practice is flexible.

The elaboration of end-of-waste criteria to a given waste stream is envisaged as the task of a technical working group, convened for the purpose, which shall ideally gather experts from industry, academia and Member State authorities to ensure a robust outcome. The definition of end-of-waste criteria involves in most cases a preliminary step of detailed analysis and synthesis of large amounts of information on technology, economy and markets, legislation, environment and social acceptance.

1.2 Concept of end-of-waste

The revised Waste Framework Directive (WFD) ([2]) includes a provision by which certain specified waste shall cease to be waste when it has undergone a recovery ([3]) operation and complies with specific criteria developed in accordance with a number of conditions. These conditions are:

(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;*

(d) *the use of the substance or object will not lead to overall adverse environmental or human health impacts.'*

The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.'

The criteria shall take into account any risks of environmentally harmful use or shipment of the substance or object, and shall be set at a level that guarantees a high level of protection for human health and the environment.

The first two conditions above are complementary and compliance with these ensures that the substance or object is more likely to be put to a useful purpose and is less likely to be discarded. These two conditions preclude the establishment of end-of-waste criteria for material for which uses and demand are not yet developed. Indicators of compliance with these two conditions include the existence of trade between supplier and user; normally a verifiable positive market price paid for the substance or objects and, linked to the third condition, the existence of standards or specifications used for trading. The existence of recognised standards and specifications for trading, as it is for instance the case for metal scrap, is a clear indicator in favour of end-of-waste in these cases.

The third condition requires that a substance or object can only cease to be waste once it has become fit for use without any further waste-related processing or handling. In essence, once a substance or object ceases to be waste it would be covered by legislation and standards applicable to products and end-of-waste can only apply if the subsequent use of the substance or object would be lawful. Indicators for compliance with this condition include compliance with any equivalent technical standards and specifications applicable to primary raw materials used for the same purpose. End-of-waste could not apply if the substance or object in question requires special measures or processing which would not be required for equivalent primary raw materials. In the case of recycled or secondary aggregates, compliance with the requirements of the Construction Products Directive is one indication in favour of end-of-waste for those recycled or secondary aggregates.

([2]) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste.

([3]) The term 'recovery' is used in this report with the definition spelled out in Article 3 of the revised Waste Framework Directive, that is, 'any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy.' Annex II of the Directive sets out a non-exhaustive list of recovery operations. Following this definition, the term 'recovery chain' is used in this report to describe the stepwise processing of a waste until it is fit for replacing other materials, see also Figure 1: Recovery chain and the possible points of intervention of end-of-waste criteria for an end-of-waste candidate product or material.

The fourth condition basically requires that the substance or object in question does not merit application of waste legislation to protect human health or the environment. As above, if a substance or object ceases to be waste then it is covered in respect of risks to human health and the environment as a product. To assess compliance with this condition it is necessary to compare the use of the substance or object under the relevant product legislation to the use of the same under waste legislation. Inclusion of ‘overall’ implies that a holistic view be taken in such a comparison and life cycle thinking should be used to infer compliance or otherwise.

The existence of a market or demand and the purposes for which the substance or object is used will never be explicitly part of any technical requirements within end-of-waste criteria. They form part of the background and are thus demonstrated not in the technical requirements as such but in the analysis of the market and uses prior to development of any technical requirements. Secondly, there is some scope for confusion between ‘technical requirements’ for products to be fit for use in a specific purpose and ‘technical requirements’ which may be developed as part of end-of-waste criteria themselves. The former is more related to the trading of substances or objects and their fundamental fitness for purpose, the latter is potentially imposed under waste management law for a substance or object to cease to be waste. Ultimately it is expected that the final report of a technical working group will have to demonstrate full compliance with the four bullet points of Article 6(1) for any recommendations to be accepted by the Commission and subsequently adopted. However, demonstrating ‘compliance’ with Article 6(1) could be more objective in some cases and more subjective in others. In any case, the technical requirements to be imposed as part of an end-of-waste proposal would only ever address either Article 6(1)(c) or (d) or possibly both.

Definition of end-of-waste criteria

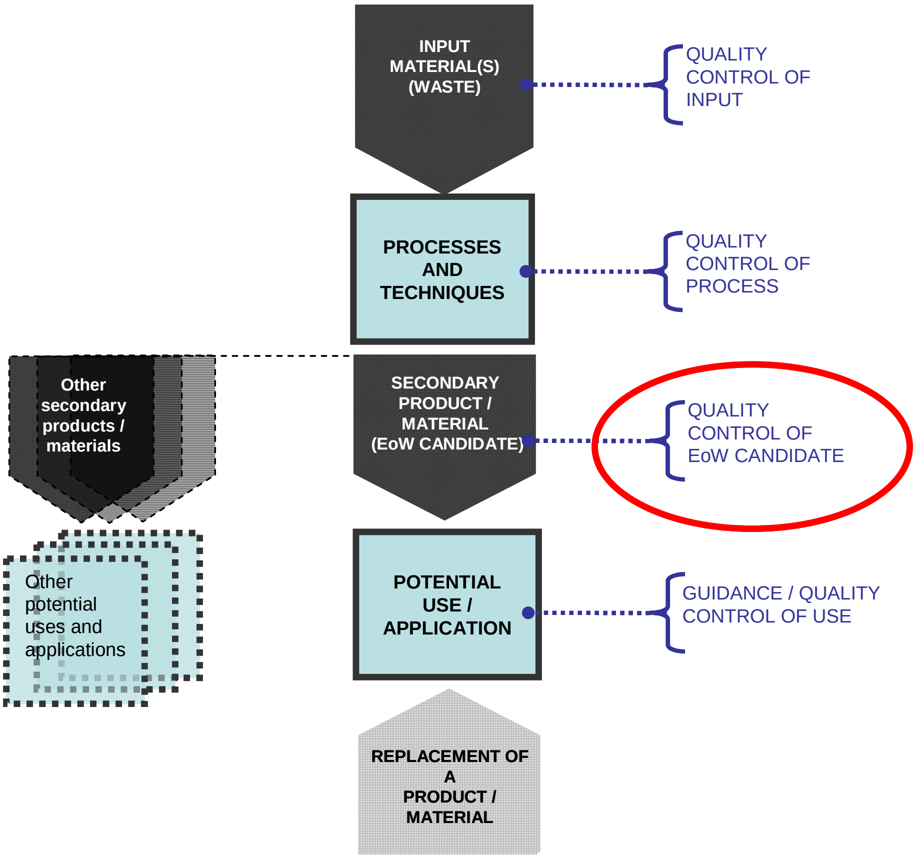
Substances classified as waste cease to be waste when they have undergone a recovery operation and fulfil a number of criteria, so-called end-of-waste criteria, developed according to the basic concepts set out in the four conditions of the WFD described above.

End-of-waste criteria are ***all the requirements that have to be fulfilled by a material derived from waste, and which ensure that the quality of the material is such that its use is not detrimental for human health or the environment.***

Given the different nature of existing end-of-waste candidate materials, and the environmental concerns associated to them, it is obvious that end-of-waste criteria are material-specific, and will be defined individually for different categories of waste and its potential secondary products and applications.

The focus of the criteria is **the quality of the material candidate for end-of-waste** (see Figure 1). However, defining specific characteristics, composition and limit values of pollutants in the secondary material is not the only leverage point available for achieving this, and there are a number of possible options for ensuring this quality, which may be more effective in technical and economic terms. For instance, some end-of-waste criteria may more effectively be defined on the quality of the source waste (e.g. by source separation of materials like construction and demolition waste, paper, or glass), on the processing (e.g. control of temperature in compost) or on the use (e.g. labelling with recommendations for the application of nutrient-containing waste in agriculture).

Figure 1: Recovery chain and the possible points of intervention of end-of-waste criteria for an end-of-waste candidate product or material.



Through the assessment of three case studies on compost, scrap metal and aggregates, it has also been learned that a complete analysis of risks to human health and the environment needs the use of a holistic approach that includes one or more of the following elements of the recovery chain (see also see):

- input materials;
- processes and techniques;
- quality control procedures;
- product quality;
- potential applications or uses.

In some cases, end-of-waste could apply equally to substances and objects from more than one source and in other cases, end-of-waste could apply only to one specific source. By way of example, whether scrap metal is separated at source and is already clean enough for direct reuse or is separated and cleaned in processing to an equivalent standard, basically the same technical standards could apply, it is merely a question of when all the criteria are fully met.

An alternative example is with secondary or recycled aggregates. Whereas it is possible that uncontaminated hard waste from selective demolition, i.e. crushed bricks and concrete, could be considered to be directly fit for use as aggregates without further requirements to prove that they comply with minimum environmental requirements, some ashes and slags could equally be fit for similar use as aggregates but it will have to be proved that they comply with some chemical standards.

However, there are cases where the processing of one waste stream gives rise to a number of output material streams, some of which could be products and some of which would be waste. In these cases, 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 and end-of-life vehicles are typically processed into their component parts before becoming directly fit for a number of further uses and therefore potential candidates for end-of-waste. Tyres can be used whole as filler materials in civil works, as fuel in cement kilns, and as cushioning element in harbours and motorsport circuits. Being that the contact with the environment is different in these applications, not all of them may follow the same end-of-waste requirements. Tyres can also be processed into rubber crumb, steel, and textile; all three with a spectrum of possible uses. 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 or of its processed material fractions. End-of-life vehicles are similarly broken into their component parts of ferrous metals, non-ferrous metals, plastics and low density 'fluff' after decontamination steps to remove fluids, batteries, etc. Again, if end-of-waste is appropriate at all, it would not apply to end-of-life vehicles as such but to the material output streams from ELV (end-of-life vehicles) processing in specific applications.

Rationale of the establishment of end-of-waste criteria

The purpose for defining end-of-waste criteria for a particular waste stream is to facilitate and promote recycling, ensuring a high level of protection of the environment and the economic feasibility of the process.

The recycling of wastes is sometimes hampered by several factors which could be partially or totally overcome by defining a clear border when a waste ceases to be a waste and becomes a secondary product. The paragraphs below, which are based on the analyses carried out in the context of the case studies, discuss in general terms the rationale of adopting end-of-waste criteria as a mean to promote recycling. The reasons to establish end-of-waste criteria will have to be discussed for each waste stream under consideration.

Improve the functioning of the internal market.

The lack of harmonisation may create legal uncertainty for waste management decisions and for the different actors dealing with specific waste streams, including the producers and users of recycled material. The uncertainty arises especially when trade between Member States is involved. Some Member States have developed different, and not always compatible, frameworks for regulating the recovery and reusing of secondary materials. In some cases secondary materials produced in one Member State according to national rules are not considered to be wastes. They are transported and used within the country as products without waste management controls. However, the trade between different countries of these materials may be prevented by a different regulatory approach in the country of destination.

As a consequence, producers and users tend to restrict themselves to the national (or regional) market because they want to avoid the administrative and judicial costs or risks of an unclear waste status of the material. This means that the materials do not always reach the place where they could in principle be used best, i.e. economically and delivering the highest benefits with the proportionally lowest environmental and health risks. The volume of traded, recovered waste could increase with clear rules about when waste ceases to be waste.

The analysis of specific waste streams should show whether European-wide criteria may contribute to eliminate trade barriers and provide environmental and economic benefits.

Increase recycling capacity

The legal uncertainty regarding the status of certain materials can also affect investment decisions on new treatment capacities for waste management. It is reported that material classified as non-waste by one authority has been regarded as waste by another authority thus effectively blocking the use of that material as a non-waste product. Such uncertainty evidently comes at a cost when it hinders the development of the recycling sector in situations where, in reality, the conditions would exist for waste to cease to be waste.

Uncertainties regarding the status of the waste hindering the development of the recycling sector may easily lead to opting for another waste treatment option even if a need and environmentally suitable absorption capacity for the recovered waste exists.

It should be assessed whether harmonised end-of-waste criteria can promote for certain waste streams the development of the recycling sector, by encouraging investments and discouraging other less favourable waste management options.

Remove unnecessary administrative burdens

The waste legislation imposes controls to waste materials in order to protect the human health caused by the collection, transport, treatment, storage, and tipping of waste. In some cases these administrative burdens may not be justified for wastes where little risk is involved and the certainty of use of the material is guaranteed. Administrative procedures associated with the waste status have also an economic impact on the final price of the secondary material. Additionally the administrative burdens associated with the use of the secondary materials (e.g. the need for a waste permit) influence the user’s decision to use secondary material instead of primary materials.

The analysis of specific waste streams should show whether the removal of administrative burdens associated with the change of status of waste, when this status is not necessary, may be an economic incentive encouraging the recycling and reusing of the secondary materials.

Promote higher quality of secondary materials

End-of-waste criteria can promote, for certain waste streams, higher quality of secondary materials by defining the technical and environmental minimum requirements to be fulfilled by these materials. Such requirements may include limit values for pollutants, specifications on properties adding value to the product and, eventually, standardisation in sampling and testing.

Information on product characteristics facilitates their comparison and may enhance the final quality of the products, increase their demand and have a positive impact on recycling rates. In this respect it is important to dispose of reliable and comparable information on the environmentally relevant product properties. Claims made on product properties must correspond closely to the 'real' properties, and the variability should be within known limits. Harmonised end-of-waste criteria may also be an opportunity to promote quality assurance schemes recognised at European level.

The production and use of high-quality material could be encouraged by the end-of-waste criteria, becoming a preferable option compared to lower quality materials for users and operators of recycling plants and in strategic waste management decisions.

Improve user perception

The use of waste in the replacement of primary materials, in particular by final consumers, e.g. compost or aggregates, is often prevented by different prejudices against material simply because it is legally classified as waste. Waste is associated with discarding and users may fear using waste instead of primary material which has a predicted quality.

For those waste streams that are further processed by industry, e.g. waste paper or waste glass, the waste status has, if any, a minor influence in the perception of the user.

End-of-waste criteria may alleviate any user prejudice, increase the confidence of the users on the quality standards of the material and encourage the use of secondary materials instead of the primary materials.

1.3 Waste stream analysis — data requirements

The case studies on compost, metal scrap and aggregates have made it clear that there is a large amount of detailed information which one needs to examine in order to have a sufficient judgement basis for proposing end-of-waste criteria. The data needs include aspects such as the technical and economical viability of producing a material conforming to end-of-waste criteria, competing material in the perceived market and non-waste legislation which would regulate the management and use of the material. Full market and environmental assessments are required to reach robust conclusions on the overall beneficial or detrimental monetary, environmental and health impacts of applying end-of-waste criteria.

A numbering and brief description of the specific data elements considered necessary to prepare end-of-waste criteria are presented in this chapter.

For any given material, it is fundamental to reach a deep understanding on how the recovery chain applies to the material: how collection is structured; the treatment processing involved; the applicable legislation; the utilisation options of the secondary material.

The precise data needs to draw conclusions on possible end-of-waste criteria and to demonstrate compliance with the fundamental principles, expected to vary from case to case. Therefore, in the study of each waste stream it will be necessary to work within the constraints of data availability and accuracy yet follow a practicable structured approach. It should be noted that data collection and analysis is all geared to demonstrating the extent of demand for a material and identifying any risks to human health and environment associated with its storage, transport and use.

1.3.1 Data and information requirements

Background data are required for each waste stream on:

- all relevant material flows;
- current and potential uses of secondary material;
- processes applied;
- relevant national and international legislation in place;
- existing quality assurance schemes;
- standards and end user specifications;
- present market and estimation/scenarios for its evolution.

As far as necessary to draw robust conclusions appropriate for EU measures, data should cover the EU-27 and should cover a representative period of time to demonstrate trends and facilitate some future prediction. It is foreseen, however, that comprehensive data may not be available and expert judgement will need to be applied as to whether there is sufficient data to reach a sound conclusion on each point.

1.3.2 Material flows (eventual sub-streams)

Characterisation of the material flow:

- identification and brief description of material sources;
- information about its typical composition;
- quantitative description (per country, tonnes per year, and per material subclass including a number of preceding years in order to demonstrate trends);
- extent of any separated collection of material;
- amount used per type of application.

1.3.3 Uses

Identify the potential uses for the recycled/secondary materials:

- suitability of the recycled/secondary materials;
- technical limitations, if any, in respect of each possible use;
- potential of recycled/secondary materials to substitute primary/alternative materials.

Quantify the amounts of the alternative materials that are used for the same purpose (kg/year, for each Member State and type of use).

Environmental risks associated with the shipment and use of the recycled/secondary material.

Life cycle issues associated with future uses of recycled/secondary material or the ultimate fate.

1.3.4 Processes applied

Processes/treatments involved in the production of recycled/secondary materials:

- technical description of applied processes and techniques;
- emission levels and consumption of utilities;
- waste streams from the processes.

1.3.5 Relevant legislation

Specifically, in order to inform any conclusion on the impact of proposed end-of-waste criteria and in order to introduce precautionary measures into an end-of-waste proposal, the legislation which would apply to the material either as a waste or as a non-waste and what environmental protection provisions apply from such legislation needs to be well understood.

1.3.6 Existing quality assurance schemes

Information on the key elements of currently applied quality assurance schemes for the production of equivalent or similar materials.

1.3.7 Standards and user specifications

International, national or industry specific standards and user raw material specifications must be satisfied for acceptability for a subsequent use.

1.3.8 Assessment of market (demand)

A description of the market or markets for which the material in question is to be directed and each market to be described in terms of its geographical capacity and its price elasticity.

- Geographical generation potential considering the availability of the input materials and their alternative treatments.
- Amounts of competing materials that are used for the same purpose.
- Potential for substituting natural resources.
- Market potentials for the different uses.
- Absolute price of the recycled/secondary materials and relative to the primary materials substituted.
- Imports/exports potential per country of origin/destination (proximity and the price/transport cost relation analysis).
- Transport potential.
- Analysis of sensitivity to variation in transport costs (fuel).
- Trends, time expectations and critical factors for exploiting market potentials.

1.4 Set of end-of-waste criteria

The conditions set out in the Waste Framework Directive, the detailed data collected as proposed in the previous section and the rationale for the establishment of end-of-waste criteria are the basis for the elaboration through a number of steps of the operational end-of-waste criteria. This chapter presents guiding principles to this aim.

The criteria would ideally be circumscribed to ensure the fulfilment of a number of specifications on the quality of the material candidate for end-of-waste. However, it may prove more effective in technical and economic terms to define end-of-waste criteria on the quality of the source waste, on the processing, or on the use. The end-of-waste criteria may be defined at one or more of the stages of the recovery chain.

The level of detail and complexity of the assessment on each element of the chain will vary from case to case. Each element should be developed both individually, to ensure a robust approach, and holistically to avoid any conflict or duplication between different elements of a set of end-of-waste criteria.

1.4.1 Input material

As waste is inherently a heterogeneous source of material, it is foreseen that, in many cases, end-of-waste criteria for a specific waste stream will include some requirements or limitations as regards the original source of waste material. This could be on the basis of positive listing or negative listing of waste streams or specific characteristics. Such control is seen in certain cases as a fundamental step to reduce the risk of potential pollutants or contaminants in the product. Whilst a degree of control can be exerted through the imposition of limit values for potential pollutants in the processed output material, it is rarely technically and economically feasible to cover every aspect by this means alone. Source control inevitably means excluding some material from the processing chain potentially leading to end-of-waste status, although its recovery and reuse as waste remains a possibility.

The technical and economic feasibility aspects of waste reutilisation are more of a barrier for mixed waste streams than for specific source-separated waste streams but then the cost of collecting separate waste streams can become a counter issue. There are many examples where, within a category of waste, there are substances or specific material streams which would pose a significant risk to the environment during collection, storage, transport, processing or use of the material.

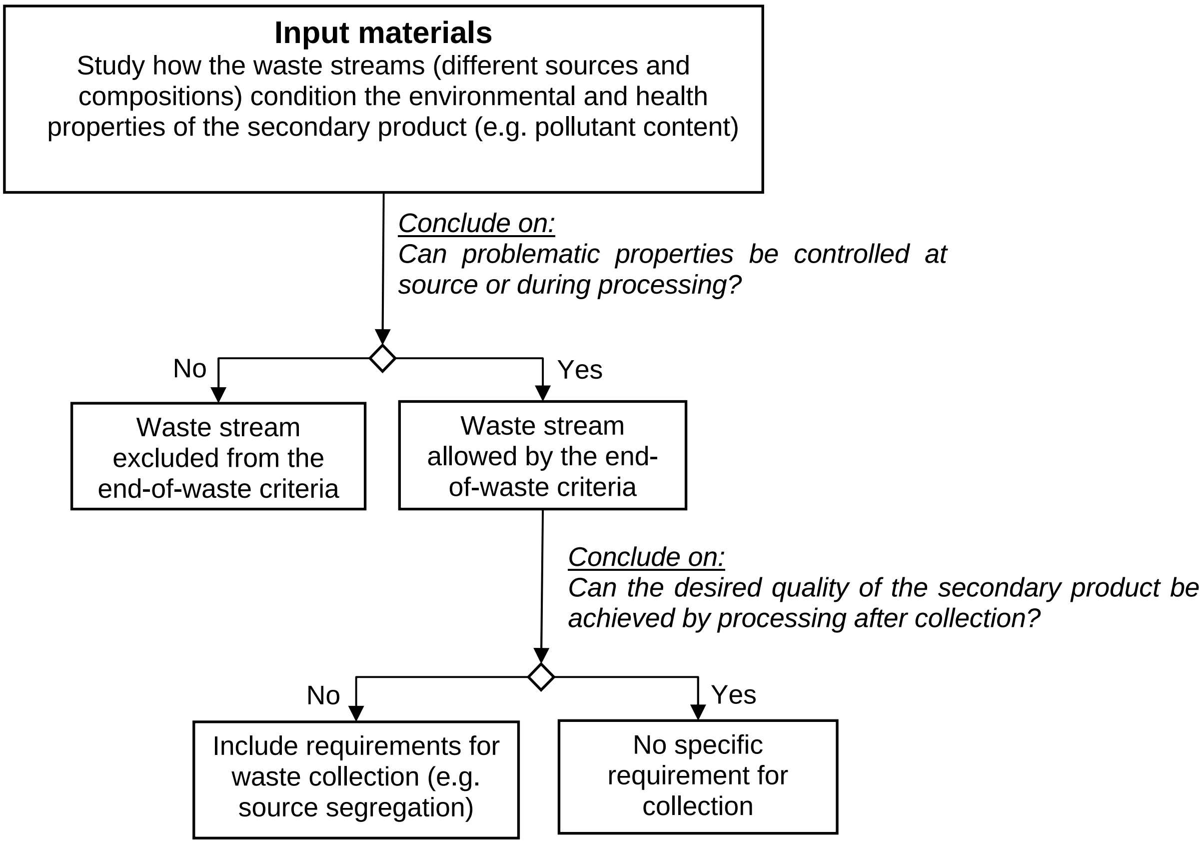
By way of examples it is documented that some old asphalt road surfaces contain tar as a binder and the level of PAHs present in this waste stream supports its exclusion from direct recycling. The tar components can be destroyed by specific thermal treatment after which the aggregates may then be suitable for recycling but the case study on aggregates proposes that road residues containing tar cannot cease to be waste. In this case, only road residues free of mineral waste and tar can be acceptable input material for the product material to cease to be waste.

It is also accepted that old structures and buildings can contain hazardous substances such as asbestos, PCBs, PAHs, or other hydrocarbons as a result of contamination during the construction or life of the building. If these hazardous substances are not removed from the structure before it is demolished then it is not technically feasible to remove them later by processing and there is a risk that they are dispersed through the final product material. On this basis the end-of-waste criteria developed for recycled aggregates accepts that selective demolition of structures, which guarantees that all hazardous substances are removed prior to demolition of the structure, is sufficient on its own for the aggregates produced by that technique to cease to be waste without further testing due to their inherently low risk to human health and the environment. On the other hand, recycled aggregates produced where selective demolition is not used can only cease to be waste after meeting leaching limit values.

In considering source waste materials which are suitable for composting, there may be some waste sources which, although technically compostable, would bring undesirable substances or characteristics to the product compost and these should be excluded on environmental grounds from the production of compost intended to be used as non-waste product. On this basis the end-of-waste criteria for compost includes a limit on levels of heavy metals and persistent organic pollutants in all input material to the composting process.

In general, therefore, it is necessary to establish the substances and hazards associated with each waste stream being studied which potentially could be processed into a substance or object to which end-of-waste criteria could be applied. In each case, it must be determined if any hazard(s) associated with a particular waste source can be adequately controlled in some way during processing or whether they need to be excluded at source to provide the requisite product quality. In which case the hazards need to be described and the level of source control considered necessary must form part of the ultimate end-of-waste criteria. In some cases source control may not be required where product quality can be assured by applying process controls and/or simply by stipulating product quality standards. The procedure is described in Figure 2.

Figure 2: Guidance to develop end-of-waste input material criteria.



1.4.2 Processes and techniques

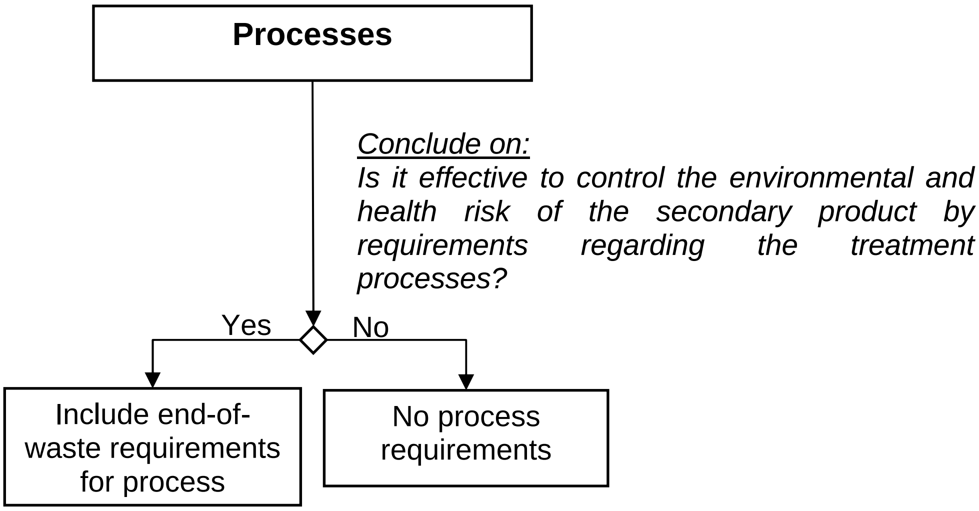
The second element for end-of-waste criteria could be some control over processing itself, possibly including technical process parameters and key process steps necessary to achieve a specific result meeting requisite product standards. It should be noted here that any processing of waste will be subject to regulation under waste regulation.

The most basic processing required is sorting of the waste into usable fractions and reject, the most basic test of quality can be as simple as visual checking at various points of the production chain. More complex processing and quality control can extend to blending of various waste sources, chemical stabilisation, chemical or biological processing, particle size reduction and full chemical analysis of the product to determine compliance with a standard relevant to a downstream user. To ensure quality of final product it is required that a waste material passes through some sort of quality controlled process to make sure it is fit for one or more specific uses.

The processing of selected waste streams will have a direct effect on the cost and quality of material produced. Process control parameters necessary to guarantee that a specific quality material is produced may include essential steps in processing, essential chemical or physical targets to be met in the process (temperature, residence time, moisture content, pH are all indicative examples of process parameters).

For all possible variants of processing, and for each step in the process chain, it must be determined which process parameters (if any), need to be controlled to ensure that the product meets relevant standards and to provide the requisite high level of protection for human health and the environment when the material is shipped or used as non-waste. These key process parameters (if any) must form part of the end-of-waste criteria for the case in question. As previously, process control may not be required where product quality can be assured by applying source controls and/or simply by stipulating product quality standards. Figure 3 illustrates this procedure.

Figure 3: Guidance to develop end-of-waste processing criteria.



1.4.3 Product quality

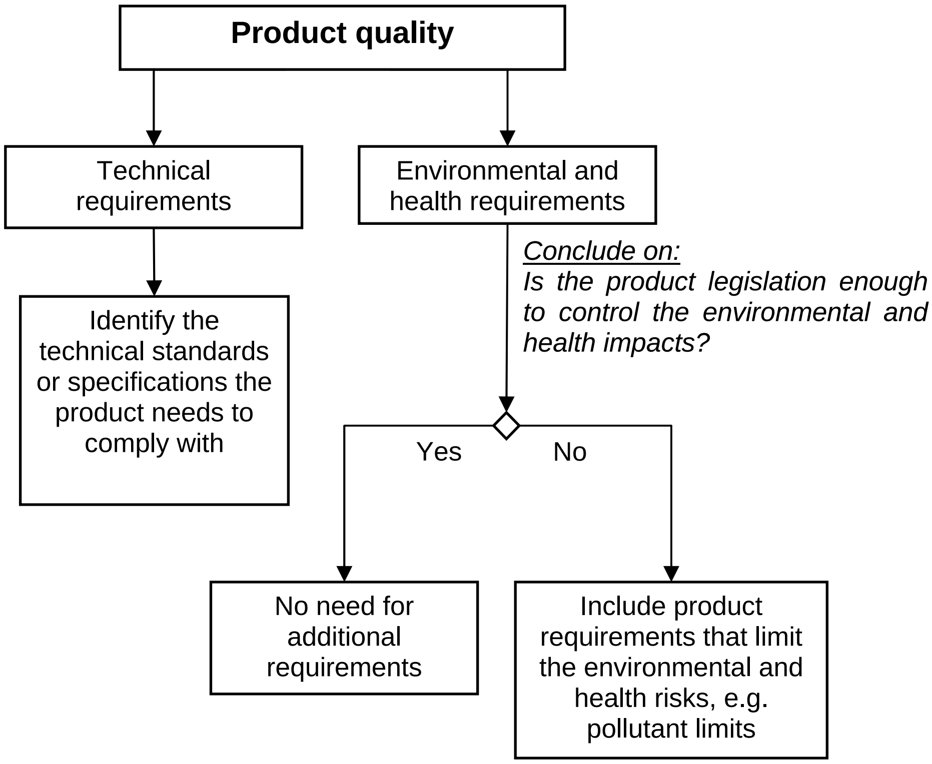
In order to relate to specific markets, processed material will need to meet some sort of quality standard. In some cases, it is foreseen that the product material will need to be tested to demonstrate compliance with the applicable quality standards if the source control and process control do not in themselves dictate the product quality. It should be borne in mind that sampling and analyses can be expensive, especially if repeated frequently.

Where national or international quality standards exist for a material, it is likely that existing processors and customers have already developed systems for production and use, based on those standards. Notwithstanding recognised quality standards, for each potential application of the material, there are likely to be specific user requirements in terms of material characteristics, amount of material available and consistency over time. Any end-of-waste criteria must be consistent with such user requirements if the market is to be sustained.

All established standards for the product need to be identified and recorded. In each case the legal and geographical basis should be noted; for example, if there are internationally agreed standards and specifications commonly used in trading or if there are ad hoc agreements between individual suppliers and users. It should also be noted if the standards apply specifically to the material as waste or apply to all competing products irrespective of their status as waste or product.

Whether or not such national or international standards exist, it is necessary to assess the environmental risks associated with storage, transport, processing and use of each material in question and to consider how waste legislation provides protection against those risks compared to how non-waste product legislation would provide protection. Arising from this analysis of risks associated with the various waste sources and the processing possibilities, specific and additional product quality standards, such as pollutant limit values, maximum content of impurities, etc., may be incorporated into the end-of-waste criteria to ensure environmental risks are reduced or eliminated. Figure 4 illustrates how the technical and environmental requirements are incorporated in the end-of-waste criteria.

Figure 4: Guidance to develop end-of-waste product quality criteria.



There are a number of possible bases for developing these specific and additional end-of-waste quality standards including the application of best practice throughout the sequence from source to production. Alternatively quality standards could be derived which are comparable to primary materials which may be substituted by the ex-waste product. In any case, any quality standards should be derived to contribute to a high level of protection for human health and the environment during shipment and use of the material and such standards should be explicit within the end-of-waste criteria for the case in question.

1.4.4 Potential applications

Whilst consideration of potential uses is required in order to establish market or demand and environmental risks associated with such use, it is envisaged that end-of-waste criteria could not actually regulate or control such use. To do so would render the end-of-waste criteria futile by imposing a regulatory burden equivalent or even greater than that of the original waste legislation. For example if scrap metal could only cease to be waste at the point of charging to a melting furnace, or if compost could only cease to be waste when it is actually applied to land, then there is no effective change from continuing to apply the waste legislation. It is foreseen, however, that the producer of any material fit for specific uses would be obliged to label the material in terms of its compliance with any standards for use and also label the material if it is not fit for other purposes.

In many cases, the use of a substance or object is regulated equally whether the substance or object is waste or not. When the substance or object is returned to a principal manufacturing process, as in the cases of metal scrap, glass cullet, and waste paper, the processing of that substance or object is highly likely to be regulated for environmental purposes by community legislation such as the IPPC Directive. In the few cases of substances or objects that are used directly in the environment, such as for compost and aggregates, it is likely that the use is regulated to an extent by specific non-waste-related legislation and also by waste legislation if the substance or object remains waste. The use of compost in soil may be regulated by general regulations relating to fertilisers and the use of aggregates is regulated to an extent under the Construction Products Directive. According to the general conditions for end-of-waste, the specific non-waste legislation needs to provide an equivalent level of protection for human health and the environment, for end-of-waste criteria to be accepted.

Given the precondition for end-of-waste that the substance or object in question is already commonly used for a specific purpose, it will always be the case that at least one application is studied in detail in respect of market and technical standards appropriate to that use. Also given the precondition that the substance or object must meet the legislation and standards applicable to products, this then leads to a requirement within all end-of-waste criteria that a product which ceases to be waste must be labelled as to:

(a) the purposes for which it is fit for use;

(b) any potential purposes for which it is not fit for use;

(c) its conformity with any standards applicable to its use in the intended market;

(d) its conformity to any standards which are met pursuant specifically to the end-of-waste criteria themselves.

The point of application of end-of-waste criteria will de facto occur on a site regulated under waste legislation as, until the point of application of end-of-waste, the substance or object is waste. Thus the monitoring and enforcement of any labelling requirements for a substance or object to cease to be waste will always be possible under waste legislation. Only once the substance or object ceases to be waste does the waste legislation cease to have effect but the substance or object becomes a product and is thus subject to both normal product related legislation in terms of health and safety and normal 'pollution control' legislation, meaning the general obligation to prevent pollution of the environment in all its respects. In reality, the vast majority of candidate substances or objects for end-of-waste development are not dispersed into the environment in their use phase but are taken as raw material input to an industrial installation which itself will be regulated either explicitly by the Industrial Emissions Directive or in some other more general means (for non-IPPC industry).

1.4.5 Quality control procedures

In every foreseeable case, it is expected that the whole process of waste collection and processing needs to be subject to a recognised quality assurance procedure to provide confidence that the criteria are met in reality. As end-of-waste de facto means producing a material which is not waste, the producer would carry obligations pertinent to their responsibility as a producer especially in respect of being able to certify the quality of the produced material and its fitness for use. To achieve this it would be necessary to be able to certify that every critical step of the production had been carried out according to relevant process or quality standards and that any sampling and analysis had been carried out to recognised standards. The need for external verification and third-party audit of a quality assurance scheme is not simple to establish although it remains an option to consider depending on the merits of the specific case. Whilst there are established quality assurance schemes available, there are many examples of larger enterprises developing bespoke quality assurance schemes which deliver high confidence in product quality. The most important element is that there is a clear and auditable record of compliance with each step of the production chain from waste material to potential product.

A quality assurance scheme as such does not guarantee the quality of an end product but it can assure consistency of applied processes throughout the production chain. Therefore, where end-of-waste criteria include specific conditions to be met, especially relating to material input control, processing parameters and product standards, a quality assurance scheme can assure compliance with every one of these conditions. A quality assurance scheme itself includes a number of elements:

- a set of procedures that cover all key processes in the business;
- monitoring processes to ensure they are effective;
- keeping adequate records;
- checking output for defects, with appropriate and corrective action where necessary;
- regularly reviewing individual processes and the quality system itself for effectiveness;
- facilitating continual improvement.

Having a quality assurance scheme examined and validated by an accredited certification body or an external verifier complements any internal verification procedure and provides a higher credibility to the chosen scheme itself. ISO 9000 is the most widely used standard as a basis for quality management systems in general.

In developing end-of-waste it is essential to identify the steps in the whole production chain which are critical to achieving the various objectives of end-of-waste and which contribute to compliance with the conditions set out for end-of-waste. Whilst it may not be possible to dictate a particular quality assurance scheme within end-of-waste criteria, a quality assurance scheme should be required which includes all of the critical steps and thus can be used to demonstrate compliance with all end-of-waste criteria.

1.5 Impact assessment

When one or more draft sets of end-of-waste criteria have been developed for a specific waste stream based on collected data, evidence and expert opinion, they must be assessed in terms of their potential impact from a number of aspects before they can be taken forward as a proposal. This assessment includes legal, economic, market, social and environmental aspects to ensure that the principles of end-of-waste are fully respected. If it is shown that a draft set of end-of-waste criteria does not fully respect the requisite principles then that draft must be rejected, or revised and reassessed.

1.5.1 Environmental and health impact

The process of defining end-of-waste criteria is guided by the four conditions set out in Article 6 of the revised Waste Framework Directive ([4]). Condition (d) requires that the use of the substance or object will not lead to overall adverse environmental or human health impacts (it is understood that use includes not only the application for the final purpose but also prior transport and handling once the product is placed on the market). It is a key element of the whole methodology to avoid making proposals for end-of-waste criteria with negative environmental and health impacts. Strong increases or important new environmental impacts as a consequence of the proposed end-of-waste criteria can, therefore, not be expected once the process has arrived at the impact assessment step. It is, nevertheless, necessary to address the environmental and health impacts again at the impact assessment stage for a number of reasons:

- to confirm that the interplay of the different, specific criteria included in the set of end-of-waste effectively excludes the possibility of overall adverse impacts of using the product, or, preferably, even reduces these impacts, and that the specific proposed pollutant limit values, if any, are appropriate;
- to assess the possibility of geographical variations of the environmental and health impacts across different parts of the EU ([5]);
- to assess indirect environmental and health impacts, i.e. impacts that are not directly related to the use of the product that meets the end-of-waste criteria.

<u>Types of effects</u>

The introduction of pollutant concentration limits and other criteria influencing the product quality, a change in the applicable regulatory controls to the use of the material, and induced changes in the product market situation (e.g. increase in the supply and use of the material) are the main factors that affect the <u>direct</u> environmental and health impacts of using the material.

Examples of <u>indirect</u> environmental and health impacts include the following.

- Changes in the process-related emissions (and other types of environmental interventions) upstream in the recovery chain. End-of-waste criteria may induce such changes, for example, when extra processing efforts are made to meet demanding concentration limit

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([4]) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste (OJ L 312, 22.11.2008, p. 3).
([5]) Geographical differences are relevant at least for two reasons: local differences in the sensitivity to environmental stresses and differences in the applicable environmental and health protection regulations between (and even within) Member States.

values for pollutants in the product. At least theoretically, there is the possibility that applying a strict quality standard to a product material in order to reduce its inherent environmental and health hazards may actually have greater impact on the environment due to increased processing impact (e.g. by increased energy need) than that represented by the original risk itself. This possibility is attenuated by the fact that upstream processes in the recovery chain, i.e. before the step where the material ceases to be waste, remain under waste law and will require the corresponding permits. In many cases these processes will also be covered by the provisions of the Integrated Pollution Prevention and Control (IPPC) Directive.

- Indirect effects of increased recycling. When end-of-waste criteria facilitate a specific waste recovery route, this will change the share of the alternative waste recovery and/or disposal options for the treatment of the waste. If the alternative treatments have different environmental and health profiles, this will also change the overall environmental impacts of treating the waste. Since, according to this methodology, end-of-waste criteria are only proposed for recovery routes that generally perform well regarding environmental and health protection compared to alternative treatment options, the overall effect of more recovery should in principle be positive. However, this may require verification based on the specific features of the end-of-waste criteria, taking account of the expected size of the recovery promoting effects and applying an appropriate geographical resolution.

- Indirect effects of product quality assurance. Usually, end-of-waste criteria require a stringent product quality assurance. This may have positive effects not only on product quality but also on the management of the recovery processes, for example, if product quality assurance is carried out as part of an environmental or quality management system at the recovery facility. In such a case, it is likely that environmental and health protection will be strengthened not only for the use of the product but also regarding the prior recovery processes. The exact size of these indirect effects will, however, be difficult to quantify.

- Environmental and health impacts of materials that do not meet the end-of-waste criteria. Materials that do not meet the applicable end-of-waste criteria, for example because they exceed pollutant limit values, may either be disposed of, undergo further treatment and cease to be waste at a later stage, or be used for a purpose without further treatment (similar as materials that comply with the criteria). In the latter case, the non-compliant material remains waste until its ultimate use. It is therefore fully covered by waste-law-derived controls. In any of the cases, the environmental and health impacts and risks may be different from a situation where end-of-waste criteria do not exist. A reason is that end-of-waste criteria establish clarity that a certain material has to be considered waste where without such criteria different interpretations were possible and the material may not always have been under waste-law-derived controls. In such cases, when end-of-waste criteria reinforce the application of regulatory controls, they are likely to reduce the environmental impacts and risks from non-compliant materials.

Assessment approach

Assessing the impacts of introducing the end-of-waste criteria can best be achieved by comparing an 'end-of-waste criteria scenario' with a 'no action scenario'.

In principle,

- The assessment should cover all environmental and health impacts that are expected to be different in the two scenarios, independent of whether the changes are due to direct or indirect effects of introducing and applying end-of-waste criteria. This means the scope of the assessment should cover the full recovery and use chain of the material, plus other processes that are indirectly affected (application of life cycle thinking).

- The assessment should assess both the impacts that are caused by the normal operation of the recovery and use processes and the risks of impacts in case of accidents or the possible misuse of the material.

- The impact assessment should cover the impacts through all environmental media (in particular soil, water, air) and all relevant environmental and health impact categories. As far as possible, state-of-the-art life cycle impact assessment methods should be used at the so-called midpoint or end point impact levels.

  Recent reviews of the state-of-the-art of life cycle impact assessment can be found in Udo de Haes et al. (2002) and Jolliet et al. (2004) ([6]). The common approach is that for each impact category a category indicator is chosen and a characterisation model is applied to convert the relevant inventory results (e.g. emissions of different substances) to a common unit, i.e. the unit of the category indicator. Among the different existing impact assessment methods, there is a reasonable similarity in the impact categories included. The differences between the methods are rather in the models applied to characterise each impact category, and in the extent to which the midpoint results (for individual impact categories) are modelled further in the impact chain towards a single end point.

  Examples of typically used impact categories are:

  - acidification
  - ecotoxicity, aquatic
  - ecotoxicity, terrestrial
  - eutrophication, aquatic
  - eutrophication, terrestrial
  - global warming
  - human toxicity
  - mineral extraction
  - nature occupation
  - non-renewable energy

([6]) Udo de Haes, H. A., Finnveden, G., Goedkoop, M., Hauschild, M., Hertwich, E., Hofstetter, P., Jolliet, O., Klöpffer, W., Krewitt, W., Lindeijer, E., Mueller-Wenk, R., Olsen, I., Pennington, D., Potting, J., Steen, B. (2002), Life Cycle Impact Assessment: Striving towards Best Practice. Pensacola: Society of Environmental Toxicology and Chemistry (SETAC).
Jolliet, O., Müller-Wenk, R., Bare, J., Brent, A., Goedkoop, M., Heijungs, R., Itsubo, N., Peña, C., Pennington, D., Potting, J., Rebitzer, G., Stewart, M., Udo de Haes, H., Weidema, B. (2004), The LCIA Midpoint-damage Framework of the UNEP/SETAC Life Cycle Initiative. International Journal of Life Cycle Assessment 9(6): 394–404.

- ozone layer depletion
- photochemical ozone impacts on vegetation
- respiratory inorganics
- respiratory organics (photochemical ozone impacts on human health).

Examples of end point impact categories are:

- impact on ecosystems
- impacts on human well-being
- impacts on resource productivity.

Ideally, the environmental and health impacts would be summarised in a single aggregated indicator. If this is done in monetary terms, the value can then be compared to the economic impacts, allowing an overall cost-benefit assessment.

In practice,

- The assessment best concentrates on those environmental impacts and interventions that were already identified as the most substantial ones in the waste stream analysis prior to proposing the end-of-waste criteria. In addition, it needs then also be checked if there are any new substantial environmental or health impacts that emerge after applying the end-of-waste criteria.

- In most cases, special attention will have to be given to those parts of the recovery chain that come after end-of-waste is reached, because it is only after this point that the applicable regulatory controls with the aim to protect health and the environment ([7]) are different between the scenarios.

- Since the assessment approach is differential (comparing scenarios), it will often not be necessary to calculate absolute indicator values of environmental impacts. Instead it may be sufficient to identify the pollutants that are responsible for the main environmental impacts and then directly compare for these pollutants the emissions or loads in the product flow. This simplification is valid if no significant trade-offs between the environmental impacts of different types of pollutants are involved. If there are significant trade-offs, an assessment involving some sort of weighting and comparison of different impacts is unavoidable, and the calculation of aggregated impact indicators such as the midpoint or end point indicators mentioned above are the standard way to do so.

- In the case that the use of the material consists in introducing it in the environment and the material cannot be considered inert (e.g. use of compost as soil improver), the concentration of pollutants in the product, combined with the quantity of product used, can be used directly as proxy indicators for the difference of the environmental impacts of product use.

- In the case that the use of the material consists in introducing it in the environment and the material is considered relatively inert (e.g. use of aggregates for construction works), the leaching values of pollutants in the product, combined with the quantity of product used,

([7]) In principle, the waste legislation allows case-by-case control of source, processing, storage, transport and end use of the material.

can be used directly as proxy indicators for the difference of the environmental impacts of product use.

- In the case that the material is used as input to industrial processes, it needs to be assessed if, and how, the emission levels of these processes are affected and if the compositions of the resulting products are affected.

- A further simplification is to make the comparison between scenarios not based on actual pollutant concentrations or leaching characteristics of the material, but use the legal limit values instead (including the pollutant limit values included in the end-of-waste criteria). Often this will be the only practical solution. Note that limit values for use (concentration, leaching) may be different for different applications of the material and in different Member States. Limits for certain applications may be stricter than limit values as part of the end-of-waste criteria.

- An important aspect of the impact assessment is to compare the way in which waste and other legislation protect against risks to human health or the environment associated with storage, transport, processing and use of the material in question to the way the applicable legislation would provide such protection when the material ceases to be waste.

- The changes in the applicable regulatory controls (such as inspection, registration, etc.) as a consequence of applying end-of-waste criteria affect the risks to human health or the environment associated with storage, transport, processing and use of the material in question. They are also the prime reason, apart from the pollutant limit values, for possible changes in the environmental and health risks due to potential misuse and the possibility of accidents. The assessment of how changes in regulatory controls affect environmental and health protection will often be qualitative. It should be based on a good understanding of how effective the different applicable administrative controls are in both scenarios, i.e. with and without end-of-waste criteria. It should be noted that much of the non-waste legislation applies regardless if the material is waste, while other legislation only applies when the material ceases to be waste. The REACH legislation on chemical substances is a prominent example of the second case.[8]

The environmental and health impact 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 not be negative (in such a case the proposed end-of-waste criteria would have to be revised or the proposal withdrawn) and should preferably be clearly positive. For existing risks and any negative impacts on partial aspects it should be judged if they are deemed acceptable if compared to the overall benefits that the end-of-waste criteria offer and if there are proportionate measures to address them.

1.5.2 Economic impact

This section of the impact assessment is about the direct costs and benefits incurred at the different stages of the recovery chain (waste collection, transport, storage, pretreatment,

([8]) Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (OJ L 396, 30.12.2006, p. 1).

treatment, marketing, use). Further economic implications are treated also in the section on market impacts.

Types of effects

The following lists give examples of the direct costs and benefits that may change when end-of-waste criteria are introduced.

- Operating and investment costs of the different processes in the recovery chain (e.g. changed input of energy or materials to allow complying with the end-of-waste criteria).
- Costs of product quality assurance.
- Regulatory compliance and administrative costs (licences, fees, paperwork, etc.).
- Additional transaction or adjustments costs of adapting to the introduction of end-of-waste criteria.
- Increased product value when stringent product requirements or quality control demanded by the end-of-waste criteria improve the product quality.

Assessment approach

The approach is again to compare the costs and benefits in a scenario in which the end-of-waste criteria are implemented to the costs and benefits in a 'no action scenario'.

The direct costs and benefits should be assessed for both materials that comply with the end-of-waste criteria and materials of the same type that do not comply and therefore do not cease to be waste until the ultimate use.

It should be distinguished where in the recovery chain the different costs and benefits are generated and who (which types of firms, public entities or households) will ultimately carry each of them. In this way, the potential winners and losers of introducing the end-of-waste criteria can be identified.

Changes in costs and benefits throughout the recovery chain will influence the price of the material, and this should be quantified as far as possible (although there are further factors influencing the price — see section on assessing the market impact).

Particular attention also needs to be given to the question if small and medium-sized enterprises will be affected disproportionately by costs (for example due to administrative complexity) and to differences in costs and benefits depending on the location (for example because of differences in settlement structures, environmental or administrative conditions).

1.5.3 Market impact

The provisions of the Waste Framework Directive require as a precondition for end-of-waste that the material is commonly used for a specific purpose and, to that extent, there will always be at least one existing market. The existence of a market and the theoretical market potentials have already been analysed before making the proposals on the end-of-waste criteria.

This part of the impact assessment is about how the supply and demand of the material in question would change as a consequence of introducing the proposed end-of-waste criteria, how efficient the market would work in balancing supply and demand, and which prices would be paid. It is also about identifying possible winners and users of introducing end-of-waste criteria, and how the markets for alternative materials (potential substitutes) would be affected.

Types of effects

The following lists give examples of the factors that potentially influence supply and demand of a material, as well as the market prices and the overall market characteristics.

Supply-side factors:

- changes in the production costs;
- changes in the situation of competition (e.g. if barriers to the functioning of the internal market are removed by the introduction of the end-of-waste criteria);
- removal/creation of barriers for new suppliers to enter the market;
- changes in the quantities of the material offered in the market;
- possibilities of making profits from supplying recycled material of inferior quality.

Demand-side factors:

- changes in the costs of using the material (e.g. reduced regulatory compliance costs if material use is no longer covered by waste law);
- changes in perceived value of the material (loss of waste ‘stigma’);
- changed costs and possibilities in verifying the quality of recycled material;
- increase/reduction in choices for users.

Overall factors:

- creation/removal of market segmentation;
- changes in market power;
- emergence of winners and losers, e.g. from the cost reductions/increases throughout the recovery chain;
- possibility of over or under-supply, saturation of markets (taking into account also local variations if transport costs are a factor that limits the effective range of the market);
- flexibility of the supply of the material in reacting to changes in the demand and price situation;
- possibility of withdrawal of certain products from the market (if the marketing of products becomes limited or prohibited);
- changes in investment preferences, especially regarding waste management capacities (preferences for certain of the alternative treatment options);
- possible differential treatment of alternative materials (substitutes; either other secondary materials or obtained from natural resources) in a comparable situation;
- disproportionate effects on certain sectors, and especially SMEs, or certain regions.

Assessment approach

The impact assessment should identify which of these or other factors are relevant for the specific case, and analyse how they will interact in order to come to conclusions, especially regarding:

- if, or under what conditions, it can be expected that the market will work efficiently and there will be sufficient demand to absorb the material when it ceases to be waste;
- who are the winners and losers of introducing the end-of-waste criteria;
- if there will be any significant perturbations of the market for substitute materials (which can be used alternatively to the material in question).

The following aspects should be considered in the analysis.

If applicable to the material under investigation, the assessment should consider the effects of any seasonal fluctuations in supply and demand, the extent of required temporal storage of the material, and future trends in the market situation.

While product standards as part of end-of-waste criteria have to be applied as a minimum, there is also the possibility of mandatory national or regional standards which would have to be complied with on a case-by-case basis and it is necessary to take these into account when considering the likely market.

Since the material in question is produced from waste, it is especially important to assess if the market will be efficient in balancing supply and demand and lead to appropriate price levels. It has to be considered that, in some cases, the amount of waste generated might be a decisive factor for the amount of material produced and limit the sensitivity of the production to demand and price signals.

If the end-of-waste criteria include higher product quality standards than typically applied to the material in question without the end-of-waste criteria, this may restrict the supply capacity while increasing the demand for the material. In general terms the higher the quality of the product, the lower the overall yield to be expected due to increase in rejects on quality grounds. However, customers are more likely to accept and pay more for a product guaranteed to a specific quality standard than a generic product. New quality standards would impact both on the theoretical amount of material which could be produced and on the number of potential users for the material. It could also impact upon the production economics as a stricter quality standard implies a greater degree of processing but the product may then command a quality premium in the market.

The increased use of an ex-waste material is usually expected to replace the use of other materials which may or may not be natural resources in their own right. If these other materials are by-products or also waste materials, such substitution could potentially lead to increased waste generation elsewhere.

Special attention should also be given to the market effects if end-of-waste criteria facilitate or hamper imports and exports between EU Member States, as well as between the EU and the rest of the world.

The market impact assessment should cover both materials that comply with the end-of-waste criteria and materials of the same type that do not comply.

1.5.4 Legislative impact

When any end-of-waste criteria have effect, de facto the waste management legislation that would have applied to the material as a waste no longer applies. The question remains as to what other legislation may apply because a material ceases to be a waste and what legislation applies regardless of the material being waste or not waste.

The REACH regulation, as an example, explicitly exempts waste from its scope and therefore in every case of end-of-waste it has to be considered how marketing and use of the material might be affected by REACH.

On a case-by-case basis, other legislation which would come into effect if a material ceases to be waste must be considered, for instance, in terms of how it influences storage, shipment and use of the material as a non-waste and any protection of human health and the environment thus achieved.

The implications of the changes in the applicable legislation are essentially dealt with in the environmental and health, economic, and market chapters of the impact assessment.

In certain Member States, and for certain waste streams, there exists specific national legislation setting out end-of-waste criteria. It can be foreseen that such legislation would have to be adapted when the EU end-of-waste criteria are introduced. The impact assessment should identify such cases.

In other cases there are official rulings or practices by regulatory authorities that link end-of-waste to compliance with certain standards or protocols. An adaptation to the EU end-of-waste criteria (for example concerning limit values or the need for quality assurance) would also be required in these cases, although these would probably not have to be of a legislative nature.

As a complementary measure to the end-of-waste criteria, there may also be a need to adapt existing legislation in Member States regulating the use of the relevant materials to harmonised technical standards on product parameters, sampling and analysis. The need for complementary measures should be identified by the impact assessment.

1.5.5 Other socioeconomic impacts

Waste is generally perceived as a low quality material not fit for useful purpose. In many cases this is not strictly true as some wastes are merely materials surplus to requirements and are fit for one or more useful purposes. There are two foreseen social impacts in respect of end-of-waste, the first relating to possible source separation and separate collection of wastes which requires some degree of involvement and collaboration with the waste producer. The second impact is how the processed material is accepted as a quality product and not necessarily as a second-class product.

A successful set of end-of-waste criteria should enhance perception of material as a product with specified quality fit for certain purposes and could increase the general acceptability of using such material. Demonstrated compliance with each and every element of a set of end-of-waste criteria would be a specific and public statement, labelling the produced material as such. However, the social impact of this is only significant for those materials entering a public consumer market. In many cases the waste becomes secondary material which is processed to new material, such as metals, glass and paper. These products are not necessarily recognised as containing a waste element.

A more direct potential social impact could be behavioural changes required to implement, for example, separate waste stream collection. Through the application of the requisite quality control procedures, waste being collected for processing into specific products begins to take on a value in the eyes of those handling it. Failure to comply with source separation criteria would either result in material being rejected for processing or would attract economic penalty compared to compliance with those criteria. An assessment should be made of the social and economic issues associated with informing and encouraging the respective waste producers to comply with all critical criteria relevant to the eventual application of end-of-waste.

Finally, it should be analysed if there are other types of socioeconomic impacts to be expected. If yes and if the impacts are potentially important, they should be included in the assessment. Long lists of potential types of impacts can be found in Tables 1 and 3 of the Impact Assessment Guidelines of the European Commission ([9]). Examples of potentially relevant impact types include the following.

- Impacts on the competitive position of EU firms (for instance when regulatory compliance costs in the EU or prices of secondary raw materials in and outside the EU change as a consequence of introducing end-of-waste criteria).
- Impacts on workers' health, safety and dignity.
- Impacts of the employment and labour market.
- Budgetary consequences of end-of-waste criteria for public authorities at different levels of government, both immediately and in the long run.
- Impacts on innovation: do the end-of-waste criteria facilitate/inhibit the introduction and dissemination of new production methods, technologies and products?
- Do the end-of-waste criteria affect EU trade policy and its international obligations?
- Do the end-of-waste criteria affect developing, least developed and middle income countries?

([9]) http://ec.europa.eu/governance/impact/docs/SEC2005_791_IA%20guidelines_annexes.pdf

1.6 Operational procedure

Having presented the various elements of end-of-waste, this report now presents a possible 'bullet point' procedure which attempts to ensure that, in any case studied, all the requisite issues are identified, analysed and assessed in order to develop peer reviewed background information for the development of proposals for end-of-waste criteria together with robust and accurate supporting information. Ultimately, it would be for the Commission to develop any proposals for legal adoption under the Waste Framework Directive.

Whilst parts of the procedure could be carried out independently it is proposed that the work on each waste stream study be carried out with a specific expert technical working group convened for the purpose, bearing in mind that any result of any such study could only become effective after due adoption process. Experts could be selected from industry, academia and Member State authorities to bring the requisite information to the study in order to construct robust results. Ultimately, the inclusion of such practical expertise should enable a study to adequately address all aspects.

To allow time for such a group to collect and process information prior to drafting possible end-of-waste proposals, such a group would need to exist for somewhere from one to two years. There is a clear need to apply expert judgement in many of the steps and, therefore, it is envisaged that each study will need to be led by a technical expert. The procedure is intentionally silent on precisely who undertakes each step as this may vary from case to case and the existence or otherwise of EU expert organisations in the specific field. As such it will be for the lead technical expert to manage the process in this respect.

There is no guarantee that end-of-waste criteria will always be appropriate for every waste stream studied. The possibility will always exist for a candidate waste stream to be studied and the conclusion reached that end-of-waste criteria are not appropriate for all or part of the waste stream in question.

A number of waste streams are candidates for end-of-waste analysis. Applying this procedure to any specific waste stream does not require the steps to be carried out in a specific chronological order except for those steps which obviously follow from each other. There is the possibility of multiple iterations and data gathering and data processing in parallel for different steps.

Throughout application of the procedure all the details discussed earlier in this paper need to be considered.

The procedure is often iterative in nature to test initial proposals. It is envisaged that the initial assessments are done without specific quality conditions in mind for end-of-waste criteria. In most cases, such quality conditions will become part of a subsequent iteration in order to address potential environmental concerns which are identified.

The starting point for the following procedure is that a basic description of material is given (the title), such as scrap metal, waste paper, aggregates from waste, compost, waste glass, end-of-life tyres or waste textiles.

Figure 5 describes the operational procedure presented in the next paragraphs. It differentiates the different stages of the analytical and synthetic part of the process and identifies the points at which decisions are taken.

1. Initial investigation

1.1. Identify all waste material streams which fall within the given title.

1.1.1. For each waste material stream identified estimate the annual amount arising and geographical spread of sources.

1.1.2. Based upon the estimated geographical spread of sources, is there sufficient EU-wide relevance to proceed with a detailed analysis? If a material stream is very limited in geographical scope and thus unlikely to warrant EU measures, local or national measures could b-e more appropriate unless there is a likely significant potential for international trade in the material.

1.1.3. For each material waste stream identified as EU-relevant, initially estimate the environmental and health issues and risks associated with processing, shipment and use of the material.

1.2. Identify potential treatment processes applied to the waste stream.

1.3. Identify potential uses of the material after processing. Where relevant link the uses to specific processes used.

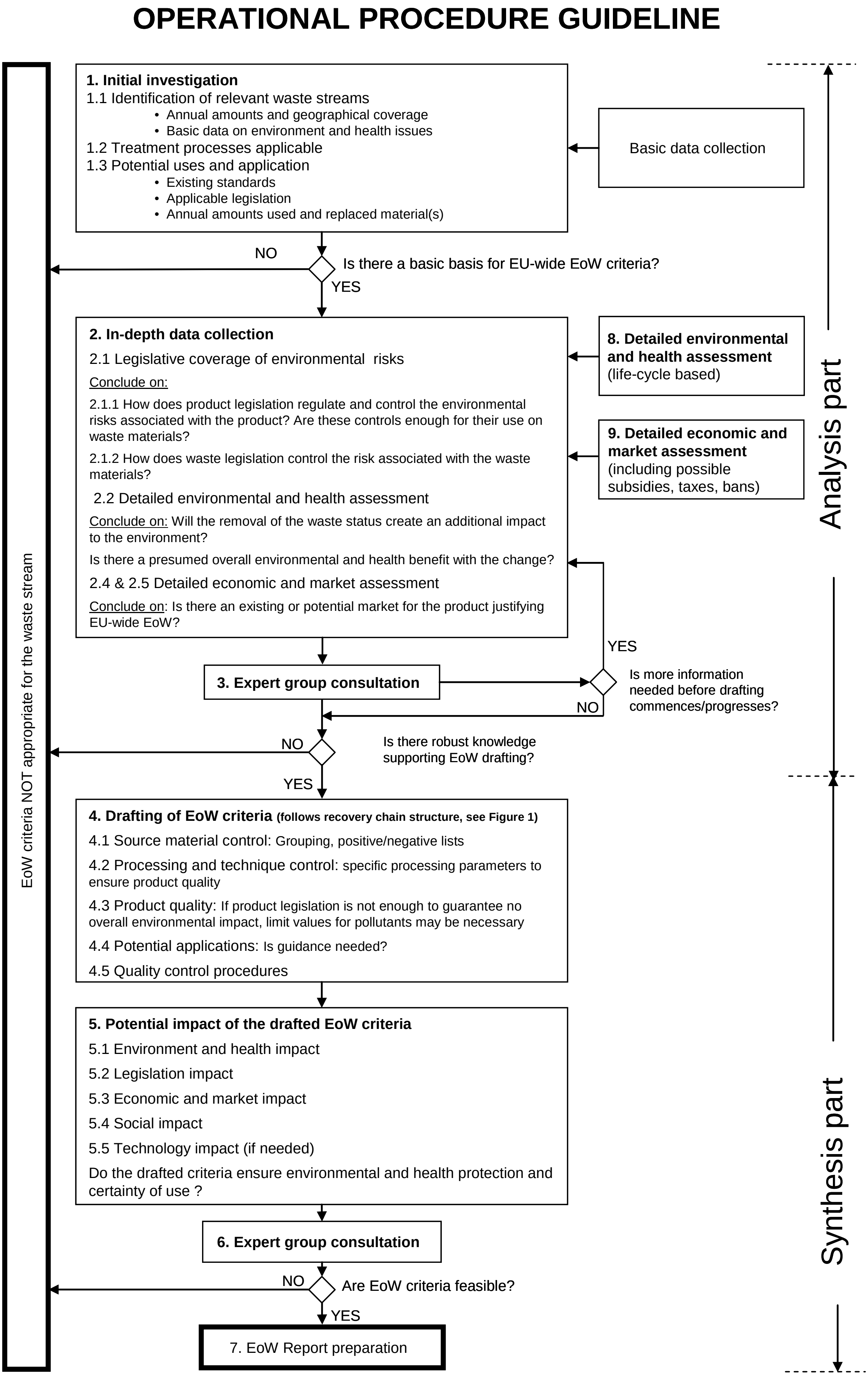
1.3.1. For each potential use of the material, identify legislation which would regulate its storage, transport and use if it ceases to be waste.

1.3.2. What would be the alternative ‘reference materials’ used if the material under study is not used for that purpose?

1.3.3. What user-relevant standards exist for the uses of the material? For each standard identified, noting whether these are legally binding, industry classifications or guidelines.

1.4. Revise initial title category into subcategory titles for assessment (loop to 1.1) or continue with title and EU-relevant material streams. Bear in mind for this initial investigation that end-of-waste criteria would be applied to specific waste streams or to certain material produced from those specific waste streams.

Figure 5: Schematic flow diagram of the proposed operational procedure guideline.



2. **Assessment** for each category or subcategory output from step 1.4.

   2.1. From the basis of environmental issues and risks identified for the material stream during processing, shipment and use:

      2.1.1. Assess how waste management legislation is used within the EU to regulate or control the risks. In general the waste management legislation provides a highly flexible regulatory regime which can control the storage, transport and use of the material on a case-by-case basis.

      2.1.2. Assess how relevant non-waste legislation would regulate or control the risks without considering any effect of possible end-of-waste conditions.

      2.1.3. Conclude from 2.1.1 and 2.1.2 the marginal difference between the regulatory regimes. If none go to 2.1.7.

      2.1.4. Consider if end-of-waste criteria could reduce or remove the difference (if any) by introducing standards or conditions for the material. If, at this point, it is not considered possible to reduce or remove the difference in risk control then record the result of the assessments and go to 2.2.

      2.1.5. Assess the extra or alternative processing and other techniques which would be required to meet the standards or conditions identified in 2.1.4.

      2.1.6. Assess any consequent waste generation (e.g. rejects) potentially caused by meeting standards identified in 2.1.4.

      2.1.7. Assess how the quality of the processed waste material and any consequent environmental impact compares to the quality of reference materials which would otherwise be used in potential applications of the material.

   2.2. In most cases, it should be possible to perform an assessment on the marginal processing and application of techniques identified in 2.1.4. Such marginal assessment carried out using life cycle thinking compares only the enhanced actions envisaged to meet the standards or conditions identified above and beyond the actions currently applied to the use of the material as waste. If it is not possible to conduct a marginal assessment it would be necessary to follow a full absolute life cycle assessment of each route. See Section 8, life cycle approach, for details.

   2.3. Assess any apparent barriers to beneficial use of the material because of its classification and consequent regulation as waste.

   2.4. Assess potential market for material. See Section 9, market assessment, for details.

   2.5. What evidence exists that the material is already used for specific purposes as a waste or as a non-waste material?

3. **Expert group consultation** to test initial findings and test support, or additional information needed to secure such support, for concluding on requisite standard answers to end-of-waste components.

3.1. Validation of initial findings by the relevant technical working group, gauging support and/or resistance to possible criteria, sources of information/data for subsequent detailed analysis.

4. **Draft end-of-waste criteria** — all following issues should be included unless demonstrably not relevant in the specific case.

   4.1. Control of source material for processing.

   4.2. Quality control on input to processing.

   4.3. Specific processes to be used or processes not to be used.

   4.4. Critical process parameters required to ensure output material quality is assured.

   4.5. Quality criteria for output material sufficient to assure that issues identified in 1.1.3 and investigated in step 2 are adequately addressed.

   4.6. Standards and/or protocol for monitoring (source materials, process and output materials).

5. **Assess the potential impact** from the legal, economic, market, social and environmental aspects from analysis of available information and expert opinions. Consider if different criteria would affect each potential impact positively or negatively and develop an optimum set of criteria or multiple scenarios based on different criteria. To what extent do the proposed end-of-waste criteria contribute to a high level of protection of public health and the environment during shipment and use of the material?

6. **Expert group consultation**

   6.1. Draft report along lines of final report described in Section 7.

   6.2. Written comments sought within consultation period.

   6.3. Expert workshop focusing on end-of-waste conclusions within draft report, comments received thereon and seeking consensus on resolution of comments.

7. **Preparation of final expert technical working group report**

   7.1. To include background information collected and assessed through application of methodology and key findings according to set conclusions.

   7.2. The amount of data and argument needed to reach specific conclusions may be very different from one report to another and depends on the sensitivity of the conclusion in the specific case. There is therefore no definitive structure or level of detail required for each report.

7.3. All conclusions and recommendations for end-of-waste criteria should be supported by information and/or argument within the report itself and referenced as far as possible to be auditable and transparent.

8. Life cycle approach

8.1. Define the options to be compared and their boundaries.

8.2. Identify the chain of processing steps within each option boundary.

8.3. Marginal comparison of identified options.

8.4. For each processing step within each comparison option identify the environmental pressures in terms of emissions to all environmental media and consumption of resources (including energy, water, etc.). Estimate all emission and consumption data per unit of throughput material.

8.5. For each option, total the emissions and consumptions of the same units (energy, dust, specific pollutants, etc.), if needed in midpoint impact categories.

8.6. Consider possible weighting of pressures or impacts into specified environmental themes. Economic and Cross Media BREF from EIPPCB provides an example of how this may be performed.

8.7. Conclude from these aspects if:

8.7.1. Treating a material as a product and not waste will clearly have no negative environmental impact and may have a positive impact.

8.7.2. Treating a material as a product and not waste will not significantly alter any environmental impact associated with the material.

8.7.3. Treating a material as a product and not waste could have a negative environmental impact under certain conditions.

8.7.4. Treating a material as a product and not waste will have a negative environmental impact. In such a case it needs to be explicitly recorded what impacts could be expected and their significance.

8.8. Consider if any specific end-of-waste criteria could be introduced to reduce or eliminate any potential negative environmental impact. If so create another option with these criteria and carry out the assessment again.

9. Market assessment

9.1. Estimate the potential production of each material category (may be different amounts of different qualities or standards). As far as possible, estimate geographical spread of production (not necessarily the same as the source of waste if processing is carried out centrally or remote from waste generation).

9.2. Estimate which materials could compete against the produced material. Some of this competition may be from natural resources and some may be from other processed materials.

9.3. Estimate any likely future trends in the market situation.

9.4. Estimate likely costs of production of each material and compare against likely costs of competing materials.

9.5. Identify possible market distorting elements such as subsidies, bans or taxes.

9.6. Conclude from these aspects if:

9.6.1. A market clearly exists for utilisation of the material at the foreseeable production rate for the foreseeable future.

9.6.2. A market clearly exists for utilisation of the material but the rate of utilisation is likely to be seasonal or related to usage campaigns and, therefore, storage of material will be fundamental to balance supply and demand over time.

9.6.3. A market clearly exists for utilisation of the material but will be highly price sensitive. Any extra cost burden imposed by possible end-of-waste criteria themselves or by increased transport costs could create a barrier and it is possible that some form of financial or regulatory assistance may be needed to ensure the processed waste can compete in the market.

9.6.4. Although a potential market exists, it is unlikely to be able to absorb the amount of material which could foreseeably be produced. It is thus likely that the excess of supply over demand will become waste at some point.

CHAPTER 2 Compost case study

2.1 Introduction

2.1.1 Objective

This part of the report presents the case study on compost within the JRC-IPTS end-of-waste project.

The objective of this case study, as of the other two (on aggregates and metal scrap), was to support the development of a methodology for proposing end-of-waste criteria under a revised Waste Framework Directive. It achieved this by demonstrating how a set of end-of-waste criteria for compost can be developed and what such criteria may look like under a certain set of basis conditions for end-of-waste criteria.

The methodology development and the case studies were closely linked and iterative. The cases studies served to test early versions of the methodology, provided feedback for the revision of the methodology, and were then further developed by applying the new versions of the methodology.

The proposals developed in this case study are merely research-based showcases and do not necessarily represent the position of the European Commission.

It was not an objective of this case study to assess end-of-waste criteria against any other possible new policy initiatives on compost or biowaste. The study merely tests the feasibility of end-of-waste criteria; however, it does not prejudge any policymaking process and whether end-of-waste criteria for compost should be proposed.

2.1.2 Scope of 'compost'

This study defines compost as the solid particulate material that is the result of composting, which has been sanitised and stabilised. Composting is a process of controlled decomposition of biodegradable materials under managed conditions, which are predominantly aerobic and which allow the development of temperatures suitable for thermophilic bacteria as a result of biologically produced heat.

Composts in the sense of this study do not include the sludges from biogas production through anaerobic digestion unless they are stabilised in a subsequent aerobic composting process and result in a solid particulate material.

Also sewage sludge and sludges from other waste water treatment are included only if they have undergone a composting process (aerobic thermophilic conditions), possibly together with other materials, and result in sanitised and stabilised solid particulate material.

Since this study is about 'end-of-waste' criteria, it only considers composts resulting from composting of wastes. It does not cover any compost produced from virgin raw materials.

2.1.3 Case study structure

The compost case study chapter consists of three main sub-chapters.

Chapter 2.2 is a comprehensive analysis of the different aspects of compost production and use. It covers the technical aspects of composting and the alternative treatment options of biodegradable wastes, the different uses of compost, the compost market, the environmental and health impacts of compost production and use, and the relevant legal framework and standards. The analysis in the first chapter provides the necessary reference information for the following chapters.

Chapter 2.3 is the central part of the case study. It identifies the reasons for the end-of-waste criteria for compost, i.e. the advantages they may deliver compared to the current situation, analyses if and how the basic general conditions for the end-of-waste criteria can be fulfilled in the case of compost, proposes a set of compost end-of-waste criteria accordingly, and suggests a number of complementary measures that may accompany the introduction of end-of-waste criteria for compost.

Chapter 2.4 assesses the impacts that the proposed end-of-waste criteria for compost would have compared to a ‘no action scenario’. The assessment covers the environment and health impact, the economic impact, the market impact and the legislative impact.

2.2 Analysis

2.2.1 The treatment of biodegradable waste

Composting is one of a number of alternative treatment options for biodegradable wastes. This section identifies the different types of biodegradable waste that may be composted, gives a short technical description of composting and the alternative treatments, and identifies the main developments concerning the management of biodegradable waste in the EU, with special attention to municipal solid waste (MSW).

2.2.1.1 Types of biodegradable waste

<u>Biodegradable fractions of MSW</u>

MSW comprises wastes from private households and similar wastes from other establishments that municipalities collect together with household waste. While the exact composition of MSW varies considerably from municipality to municipality and across Member States, it always contains an important portion of biological material. Depending on the country, kitchen waste and 'green' waste from gardens and parks make up 30–50 % of the total mass of MSW. Together they are sometimes called putrescible wastes or 'biowastes'. The term 'biowaste', however, is not always used in the same way and sometimes refers to kitchen waste only and excludes green waste ([10]). Kitchen waste consists largely of food waste. On average, the amounts of kitchen and green wastes are about the same but there are important local variations, for instance, between rural and urban areas. Also the paper fraction in MSW consists, to a large degree, of processed biological material, and so does a part of the textile waste (from non-synthetic fibres).

<u>Other biodegradable wastes</u>

Other biodegradable wastes that may be composted on their own or together with the biodegradable fraction of MSW include mainly the following items:

- commercial food waste, not collected as part of the MSW, including:
  - waste from markets
  - catering waste;

- forestry residues, including:
  - bark
  - wood residues;

- waste from agriculture, including:
  - animal husbandry excrements (solid and liquid manure)
  - straw residues
  - sugar beet and potato haulm
  - Residues of growing of beans, peas, flax and vegetables

([10]) In the Common Position of the Council of 20 November 2007 'biowaste' is defined as 'biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants.'

- wastes from the food and beverage industry, including:
  - breweries and malt houses
  - wineries
  - fruit and vegetable production industry
  - potato industry including starch
  - sugar beet residues and soils
  - slaughterhouse residues
  - meat production
  - whey;

- sewage sludge.

Practically all biological wastes are biodegradable in the presence of oxygen (aerobic conditions) and most biological materials are biodegradable also without oxygen (anaerobic conditions). The main exception is lignin (in woody materials) which does not degrade anaerobically. The speed of the degradation depends on the environment in which it takes place. Moisture, temperature, pH and the physical structure of the materials are some of the key parameters. Burning or incineration is the other main option for decomposing biological material.

2.2.1.2 Treatment options

Landfill

In the past, landfilling mixed MSW without pretreatment or separating out the biological fraction was common practice in most Member States. This option is today considered bad practice because it is associated with serious environmental and safety risks related to landfill gas, leachate and landfill settlement.

Through the Landfill Directive ([11]), the European Union has laid down strict requirements for landfills to prevent and reduce the negative effects on the environment as far as possible. Amongst other things, the Landfill Directive requires that waste must be treated before being landfilled and that the biodegradable waste going to landfills must be reduced gradually to 35 % of the levels of the total amount of biodegradable municipal waste produced in 1995.

Incineration and other thermal treatments

The combustion of waste in incinerators allows reduction of the waste for disposal in landfills to an inert inorganic ash residue. The organic carbon is oxidised to CO_2 and H_2O which are discharged to the atmosphere in the stack gas.

Large-scale mass burn incineration is the most common form of incineration today. It means that waste is combusted with little or no sorting or other pretreatment. In modern incinerators, the energy is recovered to produce electricity and/or heat. The calorific values of individual types of waste vary considerably, from about zero for wet putrescible wastes to over 30 GJ/tonne for some plastics (Smith et al., 2001). If too much wet putrescible waste comes through the waste streams, a pilot fuel may be required to ensure sufficiently high combustion temperatures.

([11]) Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).

An alternative option to mass burn incineration is to preprocess the waste to produce refuse derived fuels (RDF). Processing the waste allows materials that can be recycled to be removed from the combustible residue, along with wet organic materials such as food and garden wastes for separate treatment. The combustible fraction may be burned directly or co-combusted, for example in coal-fired power plants or cement kilns.

Newly emerging technologies involve pyrolysis and gasification to first break down the organic matter in the waste into a mixture of gaseous and/or liquid products that are then used as secondary fuels.

The Waste Incineration Directive ([12]) aims to prevent or to reduce negative effects on the environment caused by the incineration and co-incineration of waste as far as possible. In particular, the conditions laid down in the directive should reduce pollution caused by emissions into the air, soil, surface water and groundwater, and thus lessen the risks which these pose to human health. This is to be achieved through the application of operational conditions, technical requirements, and emission limit values for waste incineration and co-incineration plants within the Community.

Mechanical biological treatment

In mechanical biological treatment, the mixed MSW undergoes a mechanical sorting of the whole waste into a biodegradable fraction and a reject fraction, which may be further split, especially to sort out and recycle metals. The remainder of the reject fraction is either landfilled or incinerated.

The biodegradable fraction is then composted or aerobically digested. The volume of the composted residue and its further degradability are reduced (stabilisation). When landfilled, the stabilised waste has a much reduced capacity for producing landfill gas and leachate, and it can provide a very compact material. Usually the material is not of sufficient quality to be useable in agriculture or horticulture, but it can be used to cover or restore land on landfills.

Composting

Composting is the aerobic degradation of waste to produce compost. It has a long history in many parts of Europe. Originally it was used in the form of simple processes on a small scale for farm and back yard composting. In the last two decades, composting has received renewed and widened interested as a means of addressing current waste management challenges, in particular for reducing the amount of wastes going to landfills and the associated CH_4 emissions from the degradation of organic materials in landfills. The production of compost is also seen as an opportunity for providing a material that can be used as a component in growing media or as an organic fertiliser or soil improver. This and other uses of compost are discussed in more detail in Section 2.2.2 below.

Many installations which produce composts for use as growing media or soil improvers rely on source-separated biological fractions of MSW (kitchen waste and/or garden and park waste). The reason for this is to keep the levels of compost contamination with undesirable materials, such as glass or plastic, and other substances, such as heavy metals and organic

([12]) Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (OJ L 332, 28.12.2000, p. 91).

pollutants, as low as possible. Recently, technologies have been under development with the aim of achieving high compost purities from mixed MSW by means of enhanced material separation before and throughout the composting process. The other main types of compost are compost produced from bark, manure and from sewage sludge (together with bulking material).

The size of composting plants ranges from treatment capacities of less than 1 000 tonnes to more than 100 000 tonnes/year. The process technologies of composting are very diverse. Distinctive features of different composting technologies are:

- open or closed composting
- with or without forced aeration
- different process techniques like windrow, container, box channel or tunnel composting.

Open-air windrow composting is the simplest technique. Generally, these plants work without forced aeration and waste gas collecting. Techniques with forced air systems are mostly associated with the collecting and treatment of waste gas. Combined scrubber and biofilter systems are a typical form of waste gas treatment. Different types of mechanical separation techniques are usually applied before, during or after the composting processes to sort out undesirable components from the material.

Depending on the composting technique applied and the 'maturity' of the compost product, the duration of the composting process ranges from a little more than a week to several months.

An important part of the composting takes place by the action of thermophilic micro-organisms at a temperature of up to 70 °C and sometimes even more. If temperatures are maintained for a sufficiently long time, pathogenic micro-organisms are killed off along with the weed seed, and the material can be considered hygienically safe.

<u>Anaerobic digestion</u>

Alternative to, or in combination with, aerobic composting, biological wastes can also be decomposed in a controlled process in the absence of oxygen. The process runs in airtight vessels, usually for two to three weeks, and produces methane-rich biogas. The biogas is burnt to generate electricity and/or heat. A part of the energy may be used to heat the process and keep it at the required temperature (30–60 °C). The process also produces a sludge-like or liquid residue, termed 'digestate', which may be used on farmland as liquid organic (NPK) fertiliser. In some plants the digestate is dewatered and 'cured' by composting to stabilise the material which can then be used as an organic fertiliser or soil improver if it is of a sufficient quality. The liquid from the process is recycled back into the process to a large extent, and the excess, if any, can be used as a liquid fertiliser if the quality allows this. Otherwise, it is disposed of into the sewerage system.

Anaerobic digestion is applied to the putrescible fractions of MSW, agricultural wastes (excrements, litter, straw, beet and potato leaves), food industry wastes (residues from brewing, grape pressing, sugar production, slaughterhouse by-products and meat processing residues, waste water from milk processing) and sewage sludge.

Typically, anaerobic digestion applied to MSW uses source-separated putrescible waste as the input, possibly in co-digestion with agricultural residues, if the digestate is to be spread on land.

2.2.1.3 Developments in the treatment of biodegradable waste

The Landfill Directive ([13]) requires that the biodegradable waste going to landfills is reduced to

- 75 % by 16 July 2006
- 50 % by 16 July 2009
- 35 % by 16 July 2016

compared to the total amount of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which standardised Eurostat data are available.

Member States that landfilled more than 80 % of their municipal waste in 1995 were allowed to postpone each of the targets by a maximum of four years.

The Landfill Directive requires Member States to set up a national strategy for the implementation of the reduction of biodegradable waste going to landfills. On 30 March 2005, the European Commission reported on the national strategies it had received from Denmark, Germany, Greece, France, Italy, Luxembourg, the Netherlands, Austria, Portugal and Sweden as well as on the regional plans for England, Wales, Scotland, Northern Ireland, Gibraltar, the Flemish Region and the Walloon Region. The report shows that there are large differences in the roles given to composting in the different national and regional strategies. The following three examples illustrate the diversity of the national strategies.

Austria has introduced a legal obligation to collect biodegradable waste separately, which may then be used to produce compost. As a consequence, the amount of separately collected biodegradable waste increased from a few thousand tonnes in 1989 to approximately 500 000 tonnes in 2001 (in 1995, the amount of biodegradable municipal waste produced in Austria was 267 5300 tonnes.) This was complemented by the entry into force of an Ordinance on Composting in 2001, which regulates the quality requirements for composts from waste, the type and origin of the input materials and the conditions for their placing on the markets. Austria has already achieved the last reduction target as stated in the Landfill Directive.

Denmark has also already achieved the last target, but with a completely different strategy. An Order regarding waste issued in 2000 requires all Danish municipalities to send waste that is suitable for incineration to incineration. In recent years, only very small amounts of biodegradable municipal waste have therefore been landfilled, corresponding to far less than 10 % of the total amount of biodegradable municipal waste produced in 1995.

Italy is an example of a country that has opted for a mixed strategy. The country already fulfilled the target for 2006. In 2002, 830 0000 tonnes of biodegradable waste were diverted from landfills through:

- separate collection (3 800 000 tonnes);

([13]) Article 5(2) of Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).

- mechanical biological treatment (5 600 000 tonnes of unsorted waste with an estimated biodegradable fraction of 3 100 000 tonnes);
- incineration (2 700 000 tonnes of waste, of which about 1 500 000 tonnes was biodegradable).

A brief characterisation of biodegradable waste management in 25 EU Member States is presented in Annex 2-1.

2.2.2 Compost as a product

There are two main uses of compost as a product: as a soil improver/organic fertiliser and as a component of growing media.

2.2.2.1 Compost as a soil improver/organic fertiliser

Compost is considered a multifunctional soil improver. It is therefore used in agriculture and horticulture as well as to produce topsoil for landscaping or land restoration. The application of compost usually improves the physical, biological and chemical properties of soil. Repeated application of compost leads to an increase in soil organic matter, it often helps to reduce erosion, it increases the water retention capacity and pH buffer capacity, and it improves the physical structure of soil (aggregate stability, density, pore size). Composts may also improve the biological activity of the soil.

Compost is often considered an organic fertiliser, although the fertiliser function of compost (supply of nutrients) is, in many cases, less pronounced than the general soil improvement function. According to Kluge (2008) the supply of plant-available nitrogen by compost is rather low, especially in the short term, and only repeated applications over long periods may have a relevant effect. However, the phosphate and potassium demand of agricultural soils can, in many cases, largely be covered by adequate compost application. Compost also supplies calcium, magnesium, sulphur and micronutrients.

The effects of compost also depend on the local soil conditions and agricultural practices, and many aspects are still not well understood.

The quality parameters that positively characterise the usefulness of compost in agricultural applications include:

- organic matter content
- nutrient content (N, P, K, Mg, CaO)
- dry matter
- particle size
- bulk density
- pH.

2.2.2.2 Compost as component of growing media

The second main use of compost is as a component of growing media.

Growing media are materials, other than soil, in which plants are grown. About 60 % of growing media are used in hobby applications (potting soil), and the rest in professional applications (greenhouses, container cultures). The total volume of growing media consumed in the EU is estimated to be about 20–30 million m^3 annually. Worldwide, peat-based growing media cover some 85–90 % of the market. The market share of compost as a growing medium constituent is below 5 %. Growing media are usually blends with materials mixed according to the required end product characteristics (SV&A, 2005).

The Waste and Resources Action Programme (WRAP) together with the Growing Media Association have issued guidelines for the specification of composted green materials used as a growing medium component based on the BSI PAS 100 specifications for composted materials (WRAP, 2004). The guidelines introduce additional requirements to those of BSI PAS 100, e.g. concerning heavy metal limits.

According to these guidelines, any growing media shall:

- have a structure which physically supports plants and provides air to their roots and reserves of water and nutrients;
- be easy to use with no unpleasant smell;
- be stable and not degrade significantly in storage;
- contain no materials, contaminants, weeds or pathogens that adversely affect the user, equipment or plant growth;
- be fit for the purpose and grow plants to the standard expected by the consumer in accordance with the vendor's description and claims.

Specifically for compost, the guidelines identify the fundamental requirements of a composted green material supplied as a component of a growing medium. It shall:

- be produced only from green waste inputs;
- be sanitised, mature and stable;
- be free of all 'sharps' (macroscopic inorganic contaminants, such as glass fragments, nails and needles);
- contain no materials, contaminants, weeds, pathogens or potentially toxic elements that adversely affect the user, equipment or plant growth (beyond certain specified limits);
- be dark in colour and have an earthy smell;
- be free-flowing and friable and be neither wet and sticky nor dry and dusty;
- be low in density and electrical conductivity.

According to the WRAP guidelines, such composts 'would normally be suitable for use as a growing medium constituent at a maximum rate of 33 % by volume in combination with peat and/or other suitable low nutrient substrate(s) such as bark, processed wood, forestry co-products or coir.' Higher rates usually affect plant growth negatively because of the compost's naturally high conductivity.

According to ORBIT/ECN (2008), the proportion of compost in growing media depends very much on the composting process and final compost quality. The main criteria are maturation and degree of humification, concentration of mineral nitrogen components, salt content and structural stability (porosity, bulk density, aggregation) and purpose for use. In growing media for hobby gardening 40–50 % (by volume) compost can be used; in growing media for professional use 20–30 % (by volume) compost can be used. In the German quality assurance system for compost (RAL, 2007) specific criteria are laid down for compost in potting soils (growing media). Two types of compost suitable as mixing compound for growing media with different mixing volumes are described regarding stability level, nutrient and salt content.

It is important to note that compost produced with a high proportion of cooked kitchen waste is usually only suitable in lower portions as growing media component because it tends to have a higher salinity and nutrient content.

2.2.3 Compost market

This section characterises the compost market in the EU in terms of current compost supply and use, imports and exports, production costs, compost prices, and the agronomic value of compost. It also presents a compost market outlook based on theoretical production and use potentials.

2.2.3.1 Compost supply

ORBIT/ECN (2008) estimated that the yearly production of compost in the EU in 2005 was more than 13 million tonnes (compost from the biodegradable fraction of MSW and sewage sludge). Only a few countries make up most of the compost production from MSW in the EU. In absolute amounts, Germany is the biggest compost producer with about three million tonnes, followed by France, the United Kingdom, the Netherlands and Italy. On a per capita basis, compost production is highest in the Netherlands, followed by Austria, France and Germany. Of these countries, Germany, the United Kingdom, the Netherlands and Austria rely mainly on source-separated biodegradable fractions of MSW for compost production. In France and Spain, compost is also produced in considerable quantities from mixed MSW. France, Spain and Italy also produce sizeable amounts of sewage sludge compost. In the 12 new Member States, compost production plays a very small role.Table 1 presents compost production data country by country.

Apart from MSW and sewage sludge, compost can also be produced from wastes from agriculture, forestry, and the food and drink industries. The quantities of composts produced from these sources are unknown but are assumed to be much smaller than from MSW and sewage sludge.

Table 1: Compost produced in the EU in 2005 (tonnes/year). Source: ORBIT/ECN (2008).

	Year	**Total**	**Biowaste compost**	%	**Green waste compost**	**%**	**Sewage sludge compost**	**%**	**Mixed waste compost**	**%**
AT	2005	**416 000**	218 400	34	380 000	60	32 000	5	4 000	1
BE/Flanders	2005	**342 000**	103 000	30	239 000	70	0	0	0	0
BG		**0**	0		0		0		0	
CY		**0**	0		0		0		0	
CZ	2006	**77 600**	4 000	5	21 600	28	52 000	67	0	0
DE	2005	**2 966 935**	2 089 139	70	848 486	29	29 310	1	0	0
DK	2005	**350 000**	15 200	4	294 800	84	40 000	11	0	0
EE		**0**	0		0		0		0	
ES	2005	**855 000**	35 000	4	0	0	180 000	21	640 000	75
FI	2005	**180 000**	150 000	83		0	30 000	17		0
FR	2005	**2 490 000**	170 000	7	920 000	37	800 000	32	600 000	24
EL	2005	**8 840**	0	0	840	10	0	0	8 000	90
HU	2005	**50 800**	20 000	39	30 800	61	0	0	0	0
IE	2006	**100 500**	25 000	25	34 000	34	17 000	17	24 500	24
IT	2005	**1 200 000**	850 000	71	180 000	15	170 000	14	0	0
LT		**0**	0		0		0		0	
LU	2005	**20 677**	20 677	100	0	0	0	0	0	0
LV		**0**	0		0		0		0	
MT		**0**	0		0		0		0	
NL	2005	**1 654 000**	719 000	43	935 000	57	0	0	0	0
PL		**0**	0		0		0		0	
PT	2005	**29 501**	2 086	7	1 730	6	2 500	8	23 185	79
RO		**0**	0		0		0		0	
SE	2005	**154 800**	38 800	25	100 000	65	0	0	16 000	10
SI		**0**	0		0		0		0	
SK	2005	**32 938**	1 836	6	27 102	82	4 000	12	0	0
UK	2005/06	**2 036 000**	316 000	16	1 660 000	82	15 000	1	45 000	2
EU-27		**13 183 991**	**4 778 139**	**36**	**5 673 358**	**43**	**1 371 810**	**10**	**1 360 685**	**10**
Bio and green waste compost					**10 451 496**	**79**				

2.2.3.2 Compost use

The suitable uses of compost depend on source material type, compost class and quality. Application areas like agriculture just require standard quality. Landscaping and, even more so, the growing media sector need an upgraded and more specialised product. Here, further requirements of the customers have to be met and it is up to the marketing strategy of the compost plant to decide whether to enter into this market segment.

Compost producers often face difficulties in marketing because they lack understanding of the potential use sectors such as the landscaping and horticultural sectors (e.g. knowledge of plant growing and the related technical language). Declaration, advertisement and marketing are not always of a standard comparable with competing products.

An important factor determining compost use is the national environmental and fertilising policy. The manure policy in Belgium, for instance, makes it very difficult to sell compost to farmers (only 11 % of compost goes to agriculture). In the Netherlands, however, with the same animal husbandry and nutrient situation, most of the kitchen/biowaste compost is used in agriculture (75 %).

In Europe, more than 50 % of the compost goes to mass markets which require standard quantities. Twenty to thirty per cent of the market volumes are used in higher specialised market areas which require an upgrade and mixing of the compost in order to meet the specific requirements of the customers.

Table 2 provides an overview of compost use in the main compost producing countries in the EU.

Table 2: Compost use distribution (%) in major compost producing countries. Source: ORBIT/ECN (2008).

	AT 2003	BE/ Fl 2005	DE 2005	ES (1) 2006	FI 2005	FR (2) 2005	HU 2005	IE 2006	IT 2003	NL bio-waste 2005	NL (1) green waste 2005	PL (2) 2005	SE 2005	UK 2005	Mean EU
Agriculture	40.0	1.0	53.4	88.0	20.0	71.0	55.0	37.0	51.0	74.8	44.4	—	—	30.0	48.0
Horticulture & green house production	10.0	1.0	3.9	8.0	—	25.0	15.0	3.0	—	—	15.5	—	5.0	13.0	11.3
Landscaping	15.0	22.0	15.9	4.0	20.0	—	10.0	6.0	6.0	3.6	12.3	—	20.0	14.0	12.4
Blends	15.0	6.0	13.6	—	10.0	—	—	16.0		15.0	5.1	—		2.0	10.3
Soil mixing companies	2.0	21.0	—	—	—	—	—	—	—	—	9.4	—	10.0	—	10.6
Wholesalers	—	9.0	—	—	—	—	—	—	—	—	5.2	—	15.0	—	9.7
Hobby gardening	15.0	20.0	11.9	—	—	4.0	5.0	—	27.0	1.1	2.3	—	10.0	25.0	11.0
Land restoration and landfill cover	2.0	1.0	—	—	50.0	—	15.0	38	2.0	—	—	100.0	40.0	16.0	26.4
Export	1.0	7.0	—	—	—	—	—	—	—	5.5	5.0	—	—	—	4.6
Others	—	2.0	1.3	—	—	—	—	—	—	—	0.8	—	—	—	1.4

(1) Green waste compost.
(2) Mainly mixed waste compost.

In recent years, the use distribution in countries with developed markets (such as Belgium, Germany and the Netherlands) was relatively stable. Changes in the fertiliser legislation in the Netherlands have, however, led to a reduced share of agricultural use after 2005.

2.2.3.3 Compost imports and exports

According to ORBIT/ECN (2008), the main compost exporting countries in the EU are probably Belgium and the Netherlands. On average, they exported 4.5 % of their annual production in 2005 and 2006. The main reason for exports in these cases was a low national demand because of strong competition of other cheap organic material (mainly manure).

Generally, compost plants supply their product within 50 km of the plant. This corresponds to the distance a large lorry of 25 tonnes capacity can make within an hour for the cost of EUR 50–60. These transport costs and the other marketing expenses are still covered by prices of around EUR 5/tonne (EUR 125/lorry load). All plants close to borders (less than 50 km distance) contacted by ORBIT/ECN underlined the importance of this local market and expressed their appreciation of the end-of-waste provisions which could potentially help them to overcome the constraints of selling their compost over the border.

ORBIT/ECN reports not having detected a ‘real import demand’ for compost. The low value per weight of compost does not cover the cost of the transport to the areas where the main needs exist, such as the Mediterranean countries.

The main continuous import and export activities and potentials are related to the growing media sector. Using compost in various products based on green waste are a common business especially for the large international companies producing and dealing with peat, soil and bark. However, growing media products containing compost as one of the components are generally not considered subject to waste legislation.

2.2.3.4 Production costs and compost prices

The costs of composting depend on local conditions and the quality of the material to be composted. Eunomia (2002) reviewed the information from various sources regarding the cost of composting source-separated biological waste, and made a cost estimate of EUR 35–60/tonne of waste for larger ‘best practice’ plants in closed systems, although higher costs had also been reported in some cases. The cost of low-tech windrow composting may be less than EUR 20/tonne of waste. There are also some cost differences between countries following the general tendencies of producer prices. Gate fees charged for green waste tend to be smaller than for kitchen waste or for mixed kitchen and green waste.

The price of bulk compost for use as an organic fertiliser or a soil improver is much lower than the ‘production costs’, i.e. the costs of treating biological wastes in a composting plant. The prices achieved for composts for agricultural use in central Europe are rarely higher than EUR 5/tonne of compost and, in most cases, lower. Often, the compost is actually given away to farmers free of charge. A typical scenario in Germany is that the compost producer offers the transport, the compost and the spreading of the compost on the field as a service to the farmers (usually through subcontractors) and charges about EUR 1–2/tonne for everything.

Compost sales to agriculture become very difficult when there is a fierce competition with manure. This is the case in Belgium and the Netherlands, where, on account of the huge animal husbandry, a surplus in manure arises and up to EUR 30/tonne of manure is paid to the users. This and a restrictive application regulation make it difficult to sell compost for agricultural uses in those countries (ORBIT/ECN, 2008).

A recent French compost market study for ADEME (2006) reports the following price ranges for compost use in agriculture (grandes cultures):

- compost from green waste: EUR 0 (in most cases) to EUR 10–12/tonne (including the cost for transport and spreading)
- compost from mixed MSW: EUR 0 (most frequently) to EUR 2–3/tonne (including spreading).

The combined separation-composting plant for MSW at Launay Lantic (France) sells most of the compost produced to artichoke or cauliflower growers at a price of EUR 2.34/tonne (personal communication).

In Austria, decentralised composting plays an important role and often farmers run small and simple windrow composting facilities in which they treat source-separated biological waste from nearby municipalities. The farmers use the compost on their own farmland, and if their farmland is of a suitable size, there is no need for these compost producers to sell or give away the compost. For the highest quality compost, which is suitable for organic farming, prices of a little more than EUR 10/m^3 have been found. An example of the gate fee charged by a 'farmer-composter' in Austria is EUR 48/tonne biowaste from separate collection.

In 2001, the average sales price for compost made from pure garden and park waste in Denmark were reported to be about EUR 8–9/tonne (Hogg et al., 2002).

According to ORBIT/ECN (2008), soil manufacturing companies and blenders are interested in getting cheap raw material and are therefore not willing to pay high prices, so sales prices range from EUR 2.40 to EUR 3.20/tonne.

Landscaping and horticulture require medium efforts in product development and marketing, which reflect the price of EUR 6–15/tonne. Hobby gardening prices are on a similar level.

Relatively high prices from EUR 90 to EUR 300/tonne follow from situations where the compost is sold in small bags, e.g. as blends, to hobby gardeners or to wholesalers. Bulk deliveries to wholesalers, however, only lead to about EUR 7/tonne.

Unless sizeable proportions of the compost produced can be sold to outlets other than agriculture for higher prices, the financial feasibility of the composting plants essentially depends on the gate fees charged for the treatment of the wastes used as input or on subsidies. According to ORBIT, this is true for all European countries. Ninety-five per cent of the plants rely on the gate fee. Only very few companies have developed their local market so well that compost sales contribute substantially to their economic feasibility. In most cases, only a relatively moderate pressure exists for entering into the revenue-oriented high price markets, which requires additional efforts and competence in market and product development and marketing.

The low value per tonne of compost soil improvers and fertilisers is a strong limitation to the distances over which the transport of compost for agricultural uses makes economic sense. Transportation over more than 100 km for agricultural uses will only be feasible if there are specific areas where agriculture has an exceptionally strong demand for organic fertilisers that cannot be satisfied from local sources or if the waste management sector 'cross-subsidises' the transport cost (negative prices of the compost before transport). The latter is likely to occur if the alternative treatments for biological waste, such as landfill or incineration, are more expensive than composting.

2.2.3.5 Agronomic value of compost

ORBIT/ECN (2008) estimated the agronomic value of compost based on the fertiliser prices published on 10 April 2007 by the Chamber of Agriculture of North Rhine-Westphalia. For example, fresh compost produced from kitchen and garden wastes, rich in nutrients and well structured, and declared as organic NPK fertiliser 1.40 (N)–0.60 (P_2O_5)–1.02 (K_2O) has a nutrient value of EUR 8.49/tonne fresh matter. The fertiliser value of well-structured compost with lower nutrient contents (organic PK fertiliser EUR 0.43/kg P_2O_5–EUR 0.22/kg K_2O) was calculated to be EUR 3.93/tonne fresh matter. The nitrogen content was calculated on the basis of the available contents. The contents of phosphorus and potassium were calculated at 100 % on recommendation of agricultural consultants.

In addition to the nutrient value, ORBIT/ECN also calculated the humus value for an average compost application (ca 2 800 kg humus-C/hectare incorporated within a three-year crop rotation). Taking the substituted supply costs of humus via ‘green manuring’ with *Phacelia* or *Sinapis arvensis* and/or straw sale as the reference, the humus value of compost was calculated to be EUR 3.28/tonne fresh matter.

Comparing this with compost prices for agricultural use, it appears that the agronomic value can be substantially higher than the price paid for it.

2.2.3.6 Market outlook

In this section, the theoretical potential of compost production from the source-segregated biodegradable fractions of MSW is estimated and compared to the theoretical compost use potential. Also, the amounts of alternative materials, which can be used instead of compost, are estimated.

<u>Compost production potential</u>

According to ORBIT/ECN (2008), about 29.5 % or 23.6 million tonnes of the estimated total recoverable potential of the 80 million tonnes organic waste fractions is currently separated at the source and treated predominantly through composting. This corresponds to an average per capita biowaste and green waste collection rate of about 50 kg/year.

Experience in certain countries showed that a collection rate of up to 180 kg/capita/year of source-separated organic waste suitable for biological treatment can realistically be achieved (for example in the Netherlands or Austria). A reasonable and realistically achievable European average rate might be 150 kg/capita/year (ORBIT/ECN 2008). Using this as a reference, it would imply a potential of separate biowaste and green waste collection in the EU of about 80 Mtonnes/year. If all this were used for compost production, 35–40 Mtonnes of compost could be produced per year. Table 3 shows estimates of current amounts of separately collected wastes as well as of the maximum potentials for the 27 Member States of the EU.

**Table 3: Potential and actual amounts of biowaste and green waste collected for composting in the EU-27 (1 000 tonnes).
Source: ORBIT/ECN (2008).**

		Potential quantities			Separately collected today (without home composting) ([3])			Separately collected (% of total potential)
	Total MSW ([1])	Biowaste	Green waste	Total ([2])	Biowaste	Green waste	Total	
AT	3 419	750	950	1 700	546	950	1 496	88
BE	4 847	n.d.	n.d.	2 573	n.d.	n.d.	885	34
BG*	3 593	n.d.	n.d.	1 164	0	0	0	0
CY*	554	n.d.	n.d.	112	0	0	0	0
CZ	3 979	1 354	180	1 534	10	123	133	9
DE	37 266	8 000	8 000	16 000	4 084	4 254	8 338	52
DK	3 988	433	750	1 183	38	737	775	66
EE	556	195	130	325	0	0	0	0
ES*	25 694	n.d.	n.d.	6 456	n.d.	n.d.	308	5
FI*	2 451	n.d.	n.d.	785	350	100	450	57
FR*	46 000	n.d.	n.d.	9 378	300	2 400	2 700	29
EL*	4 854	n.d.	n.d.	1 662	0	2	2	0
HU*	4 446	n.d.	n.d.	1 515	n.d.	n.d.	127	8
IE*	3 041	n.d.	n.d.	616	52	71	123	20
IT	31 687	n.d.	n.d.	8 700	2 050	380	2 430	28
LT*	1 295	n.d.	n.d.	514	0	0	0	0
LU*	321	n.d.	n.d.	68	n.d.	n.d.	52	76
LV*	715	n.d.	n.d.	346	0	0	0	0
MT*	246	n.d.	n.d.	60	0	0	0	0
NL*	10 900	n.d.	n.d.	2 446	1 656	1 700	3 356	137 ([4])
PL*	9 353	n.d.	n.d.	5 726	n.d.	n.d.	70	1
PT	4 696	n.d.	n.d.	1 579	24	10	34	2
RO*	8 274	n.d.	n.d.	3 249	0	0	0	0
SE*	4 343	n.d.	n.d.	1 352	125	250	375	28
SI*	845	n.d.	n.d.	300	0	0	0	0
SK*	1 558	n.d.	n.d.	808	5	68	73	9
UK*	35 075	n.d.	n.d.	9 009	n.d.	n.d.	1 872	21
EU-27	257 947			80 101			23 598	29.5

([1]) Source: Eurostat website (http://epp.eurostat.ec.europa.eu).
([2]) In most cases individual estimations by national experts were missing. For all Member States marked with an asterisk (*) the realistic potential of biowaste and green waste collection is based on the assumption of 150 kg/capita/year.
([3]) The estimation of currently collected biowaste and green waste was provided by national experts contacted during the elaboration of this study (see acknowledgments). The reference year was 2005.
([4]) The Netherlands with 200 kg/capita/year bio and green waste collection has already exceeded the mean potential estimated with 150 kg/capita/year. This leads to 137 % collected against potential.

Furthermore, the potential for the production of compost from sewage sludge was estimated to be from 5 to 10 Mtonnes/year. The potential for the production of compost from other organic materials cannot reasonably be quantified, because of the very heterogeneous properties even within one sub-waste stream (e.g. market wastes). The suitability of treating those materials in an aerobic composting process depends on the composition, degradability, water or nutrient content (C/N ratio). Composting is not always the first choice. Most of the food and vegetable residues, for instance, are very wet which makes them more suitable for anaerobic digestion. For bark and wood, energy generation might sometimes be the preferred option.

Compost use potential

ORBIT/ECN (2008) suggests a simple calculation to illustrate that the theoretical potential for compost use, in agriculture alone, is much higher than the theoretical compost production potential from biowaste and green waste. The calculation is reproduced in Table 4. Similar conclusions were obtained by calculations of this type at the level of individual Member States. Furthermore, there are specific compost market studies for Germany, Ireland, Spain, France and the United Kingdom (most of them reviewed by ORBIT/ECN) that all conclude that there is sufficient potential for use of high-quality compost.

Table 4: Comparison of compost production and agricultural use potentials in the EU.
Source: ORBIT/ECN (2008).

Present situation in EU	Amount
Amount of collected bio and green waste	23 600 000 tonnes
Amount of compost produced in the EU-27	11 800 000 tonnes
Arable land for plant production in the EU-27	123 391 000 ha ([14])
A typical application rate of 10 tonnes compost/year needs	1 800 000 ha
Portion of the total arable land needed to absorb the compost	1.5 %
Theoretical compost production potential (maximum)	Amount
Potential for collected bio and green waste	80 000 000 tonnes
Potential amount of compost produced in the EU-27	40 000 000 tonnes
Arable land for plant production in the EU-27	123 391 000 ha
A typical application rate of 10 tonnes compost/year needs	4 000 000 ha
Portion of the total arable land needed to absorb the compost	3.2 %

Substitute materials for compost

As soil improvers, agricultural residues — first of all straw and manure — can create a similar benefit to compost by fertilising the soil and delivering organic matter. According to ORBIT/ECN (2008), the effect on humus reproduction is, however, much higher of compost

([14]) Source: Eurostat. Statistik kurz gefasst. Landwirtschaft und Fischerei 86/2007. Europäische Gemeinschaften 2007.

than of these materials. In the EU, there are from 1.5 to 2 billion tonnes of agricultural residues per year.

Plant nutrients contained in compost can substitute, to some extent, mineral fertilisers. In Germany for example, the substitution potential for phosphate is 28 000 tonnes, which corresponds to 10 % of the phosphate of the mineral fertilisers applied in Germany. These potentials are 9 % (43 000 tonnes) in the case of potassium and 8 % (175 000 tonnes) in the case of lime fertilisers.

Compost also competes with the land spreading of sewage sludge. Some 3.62 Mtonnes (dry matter) treated sludge from municipal waste water treatment was used in agriculture in 2003.

In growing media, compost can partly substitute peat and bark. Bog peat is still the overall predominant growing medium constituent in the EU. This is also true for Member States without domestic peat production. Peat-free growing media are highly esteemed by some stakeholder and user groups but still play a relatively minor role in the industrial production of growing media. For technical reasons, bark, coir and compost can only partly serve as substitutes for peat.

In 2005, 0.95 million m^3 compost and 2.05 million m^3 bark (including wooden materials) were used in growing media (ORBIT/ECN, 2008).

2.2.4 Environmental and health impacts

2.2.4.1 Introduction

Quite independently of the composting technique applied and the nature of the input materials, composting has a series of potential environmental interventions and health issues associated to it. They are presented in this section and include greenhouse gas and other air emissions, water emissions (leachate), soil related effects, hygiene issues and the risk of injuries, and positive environmental effects of compost use. Finally, conclusions are made with the regard to the main issues.

The fact that the potential environmental and health impacts of composting are discussed in a comprehensive manner should not be misinterpreted as an indication per se of compost being good or bad for the environment. The purpose of this chapter is simply to provide the information base for understanding the potential environmental and health impacts and risks that need to be managed. Such a comprehensive analysis is required for any material that is a potential candidate for end-of-waste criteria.

2.2.4.2 Air emissions

Gaseous emissions from the composting process include carbon dioxide (CO_2), water vapour, and, in smaller quantities ammonia, (NH_3), volatile organic compounds (VOCs), bioaerosols (fungi, bacteria, actinomycetes, endotoxins, mycotoxins) and particulates. Usually there will also be methane (CH_4) emissions, as it is often not possible to guarantee that all material will be kept under aerobic conditions at all times. Depending on the input materials, composting may release odour emissions, which can potentially be strong.

In closed composting systems, biofilters are often used to treat the waste gas to reduce the emissions of odours, some VOCs, ammonia, aerosols and particulates. On the other hand, certain emissions may also be increased by biofilters, in particular N_2O.

According to ADEME (2005) and DEFRA (2004), there is a lack of generally representative quantitative air emission data.

The DEFRA study carried out a 'Review of environmental and health effects of waste management: municipal solid waste'. It was based on a substantial sample of the available literature and data. The study systematically assessed the reliability of all the data, taking into account, for instance, the number of waste management facilities from which data were available, if an extrapolation to the full sector at a national level was possible, and whether the information came from peer reviewed literature, was endorsed by governmental bodies, or came from 'grey' literature. The study report as such underwent an external review by the Royal Society. The study concluded that the available data were not sufficient to quantify air emissions from composting, mechanical biological treatment (MBT) or anaerobic treatment.

The ADEME report, which systematically establishes emissions data for biological treatments based on a reliability assessment of data found in literature, comes to similar conclusions, and confirms that there is a general lack of representative air emissions data (and, in the case of compost, especially VOCs). It also notes a general lack of data on emissions during the storage of the biological material.

In recent years, several new investigations on gaseous emissions from composting, covering various composting techniques, have, nevertheless, been carried out and used to characterise the state of the art of composting (Amlinger et al., 2005; Cuhls and Mähl, 2008).

The CH_4 and N_2O emissions are important for the climate change impacts of composting (see Section 2.2.4.3 on greenhouse gas emissions) while the CO_2 emissions are considered climate-neutral because they originate mainly from short-cycle biomass (see also next section on greenhouse gas emissions).

The other emissions are relevant mainly for potential occupational and local population health impacts or may be perceived to be a nuisance. They make it necessary to take suitable measures to protect plant workers and residents in the surrounding areas.

Workers at a composting facility may be exposed to, and inhale, large quantities of bioaerosols if not protected by technical or operational means. It needs to be considered that there are certain individuals, for example asthmatics and the immuno-compromised, that are especially susceptible to potential adverse health effects after exposure to bioaerosols.

2.2.4.3 Greenhouse gas emissions

The fate of the organic carbon contained in the waste is one of the key factors that determine the relevance of compost production and use for climate change, i.e. the extent to which the carbon is immobilised or degraded and emitted as gas, and the proportions of CO_2 and CH_4 in the gas emissions. A second important factor is N_2O emissions during composting. Other emissions are, in most cases, of much less relevance (including those originating from process energy or transport, and the other greenhouse gases).

According to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, CO_2 from organic waste handling and decay should not be included in greenhouse gas inventories. The reason is that organic material derived from biomass sources which are regrown on an annual basis is the primary source of CO_2 released from such waste. These CO_2 emissions are not treated as net emissions from waste according to the IPCC guidelines (if biomass raw materials are not being produced sustainably, the net CO_2 release should be calculated and reported under agriculture, land use change or forestry).

However, consideration needs to be given to the fact that if organic waste or materials obtained from biomass remain at least partly un-degraded for longer times, this effectively removes carbon from the atmosphere. This is the case, for example, when compost that has been spread on agricultural land is only slowly mineralised and increases the soil organic matter, or when organic material in landfills decays only over many years.

Composting, as an aerobic biological degradation process, degrades the carbon of the input materials mainly into CO_2. The percentage of the carbon content that is converted depends on the nature of the input material. In the case of kitchen waste, composting converts about two thirds of the carbon content of the input material into CO_2. This means that about 0.9 kg CO_2 is generated per kg dry matter of the biowaste input. In the case of green waste, this value is much lower at about 0.17 kg CO_2/kg dry matter (ADEME, 2005).

After the composting process is finished and when compost is used, for example, as a soil improver, the remaining organic matter in the compost is then relatively stable and further degradation is rather slow. This depends on the physical, chemical and biological environment in which the compost is used. The further release of carbon to the atmosphere is therefore only gradual. Relatively little is known about the rates of transformation, which vary depending on climate and soil type. It has been estimated that, on average, some 13 % of the organic carbon supplied by the application of compost remains in the soil after 50 years (Eunomia, 2002; Annex p. 95). Assuming that the composting process had reduced the original organic carbon content by 50 % (for example of a mixture of green waste and kitchen waste), this means that about 6.5 % is still not degraded after 50 years. Furthermore, if compost use enhances biomass production, this may bind further carbon from the atmosphere in addition to the direct carbon input by the compost.

If compost displaces other fertilisers, this may lead to greenhouse gas emissions being saved by the avoidance of fertiliser production. If it displaces peat as a soil improver or in growing media, then this avoids the long-cycle carbon emissions emanating from the degradation of peat under aerobic conditions.

In theory, composting as an aerobic process should not generate CH_4. In practice, however, and depending on the type of composting process and its management, the oxygen supply and the aerobic conditions during the biological degradation are not perfect. The lack of oxygen may then lead to anaerobic processes and to emissions of CH_4. The proportion of the carbon content of the input material that is transformed into CH_4 emissions varies widely, depending on the type of input materials and the processes, but can be from 0.01 % to 2.4 % of the original carbon according to ADEME (2005). A typical value found for CH_4 emissions from household waste composting would be 0.04 kg CO_2-eq./kg of dry matter of the input material.

The European Compost Network suggests about half this value, based on Amlinger et al. (2008) (obtained from data of different type of composting and different types of input materials.)

Sometimes organic waste composting is preceded intentionally by a phase of initial anaerobic degradation to reduce odours, for example. If the generated gas is not captured adequately, this will lead to CH_4 emissions to the atmosphere. The CH_4 emissions of such intentional anaerobic pretreatment seem potentially important but have not yet been investigated.

It is quite likely that the application of compost on to agricultural land is neutral in terms of CH_4 emissions; however, this has not yet been scientifically confirmed. There is a lack of literature and measured data on how the use of compost on agricultural land influences the flows of CH_4 between the soil and the atmosphere (ADEME, 2005).

N_2O is generated directly by the composting processes (quantities are strongly influenced by the C/N ratio) but also in biofilters, which are sometimes used to clean the composting exhaust gas stream from other components (see for example Cuhls and Mähl, 2008). For the composting of biowaste, the N_2O emissions have been found to be in the range 0.002–0.05 kg CO_2-eq./kg of input dry matter (typical value: 0.02 kg CO_2-eq.). For household waste, the range is 0.005 to 0.125 kg CO_2-eq./kg of input dry matter (typical value 0.1 kg CO_2-eq.) (ADEME, 2005). The European Compost Network has also reported numbers within this range.

The use of compost as an organic fertiliser may, to some extent, reduce the N_2O emissions associated with the use of mineral nitrogen fertilisers. However, this effect has not been quantified reliably so far.

Generally, the figures on greenhouse gas emissions other than CO_2 (i.e. CH_4 and N_2O) are based on a limited number of measurements, which are not fully representative.

2.2.4.4 Leachate

Some composting systems recirculate leachate, whilst others treat the liquid residue if required or discharge it directly into the sewerage system. Often composting requires a net input of water because of evaporation during the composting process. In well-managed composting processes impacts on the environment can be assumed to be negligible. However, there is no consolidated information on the amounts and compositions of leachate released that considers the variety of composting plants in operation.

2.2.4.5 Soil-related

The application of compost to soil changes the soil's chemical, physical and biological properties. The parameters affected include: contents and availability of plant nutrients, soil organic matter, pH, ion exchange capacity, chelating ability, buffering capacity, density, structure, water management, biodiversity and biological activity. Composts become part of the soil humus and have long-term effects on soil properties. The ways in which compost can affect soil are very complex and far from being fully understood; however, it is widely accepted that compost will have a positive long-term effect on soil fertility if the quality of the compost used is assured and good agricultural practice is followed.

At the same time, the use of compost on soil as an organic fertiliser or soil improver has diverse environmental implications. If composts are applied to land, the chemical content of the composts is transferred to the soil. For potential negative effects, heavy metals and organic pollutants especially need to be considered.

The contents of heavy metals in composts are generally well studied and controlled in compost applications. They are determined by the materials entering the composting process as inputs. Heavy metals may be directly toxic to plants or passed through the food chain to humans. The fate of the heavy metals in soil is very site specific and depends on a number of factors such as the nature of the crop and the type and pH of the soil. Repeated applications of compost to soil generally lead to an accumulation of heavy metals but there is no consensus among researchers about how this should be assessed in terms of environmental impacts. There are important local variations concerning the accumulation of heavy metals (background concentrations are generally increasing), their leachability into groundwater, and the uptake of heavy metals by plants and consequences once in the food chain. Some metals such as zinc, copper and nickel are vital trace elements for plant growth as long as their quantity is not too high.

Relatively little is still known about the contents, fate and effects of organic pollutants in compost. Organic pollutants may be introduced into the compost through the input materials and, to some extent, may also be generated during the composting processes. At the same time, there is also degradation of organic pollutants. Persistent organic pollutants (POPs), however, are hardly removed by composting. It has been shown, for example, that some poly-aromatic hydrocarbons (PAHs) are hardly degraded during composting and are ecotoxicologically relevant when transferred with compost to soil (Kupper et al., 2006).

Recent field experiments showed, for the investigated quality assured composts in Germany, that regular applications did not lead to an accumulation of organic pollutants in soil (including PCB ([15]), PCDD/F ([16]) and PAH) (Kluge et al. 2008).

Generally, there is considerable uncertainty about the exact nature and size of the impacts and risks when compost is spread on soil, especially if no suitable compost quality assurance is applied. The reasons include the variability of the input materials used to produce compost and the fact that composting is a biological process which is more complex than, for example, many chemical processes. As a consequence, there may be a high variability in the qualities of the different compost batches produced at the same site and even more so between different compost plants. Finally, much is still unknown about what actually happens to compost and its constituents once spread on soil.

The limitations of current knowledge are also reflected in the opinion of the Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE; adopted on 8 January 2004) in the report 'Heavy Metals and Organic Compounds from Wastes Used as Organic Fertilisers' (Amlinger et al., 2004). This study was commissioned by the Directorate-General for the Environment in the framework of its background work related to possible legislative proposals concerning the biological treatment of biodegradable waste. The CSTEE concluded

([15]) Polychlorinated biphenyls.
([16]) Polychlorinated dibenzodioxins and dibenzofurans.

that the study did not provide sufficient scientific bases for the Commission to be able to propose the appropriate threshold levels for pollutants in compost. To date, there appears to be no other studies or research results that could easily provide a strictly scientific basis at a European level.

2.2.4.6 Hygiene issues and the risk of injuries

From a hygienic point of view, the application of compost is associated with risks unless the compost production is controlled appropriately. The reason is that the biological wastes used to produce compost may contain different types of pathogens, which may be bacteria, viruses, fungi, parasites and prions (at least theoretically). Compost may also contain weeds and viable plant propagules, which may encourage weed growth when spread on the land. The presence of pathogens in the input material depends on the origin, storage and pretreatment. If the composting process does not provide the required conditions to reduce or even eliminate the pathogens during the composting process, these pathogens may still be present in the compost, and, in the worst case, some of them may even have multiplied during composting. After application to land, the pathogens may then infect animals, plants or humans and pose serious health and plant disease control problems. Particular care needs to be taken in the case of grazing animals and in the production of salads, vegetables and fruits that grow close to the ground and may be consumed raw.

The main measures for controlling the contamination of compost with pathogens are to sort out especially risky material, such as nappies, from the compost feedstock and to ensure that all of the material in the compost process is subject to temperature-time profiles that kill off the pathogens (sanitation) or reduce the population to an extent where it is considered to be below a specific hazard threshold.

Macroscopic impurities of compost (especially plastic, glass and metal objects) not only reduce the aesthetic value of land, they also bring the risk of accidents, such as worker injuries when handling compost containing glass fragments.

When compost is used as a component in growing media, direct health and safety aspects are of special importance because of the often quite intense contact workers have with the material. Macroscopic glass fragments, for example, must not be present.

2.2.4.7 Positive environmental effects

The use of compost as an organic fertiliser can, to some extent, replace the use of mineral fertilisers. This is clearer for potassium and phosphate than for nitrogen because the nitrogen contained in the organic matter of compost only slowly becomes available to plants. If compost is used to reduce the need for mineral fertiliser, some of the environmental stresses of fertiliser production can be avoided. These include greenhouse gas emissions (N_2O and energy-related emissions), and impacts of phosphate extraction. The use of compost over longer periods of time and a lower use of mineral fertilisers also reduces nitrate leaching.

The humus produced from compost increases soil organic matter and stores some of the biomass carbon contained in compost in soil for longer periods of time. This carbon can be considered sequestered from the atmosphere, which acts against global warming.

Other potential positive environmental effects that have been attributed to compost include:

- reduced soil erosion;
- compost of a good quality may help to control plant diseases and thus reduce the need for applying pesticides;
- water retention is improved, reducing the need for irrigation and reducing the risk of flooding;
- the improved soil structure reduces the need to work the soil with agricultural machinery and the related use of fuel.

When compost can be used instead of peat in growing media, there is also a lower global warming potential, mainly because peat degrades relatively quickly under the release of ‘long cycle’ CO_2 when exposed to oxygen. Replacing peat also contributes to the protection of the biodiversity and landscape value of peatlands and bogs.

2.2.4.8 Conclusions with regard to managing potential environmental and health effects

There are three main groups of environmental and health issues related to composting that need to be managed.

1. Climate change

Choices about how to manage and treat the putrescible fraction of MSW have a substantial influence on the net greenhouse emissions caused in the EU. The Landfill Directive addresses this by requiring that biological wastes be diverted from landfills. In principle, composting is a valid recovery route that allows such diversion (the environmentally best treatment option needs to be assessed in each specific case; for this purpose, life cycle guidelines for the management of the organic fraction of municipal waste are being prepared by the JRC ([17]). The most critical factors for a high performance of composting with respect to greenhouse gas emissions is the minimisation of methane and N_2O emissions during the composting process, pretreatment and storage.

2. Local health and environmental impacts and risks at, and close to, the composting facility

Odour, gas emissions, leachate, and pathogens in bioaerosols are released from composting processes and may affect the local environment and the health and well-being of workers and residents. Plant permits for composting facilities address these issues more and more appropriately and some Member States have issued guidelines on state-of-the-art composting techniques that help address these aspects. Composting may also be covered by the revised IPPC Directive.

3. Soil, environment and health protection when using compost, especially when applying compost to land

([17]) http://viso.jrc.it/lca-biowaste/

This aspect is highly complex because it requires managing the trade off of the benefits of compost application on land with the environmental and health risks associated with releasing a material derived from waste that potentially contains many chemical compounds (including heavy metals and potentially organic pollutants) and biological agents on soils. Whether the benefits outweigh the risks depends on the quality of the compost and the local conditions under which it is applied. The complexity is aggravated by the fact that there are important knowledge gaps regarding soil properties and functions and the interactions with compost and its components. Furthermore, there are many uncertainties in the toxicological and ecotoxicological assessments. Nevertheless, it is widely accepted that the use of quality assured compost with relatively low pollutant contents following good agricultural practices allows achieving long term benefits to the soil-plant system that outweigh the risks and potential negative impacts.

Member States where the use of compost plays a substantial role have usually put regulations in place to ensure a positive trade-off, considering the specific situations of the countries. Depending on the countries or regions, the use of compost is regulated by soil protection, fertiliser or waste legislation or combinations thereof. If the introduction of European end-of-waste criteria changes the waste status of compost in a Member State, then this may affect the system of rules applying to the use of compost on land. This will then impact on the corresponding levels of soil, health and environmental protection.

2.2.5 Legal framework and standards

2.2.5.1 Introduction

This chapter looks at the legal frameworks and standards that have been put in place to ensure the usefulness of compost and to manage the environmental impacts and risks of compost production and use.

The previous sections have argued that the use of compost as a soil improver or organic fertiliser can improve the chemical, physical and biological properties of soil and lead to better agronomic performance as well as to positive environmental impacts. The use of compost as a component of growing media can reduce the dependence on peat to some extent. Diverting biodegradable waste from landfills to produce compost reduces the climate change impacts of waste management.

At the same time there are, however, substantial environmental and health risks associated with the production and use of compost.

Regulators are thus faced by the challenge to optimise the benefits of recycling organic matter through compost and to avoid unnecessary barriers. At the same time the health and environmental impacts and risks need to be managed to ensure adequate levels of safety and environmental protection.

The analysis here pays particular attention to those aspects that are linked to the question of whether composts are a waste or not. It looks at the current national approaches in determining the waste status of compost; systems of compost registration or certification; compost categories; regulation placed on and standards of input materials, product quality and compost use; health protection; quality assurance schemes; standardisation of compost testing.

2.2.5.2 Current approaches to determining the waste status of compost

Today, Member States follow different approaches when determining the status of compost, i.e. whether it is considered a waste or not. In some cases, there are explicit and detailed rules set by legislation under waste law. In other cases, it is mainly up to the discretion of the regulatory authorities to decide. In a third group of countries, there is an implicit assumption that compost ceases to be waste when registered as a product (e.g. as fertiliser).

<u>End-of-waste defined by national regulations under waste law or other national environmental regulations</u>

In some Member States, there is legislation under waste law that explicitly defines the conditions under which compost ceases to be waste. Examples are the Austrian Compost Ordinance ([18]) and the German Biowaste Ordinance ([19]).

The conditions included in the Austrian Ordinance for compost to be considered as a product and not a waste includes:

- a positive list of wastes from which the compost may be produced;
- specifications of the product quality (heavy metal threshold values);
- temperature-time profile during composting to achieve hygienic safety;
- labelling provisions;
- quality control provisions on the input materials and the product;
- external quality control provisions;
- mandatory record keeping (for five years) of batch-wise information on input materials and products, including details of who receives the compost;
- obligations for registering and notifying the authorities;
- analytical methods.

The German Ordinance explicitly states that compost is considered waste until it has been applied to soil (in the case of agricultural use). However, the waste law-based regulatory controls are reduced considerably if a quality assurance system is applied. End-of-waste is not explicitly defined by German regulations when using compost for the production of growing media.

In France, the product quality requirements for compost produced from MSW are defined by the French standard NF U44-051. This standard has been made statutory by the French government. The standard includes thresholds for concentrations of heavy metals and some organic compounds as well as microbiological and agronomic parameters. Compost that complies with the requirements of the standard is considered a product (and not waste).

([18]) Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über Qualitätsanforderungen an Komposte aus Abfällen (Kompostverordung). BGBl. II — Ausgegeben am 14 August 2001 — No 292.

([19]) Verordnung über die Verwertung von Bioabfällen auf landwirtschaftlich, forstwirtschaftlich und gärtnerisch genutzten Boeden. BGBl. I 1998 S. 2955, BGBl. I 2001 S. 1488.

End-of-waste determined by regulatory authorities, possibly on the basis of acknowledged protocols and standards

This is the case, for example, in the United Kingdom (England and Wales).

In England and Wales, compost must be sold/supplied in accordance with the Environmental Permitting (England and Wales) Regulations rules for the storing and spreading of compost on land. There are no explicit quality criteria, but on the registration form and from the evidence (test results for the waste) sent to the regulator, the 'agricultural benefit' or 'ecological improvement' must be justified. The regulator then makes an evaluation taking account of the characteristics of the soil/land that is intended to receive the waste, the intended application rate and any other relevant issues.

The recently agreed Quality Compost Protocol (QCP) represents the thinking of the Environment Agency for England and Wales as the reference for defining the point at which compost may become a product. It sets the criteria for production of quality compost from source-segregated biodegradable waste. Quality compost will normally be regarded as having ceased to be a waste when dispatched to the customer.

De facto end-of-waste when registered as fertiliser

In many countries, compost has to be registered under fertiliser regulations (e.g. as an organic fertiliser or as a soil improver) before it can be used in agriculture. It is then implicitly assumed that registered compost is a product and has ceased to be waste. This situation can be found in the Czech Republic, Greece, Spain, Italy, Latvia, Hungary, the Netherlands, Poland, Portugal, Slovenia and Finland.

Finally, there is a group of countries where compost production is not common, compost-specific regulations do not exist and the waste status of compost is not yet an issue.

More details on how the waste status of compost is determined today in each Member State are presented in Annex 2-2.

2.2.5.3 Systems of compost registration or certification

Usually it is required by the corresponding regulation that compost must be registered or certified before it can be used or placed on the market. Sometimes, but not always, such registration or certification implies end-of-waste.

In practice, there are three main legal bases under which compost is certified or registered:

- fertiliser legislation, with and without specific compost provisions;
- waste legislation, with specific compost or biowaste ordinances or under general waste treatment licensing procedures;
- soil protection legislation, with minimum requirements for waste derived materials, sludge and compost to be spread on land.

Standards or voluntary agreements based on criteria which are implemented by quality assurance schemes are another category, however, without direct legal status.

Following ORBIT/ECN (2008), one may distinguish four typical compost registration or certification schemes.

1. Simple registration systems without third-party verification

The main criterion of registration is final compost quality and product declaration (e.g. as an organic fertiliser or an organic soil improver). Sampling is done directly by the compost producer. External quality control is not systematic. Inspections by regulatory authorities are possible but typically not frequent. Usually, once registered, the compost can be traded as a product without further waste regulatory controls, even if formal end-of-waste is not established explicitly. According to ORBIT, this scheme can be found in the Czech Republic, Denmark, Ireland, Spain, France, Latvia, Hungary, the Netherlands and Poland.

2. Simple registration systems with third-party verification

Testing of compost quality is carried out by an external laboratory that is acknowledged by the authorities. The laboratory may also certify compliance with a wider set of legal requirements concerning the documentation, the process management and the input materials used. This system can be found in Spain and Slovakia.

3. Third-party product certification under specific compost legislation

This means full-scale product certification schemes, such as under the Austrian Compost Ordinance. Such schemes include the following elements:

- the compost producer is responsible for the compliance with all requirements for input materials, process management and documentation, external quality approval and product declaration;
- the compost producer must have a contract with an authorised laboratory;
- sampling is done by the authorised laboratory or a contracted partner of the laboratory;
- the authorised laboratory and/or a quality assurance organisation (QAO) inspect and approve the required documentation and the required quality and process management in compliance with all legislative provisions;
- based on the analytical and the on-site inspection report, the authorised laboratory or the QAO awards a product and plant operation certificate including (in most cases) the permission for the use of a quality label;
- in some cases, the compost then obtains the product status from the moment a compost batch is declared compliant according to the certificate provided by the external laboratory or QAO;
- based on the certified product labelling and declaration including recommendations for proper use in the foreseen applications and market sectors, the correct application in line with all further soil and environment related rules is entirely the responsibility of the user.

Schemes of this type exist in Belgium (Flanders), Germany, Luxembourg, the Netherlands, Austria and Sweden. Membership of a quality assurance organisation is, in most cases, voluntary, although often promoted by authorities or legal incentives. In Belgium (Flanders), the entire external certification and quality assurance system is executed by a semi-public organisation and it is obligatory for all compost producers to participate.

4. Third-party certification including the use of compost

In the United Kingdom, the Quality Protocol (QCP) issued by the Environment Agency and the Waste & Resources and Action Programme (WRAP and Environment Agency, 2007) has established a comprehensive quality assurance scheme which requires extensive documentation and record keeping from the compost producer. The QCP also contains requirements for accreditation and auditing by the sector. In this respect, the concept is similar to the scheme described above. It is different, however, in that it also requires compost use documentation in agriculture and soil-grown horticulture to be kept by the land manager and made available to the compost producer and the certification body.

2.2.5.4 Compost categories

Compost classifications are very diverse across Member States. The categories are usually defined by compost, fertiliser or soil protection legislation or by voluntary standards. The criteria typically applied for classification are the input materials used, the compost product quality (contents of hazardous substances, nutrients, impurities), and the uses for which the compost is fit. In this report, the categories defined according to input materials are called 'compost types' and the categories defined according to product quality are called 'compost classes'. Table 5 suggests a terminology for the most relevant compost categories. More detailed descriptions of existing compost categories can be found in ORBIT/ECN (2008).

**Table 5: Classification of compost.
Source: ORBIT/ECN (2008).**

Input material The compost type is defined by the type, origin and characteristics of the source materials used for the production of the compost.	
Biowaste compost	Compost from kitchen and garden waste (from source-separated waste collection). This is the material commonly collected in the commingled collection scheme for food and garden waste (brown bin, 'biobin' system).
Green waste compost	Compost produced from garden and park waste.
VFG compost	Compost from vegetable, fruit and garden waste. This type of compost has been established in Belgium (Flanders) and the Netherlands based on the collection scheme for organic household waste where the collection of meat is excluded.
Biomix compost	Biowaste, green waste, sewage sludge (quite a common system in Italy where sewage sludge is co-composted with source-separated bio and green waste).
Bark compost	Compost produced from bark; usually not mixed with other organic residues but with additives as a nitrogen source.
Manure compost	Compost from solid stable manure or from dewatered (separated) slurry.
Sewage sludge compost	Compost produced from dewatered municipal sewage sludge together with bulking material.

Mixed waste compost	Compost produced from mixed municipal solid waste (no source separation of the organic waste fraction).
Stabilised biowaste	Biologically stabilised (composted) organic fraction from mechanical biological treatment of residual waste.
Product quality Compost classes demand certain quality levels as regards the concentration of contaminants (e.g. heavy metals) and macroscopic impurities.	
Heavy metal classes	Compost classes are distinguished by limit values for heavy metals.
Impurity classes	Limits for the contents of macroscopic impurities like plastics, metals and glass. A two-class class system has been suggested, which should distinguish between composts for food production/pasture land and non-food areas.
Uses The use types classify composts for certain areas of application based on defined quality parameters. In some cases, this is linked to product quality classes.	
Compost for organic farming	For the use of biowaste from source-separated organic household waste, limit values for heavy metals have to be respected (Regulation (EEC) No 2092/91). There are no such quality criteria for other compost types like green waste compost. Any compost produced from municipal sewage sludge is forbidden in biological agriculture.
Compost for food production	Restriction of certain heavy metal or impurities related *compost classes* (e.g. Class 2 or B) for use in agricultural or horticultural food and feedstuff production.
Substrate compost for growing media and potting soils	Compost providing specific performance characteristics such as particle size, salt content, stability, plant response, nutrient availability, etc., in order to be successfully used as a constituent in growing media and potting soils.
Mulch compost	Compost of a generally coarse structure (higher portions of wood chips with a maximum particle size up to ca 35 mm) and with fewer demands regarding maturity.
Mature compost	Fully humified compost generally utilised and recommended in all — also sensitive — applications. Identification is done by methods testing the plant response or measuring the biological activity of the compost (e.g. oxygen consumption, CO_2 evolution, self-heating test).
Fresh compost	Partly degraded material that is still in a decomposition process but thermally sanitised (thermophilic phase). It is used for soil improvement and fertilisation on agricultural land. Identification is done by methods testing the plant response or measuring the biological activity of the compost (e.g. oxygen consumption, CO_2 evolution, self-heating test).

2.2.5.5 Regulations and standards on input materials

Most national regulations dealing with compost include restrictions on the input materials that may be used for compost production. In most cases, there are ‘positive lists’ of the allowed types of input materials. Materials not included on the list are forbidden as inputs. The most sensitive questions regarding input materials are whether municipal sewage sludge is allowed and in what form the biological fractions of MSW may be used as an input (whether there is a requirement for source segregation or not).

Most positive lists follow the classification of the European Waste Catalogue, and in some cases, include some additional specifications or requirements. If the waste list is directly binding, the system is rather rigid. This has been addressed, for example, in the case of Belgium, by allowing case-by-case decisions to be made by the competent authorities, based on a more generic positive list.

Usually, national regulations require that composting plants are run with a consistent control of the input material (compliance check upon receiving the waste), which includes documentation to ensure traceability and allows inspection by the competent authorities.

Annex 2-9 presents a comparative list and classification of the waste materials that are allowed for the production of compost in EU Member States.

2.2.5.6 Regulations and standards on product quality

Compost-related national regulations as well as compost quality certification schemes usually include minimum product quality requirements for ensuring the usefulness of compost and for achieving the desired levels of health and environment protection. Minimum product quality requirements typically demand that composts should:

- have a minimum organic matter content, to ensure basic usefulness and to prevent dilution with inorganic materials, as well as sufficient stability/maturity;
- not contain certain pathogens (such as salmonellae) that pose health risks;
- contain only a limited amount of macroscopic impurities (as a basic requirement for usefulness and to limit the risks of injuries);
- only have limited concentrations of pollutants (mainly regarding heavy metals and sometimes also certain types of organic pollutants).

Further requirements are often included as specifications for certain uses and application areas. For instance, there are a number of compost standards and specifications for using compost in growing media and potting soil or for use in landscaping. Examples are the RHP quality mark for compost substrate components for horticulture and consumer use, or the RAL Quality label for compost with requirements for compost for potting soils/growing media (RAL, 2007) (see also Section 2.2.2.2).

In addition to requiring that limit values for the mentioned parameters are met, it is usually also required that the values for these parameters and further properties, such as salinity or electric conductivity, are declared (without the need for complying with limits). The purpose is to inform the potential users of the compost about the material properties.

Legal limits on heavy metal concentrations are in place everywhere that compost plays a role today. Limits are usually set at a national level and differ from country to country. In some countries, limits have been set for a number of different compost classes. At the EU level, a set of heavy metal concentration limits exists as part of the EU eco-label criteria for soil improvers and growing media. Another set of limits applies to the use of certain composts in organic agriculture. Annex 2-3 provides an overview of the heavy metal concentration limits for compost in the EU.

In most places, limits also exist for macroscopic impurities. Sometimes a maximum concentration is set for the sum of plastics, metals and glass particles with a particle size of > 2 to 5 mm or there may be more complex regulations with separate limits for different types of impurities and considering more than one particle size (e.g. 2 and 20 mm fraction for plastic constituents).

Annex 2-4 shows examples of the impurity limits included in national regulations and standards.

The rules for compliance testing (number of tests, protocols for sampling, analysis) are also different across Member States. Efforts to produce European harmonised standards are, however, well advanced (see also Section 2.2.5.10.).

2.2.5.7 Health-related requirements

Provisions for the exclusion of potential pathogenic micro-organisms are established on two levels:

- direct methods by setting minimum requirements for pathogenic indicator organisms in the final product;
- indirect methods by the documentation and recording of the process showing compliance with required process parameters (HACCP concepts, temperature regime, black and white zone separation, hygienisation/sanitisation in closed reactors, etc.).

Annex 2-5 gives an overview of national regulations with respect to indirect and direct methods as well as of the requirements of the EU Eco-labels on soil improvers and growing media and of the Animal By-products Regulations. It also shows the requirements and limit values for germinating weeds and plant propagules.

At the European level, a key reference is the Animal By-products Regulation (ABPR) ([20]), which provides detailed hygienisation rules for composting and biogas plants which treat animal by-products.

The ABPR restricts the types of animal by-products that may be transformed in a biogas or composting plant. Materials that are allowed under certain conditions include amongst others:

- manure and digestive tract content;
- animal parts fit for human consumption (not intended for human consumption because of commercial reasons);
- animal parts rejected as unfit for human consumption (without any signs of transmissible diseases) and derived from carcasses fit for human consumption;
- blood, hides and skins, hooves, feathers, wool, horns, hair and fur (without any signs of diseases communicable through them);
- former foodstuffs and waste from the food industry containing animal products;

([20]) Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption (OJ L, 10.10.2002, p. 1).

- raw milk;
- shells, hatchery by-products and cracked egg by-products;
- fish or other sea animals (except sea mammals);
- fresh fish by-products derived from the food industry.

The hygienisation requirements are laid down in Annex VI to the ABPR ([21]). Amongst other requirements, this states that Category 3 materials (which include, for example, catering waste) used as raw material in a composting plant must comply with the following minimum requirements:

- maximum particle size before entering the composting reactor: 12 mm;
- minimum temperature in all material in the reactor: 70 °C;
- minimum time in the reactor at 70 °C (all material): 60 minutes.

As an alternative to the time-temperature regime of 70 °C for one hour at a particle size of 12 mm, the possibility of a process validation system to be conducted by Member States was introduced. The authorisation of other standardised process parameters is bound to the applicant's demonstration that such parameters ensure the minimising of biological risks.

The ABPR also requires control of the final product. This is divided into two measures:

- representative sampling during or immediately after processing in order to monitor the proper functioning of the hygienisation process, and
- representative sampling during or on withdrawal from storage in order to approve the overall hygiene status of the product.

Escherichia coli or enterococcae are used as indicators for the hygienisation process. The hygiene status of the product is tested with *Salmonella*, which must be absent in 25 g of the product. It is up to the competent authority to decide on sampling schemes (i.e. considering the total throughput and the maximum time span between two sampling dates).

There are possible exceptions for catering waste ([22]), which may be processed in accordance with national law unless the Commission determines harmonised measures.

2.2.5.8 Regulations of compost use

The regulations and standards for compost use vary considerably across countries. There are countries where compost use is subject to a complex network of regulations on national and/or provincial level (Germany, the Netherlands, Austria) and then there are countries where compost can be used without any legal directions (Greece, Portugal, Slovenia).

Use rules include direct regulations like dosage restrictions (admitted quantity of compost per hectare) and indirect rules such as good agricultural practice (GAP) protocols and cross-compliance requirements in agricultural application. The latter refer mainly to fertilising,

([21]) Amended by Commission Regulation (EC) No 208/2006 of 7 February 2006 amending Annexes VI and VIII to Regulation (EC) No 1774/2002 of the European Parliament and of the Council as regards processing standards for biogas and composting plants and requirements for manure (OJ L 36, 8.2.2006, p. 25).

([22]) Catering waste means all waste food including used cooking oil originating in restaurants, catering facilities and kitchens, including central kitchens and household kitchens.

which should be executed in a way that considers the nutrients in soil and in compost as well as the uptake by the plant and to manage organic matter with the target to keep soils in a proper condition

The main restrictions in EU countries usually concern the permissible quantity of compost (tonnes dry matter) at a maximum heavy metal content (compost class) which can be spread annually, or over two to five years. Annex 2-6 provides an overview of the restrictions in place.

The following systems of application rules can be distinguished:

- direct load limitation (grams of substance per hectare and year), in most cases calculated on a basis of 2 to 10 years;
- restrictions of the admissible dosage of dry matter compost per hectare and year;
- restrictions according to a maximum nutrient supply (phosphorus and/or nitrogen) to the agricultural crops.

The restrictions are usually intended to regulate continuous applications, as in agriculture. In most other applications, e.g. landscaping, compost is applied only once or infrequently. Here, larger amounts (e.g. 200 tonnes dry matter in 10 years) are used to achieve the desired application effects.

In some cases, the factor which limits application rates is not only the heavy metals but the nutrient contents, especially phosphorus and nitrogen.

The ranges of restrictions for the amounts of compost (on a dry matter basis per hectare) or plant nutrients to be applied can be summarised as follows:

• quantity of compost (*)	agriculture/regular	3 (pasture)–15 (arable) tonnes/ha
	non-food/regular	6.6–15 tonnes/ha
	non-food/once	100–400 tonnes/ha
• quantity of N	agriculture/regular	150–250 kg/ha
• quantity of P_2O_5	agriculture/regular	22–80 kg/ha
	set aside land	20 kg/ha

(ha = hectare)

(*) In most cases quantity differentiation depends on quality class obtained.

More details, country by country, are provided in Annex 2-7.

In many cases, the need to comply with the EU Nitrates Directive or national water protection legislation has led to maximum application regimes for nitrogen or forbidding the application of compost during the winter season.

Finally, it becomes more and more common to consider the application of compost in fertiliser management systems. Germany for example refers to the need to follow ‘best fertilising expert practise’, whilst in the Netherlands, the Mineral Accounting System MINAS (obligatory since 2001 for all farmers with more than 0.5 livestock units) requires farmers to account for the mineral balances when nutrients are applied in any form.

2.2.5.9 Quality assurance systems

About 700 composting plants in the EU operate under a formal quality assurance system. Quality assurance typically comprises the following elements:

- raw material/feedstock type and quality;
- limits for hazardous substances;
- hygiene requirements (sanitisation);
- quality criteria for the valuables (e.g. organic matter);
- external monitoring of the product and the production;
- in-house control at the site for all batches (temperature, pH, salt);
- quality label or a certificate for the product;
- annual external quality certification of the site and its successful operations;
- product specifications for different application areas;
- recommendations for use and application information.

In some cases, quality assurance is purely voluntary, on private initiative, but more often it is required or promoted by legislation or regulatory authorities. Sometimes there are exemptions from certain legal compliance obligations if the compost is quality certified. Annex 2-8 provides detailed descriptions of the existing compost-specific quality assurance schemes in the EU.

2.2.5.10 Standardisation of sampling and analysis

Today, compost sampling and analysis is carried out following national legal provisions and standards, which are not always comparable. However, the European Commission has already given a standardisation mandate to CEN for the development of horizontal standards in the field of sludge, biowaste and soil (Mandate M/330). The mandate considers standards on sampling and analytical methods for hygienic and biological parameters as well as inorganic and organic parameters. Consequently, the CEN Technical Board (BT) created a Task Force for 'Horizontal Standards in the fields of sludge, biowaste and soil' (CEN/BT TF 151). On most sampling and analytical topics, the final consultation and validation of the draft standards took place in autumn 2007 ([23]).

Until horizontal standards elaborated under the guidance of CEN Task Force 151 become available, testing and sampling may also be carried out in accordance with test methods developed by Technical Committee CEN 223 'Soil improvers and growing media' ([24]).

A new initiative for elaborating horizontal sampling standards has been launched by CEN TC 345 (Soil). It is intended to elaborate detailed sampling procedures for different matrices and quantities in the area sludge, soil, compost (treated biowaste). The procedure will build on the draft standards and technical reports produced by the project Horizontal which were not delivered to the responsible committee (BT/TF 151) for formal vote.

([23]) http://www.ecn.nl/horizontal/
([24]) Contact: http://www.cenorm.be/cenorm/index.htm

2.3 End-of-waste criteria

2.3.1 Introduction

The Thematic Strategy on the prevention and recycling of waste was adopted by the European Commission on 21 December 2005. One element of the proposals within the thematic strategy is the clarification, at EU level, of when waste could cease to be waste and could be regarded as a non-waste material and freely traded on the open market. Through this approach, the intention is to promote more recycling and use of waste materials as resources, reduce consumption of natural resources and reduce the amount of waste sent for disposal. A material which satisfies a set of end-of-waste criteria can then be freely traded as a non-waste material and thereby its beneficial use promoted. Potential users of the material should be able to have increased confidence on the quality standards of the material and this may also help to alleviate any user prejudice against the material simply because it is classified as waste.

The revised Waste Framework Directive ([25]) sets the following conditions for certain specified waste to cease to be waste (Article 6):

> *(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;*
>
> *(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.'*

In recital 22, the Common Position says that the end-of-waste criteria should provide a high level of environmental protection and environmental and economic benefit.

This chapter suggests how the end-of-waste criteria for compost would have to be defined so that they fulfil these conditions and purposes. It first identifies and discusses the different reasons why the end-of-waste criteria for compost would be beneficial, then it goes through the four conditions of Article 6 and analyses what they mean for the specific case of compost, and finally a set of end-of-waste criteria and accompanying measures are proposed accordingly.

2.3.2 Rationale for end-of-waste criteria

The purpose of having end-of-waste criteria is to facilitate recycling and to obtain environmental and economic benefits. This section discusses how, i.e. through which mechanisms, end-of-waste criteria may achieve this in the case of compost.

([25]) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (OJ L 312, 22.11.2008, p. 3).

2.3.2.1 Improve harmonisation and legal certainty in the internal market

There are environmental and economic benefits to be gained as the end-of-waste criteria improve the harmonisation and legal certainty in the internal market.

There is currently no harmonised way in the EU for determining whether a compost material is a waste or a 'normal' product. Member States deal with the question rather differently. There is a group of Member States where there are types of composts that are explicitly recognised as non-waste even if they are produced from input materials that are waste. However, across these Member States, the standards that composts must meet in order to qualify as normal products differ considerably. Then there are other Member States where composts made from waste are always considered waste, regardless of the quality of the material, at least until the compost has been used, for example on soil. In the remaining Member States there are no explicit general rules and the classification of compost as waste or not is left to case-by-case decisions or to interpretive protocols that are applicable to certain parts of the Member State.

The lack of harmonisation creates legal uncertainty for waste management decisions and for the different actors dealing with the material, including the producers and users of compost or haulage contractors. The uncertainty arises especially when trade between Member States is involved. However, there are also differences in interpreting the waste status of compost between different regions within certain Member States.

As a consequence, both compost producers and users tend to restrict themselves to the national (or regional) market because they want to avoid the administrative and judicial costs or risks of an unclear waste status of the material. This means that composts do not always reach the place where they could, in principle, be used best, i.e. economically and delivering the highest benefits with the proportionally lowest environmental and health risks. It may also mean that less compost is produced. In fact, the volumes of compost traded between Member States are smaller today than they could theoretically be and it is likely that with clear rules about when compost ceases to be waste, the supply and demand of compost would be balanced better.

The legal uncertainty regarding the waste status of compost also affects the investment decisions on new treatment capacities for the management of biological wastes. Such uncertainty evidently comes at a cost when it hinders the development of the composting sector in situations where, in reality, the conditions would exist for compost to cease to be waste. This is relevant not only for the situation in certain Member States, but especially also at the European level. For example, the possibility of exporting compost is an important factor for the feasibility of a composting plant in border regions. When uncertainties regarding the status of the waste reduce the export possibilities, then this may easily lead to opting for another waste treatment option even if a need and environmentally suitable absorption capacity for the compost exists across the border ([26]). Harmonised end-of-waste criteria would promote investing in compost production in such situations.

The lack of harmonisation also means that there is no system that ensures that the control of compost flows across national borders is proportionate to the related environmental risks.

([26]) Due to the relatively high costs of transporting the compost, the feasibility of a composting plant critically depends on the existence of sufficient market capacity for its use within a radius of not more than 50–100 km around the plant. If national borders within the EU work as barriers to compost use, then composting facilities close to borders have an obvious 'geometric' handicap that works to the detriment of allowing an environmentally optimised waste management and compost use.

Harmonised end-of-waste criteria could improve the management of environmental risks under waste shipment rules by excluding low risk compost from waste shipment controls, while making explicit that compost with higher risks for the environment have to be considered waste. This would avoid unnecessary costs and barriers in the first case and ensure the necessary controls (prior written notification and consent of shipment) in the latter.

Generally, end-of-waste criteria would have the benefit to make more explicit when compost has to be considered waste. This would consolidate the application of waste law derived controls to non-compliant compost and strengthen environmental and health protection.

2.3.2.2 Avoid waste status if unnecessary

There are economic benefits, when the end-of-waste criteria prevent compost being considered as waste when such a status is not necessary.

A direct economic benefit is that compliance costs are avoided. According to EU waste law, users of compost may need a permit for using compost from the waste management authorities. Compost not requiring a permit or an exemption under waste law can be used at lower costs. The Quality Protocol for compost, for example, allows the use of compliant compost in England and Wales without having to pay a waste status related exemption fee. The avoided costs were estimated at more than GBP 2/tonne of compost (The Composting Association, 2006) ([27]).

Another economic benefit can be obtained by avoiding potential users undervaluing compost simply because it is unnecessarily labelled as waste. It has been reported that farmers are hesitant to use compost as a soil improver if it is presented to them as a waste material because the waste status makes them perceive compost as of low value. In such cases, the waste status works as a stigma. Compost that is not considered waste has a higher perceived value than otherwise identical waste compost. In fact, it is likely that the agronomic value of compost is higher than the price paid for it when it is waste ([28]). If higher prices are paid for end-of-waste compost, then a part of the benefits obtained by the user is transferred back to compost producers and possibly, through reduced gate fees, further to municipalities so that the costs of waste management are reduced.

A correctly perceived value of compost and reduced costs of compost use are important factors to strengthen the demand for compost and in this way improve the feasibility of the compost route of managing biodegradable wastes.

As examples such as Austria and the United Kingdom show, Member States can effectively avoid the waste status of certain compost already within the current European framework. There would, however, be additional benefits of the European end-of-waste criteria by accelerating and consolidating the establishment of compliant compost as a freely traded product throughout the EU.

([27]) In Germany, composts do not cease to be waste before they have been used, but quality certified composts are exempted from the most onerous obligations that a full waste status would imply for the users. Also this reduces compliance costs for the use of compost.

([28]) For instance, it was a reason for including end-of-waste criteria in the Austrian Compost Ordinance to avoid that the value of compost is unduly underestimated because of unnecessary waste status.

2.3.2.3 Promote product standardisation and quality assurance

Harmonising the end-of-waste criteria is also an opportunity to introduce widely recognised product standards for compost and to promote quality assurance.

A high level of environmental protection can be achieved only if there is reliable and comparable information on the environmentally relevant product properties. Claims made on product properties must correspond closely to the 'real' properties, and the variability should be within known limits. To manage compost so that environmental impacts and risks are kept low, it must be possible for compost users and regulatory authorities to interpret the declared product properties in the right way and to trust in conformity. Therefore, standardisation of product parameters, sampling and testing is needed as well as quality assurance.

End-of-waste criteria that demand the use of harmonised standards could be a decisive factor for promoting the widespread use of harmonised standards throughout the EU. Harmonised standards for compost property parameters, sampling and testing are, to a large extent, already available to be used today, even if they are not yet fully adopted as European standards (formal adoption is expected for some of them in the near future). The outcome of the 'Horizontal' project is certainly a great achievement in this sense, although some concerns have been raised that the use of these methods might lead to increased testing costs for some of the parameters in some countries.

Where compost production and use are already well-established today, quality assurance is a common practice. While quality assurance can also be developed by industry alone, as a purely voluntary initiative, most of the successful compost quality assurance and certification schemes have benefited, however, from some sort of quasi-statutory support by regulations in Member States. By demanding quality assurance, the end-of-waste criteria would promote quality assurance throughout the EU.

2.3.2.4 Promote higher compost quality

The end-of-waste criteria can promote higher compost quality standards by including certain product quality requirements. Such requirements comprise limit values for hazardous components (maximum concentrations allowed) and for properties adding value to the product (e.g. minimum organic matter content). It is evident that high quality in this sense is important for a good overall cost-benefit balance of compost use. If only high-quality composts benefit from the cost reducing and demand enhancing effects of end-of-waste, they will become preferable as an option compared to lower quality composts not only for compost users but also for operators of compost plants and in strategic waste management decisions.

2.3.3 Conditions for end-of-waste criteria

This section discusses, one by one, what the four basic conditions of end-of-waste criteria mean in the case of compost and how end-of-waste criteria need to be formulated so that compost only qualifies when all four conditions are met.

2.3.3.1 The substance or object is commonly used for specific purposes

There are a number of specific purposes for which compost is commonly used. The main use is as a soil improver or an organic fertiliser in agriculture (from about 10 to 80 % of all compost use, depending on the country). A second important use is as a component in growing media for use in horticulture, landscaping and hobby gardening. Product specifications for using compost for these purposes exist on national levels and, to some extent, also at European level (eco-label criteria on soil improvers and growing media). Some compost is also used for land restoration and as a landfill cover. The use of compost for these purposes is common in several Member States of the EU. The main compost producing countries are also the main compost users. The nine Member States with the biggest compost production ([29]) produce about 95 % of all compost in the EU. Depending on the purpose and the specific situation, the use of compost is regulated at least in those Member States where such use is common. For use on soil, and particularly in agriculture, there are usually restrictions on the amounts of compost that may be used, often depending on the heavy metal and nutrient contents of compost.

2.3.3.2 A market or demand exists for such a substance or object

Theoretically, there is a strong need for compost in the EU, especially as a soil improver to work against the loss of soil organic matter. In practice today, the market for compost is well established only in the part of the EU where compost production and use is concentrated (see Section 2.3.3.1). In other parts of the EU, the market is being developed in a proactive manner, typically with government support. Finally, there are a number of countries in which compost does not yet play any significant role.

Where compost is being produced, the market tends to be supply-driven and prices for compost are sometimes close to or at zero. Even if globally there is sufficient use for the compost produced, there may be imbalances of supply and demand at certain places.

Removing the waste status from compost that can be safely used for a specific purpose is likely to strengthen the demand for such compost and help avoid local oversupply. To prevent the ultimate disposal of compost, the end-of-waste criteria must be demanding in terms of usefulness, ensuring a high value when used for a specific purpose. The stricter the quality requirements in the end-of-waste criteria, the higher the price will be for compost that meets them.

A compost should not cease to be waste if, in most places, it does not comply with the applicable regulations and standards on the relevant specific compost uses, because hardly any demand for the compost would exist in such a case.

Experience in countries where compost is commonly used today has shown that the compost market works well when the quality of compost supplied is high and reliable and the demand is proactively developed.

([29]) In decreasing order of production: Germany, France, the United Kingdom, the Netherlands, Italy, Austria, Spain, Denmark, Belgium.

2.3.3.3 The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products

When compost is placed on the market, there must be at least one purpose for which it can be used without requiring any further treatment. It will be up to the undertaking that places the compost on the market to declare fitness for such use, referring to the applicable legislation and standards. Market surveillance by Member State authorities will also play a role.

The existing legislation and standards for using compost for the different purposes vary between countries. It is reasonable that the specific conditions and rules for the application of compost to soils (such as how much compost and of what quality may be used on certain types of soil) are regulated at the level of Member States. Diversity in soil properties, climates, land use practices, etc., throughout the EU is very high and there is a need for regulations to be adapted to the specific conditions.

Furthermore, there does not seem to be a scientifically sound and generally acceptable way to derive comprehensive, Europe-wide technical requirements for the use of compost on land, which is the main use of compost. This implies that the conditions and rules for compost use cannot directly be part of the European end-of-waste criteria for compost ([30]). The declaration of fitness for use will therefore have to be adjusted to the national legislation and standards that are applicable in the place where the compost will be used.

Only for some technical requirements that are of a general nature for all typical purposes of compost use may minimum requirements be included directly in the end-of-waste criteria at EU level. The purpose of such minimum requirements would be to generally exclude composts from end-of-waste for which there is not use at all, except, maybe, in small niche applications.

In any case, there is a need for harmonised technical standardisation of compost quality parameters, sampling and testing across the EU, to avoid an artificial fragmentation of compost markets that is not justified by the real use requirements. The end-of-waste criteria should, therefore, be based on common standardised quality parameters, as well as common standardised testing and sampling. As complementary measures, it would be important that Member States use the same harmonised standards in the relevant legislation on compost use.

2.3.3.4 The use of the substance or object will not lead to overall adverse environmental or human health impacts

There are various aspects to consider for avoiding overall adverse environmental or human health impacts.

1. Compost use should not exert any stress on soil that may compromise the multifunctional soil functions. Therefore, the input to soil of hazardous substances through compost application needs to be limited. This is primarily a question of rules on the use of compost, which, as argued before, are best formulated at lower

([30]) Concerning the use of compost in products such as growing media, EU-wide rules may be justified because growing media are products traded freely on the internal market. This would primarily be a question of regulating growing media, and would affect the end-of-waste criteria for compost only indirectly.

geographical levels. Composts should cease to be waste only if they comply with the environmental and health regulations on compost use that apply to the purpose for which they are placed on the market (see also condition c). As complementary measures to the end-of-waste criteria, it would be important that Member States, who have not already regulated the use of composts, put such rules in place. Again, there is a need for the technical standardisation of compost quality parameters, sampling and testing across the EU, to avoid any artificial barriers to compost use that are not justified by environmental requirements. The end-of-waste criteria should therefore include the use of harmonised European standards, and as a complementary measure, it would be important that Member States use the same harmonised standards in the relevant legislation on compost use.

2. Compost should not pose any health risks because of macroscopic impurities such as sharps. This can best be controlled by including limits on such impurities as a quality requirement in the end-of-waste criteria.

3. The end-of-waste criteria should not lead to a relaxation of the quality targets for compost production. This could happen if the end-of-waste criteria included concentration limits for hazardous substances that are generally lower than those standards that determine the quality of compost produced today. In principle, if lower quality composts are produced, then overall adverse environmental impacts can only be avoided by using less compost. This would then work against the central aim of the end-of-waste criteria, namely to promote recycling. The relaxation of quality targets for compost production can be prevented by including limits for hazardous substance concentration in product quality requirements.

4. Lifting the waste status should not create any regulatory void that would impair the management of environmental and health risks. The introduction of harmonised end-of-waste criteria will require the authorities in Member States to reconsider the waste statuses of composts. This will, in some cases, mean that certain composts that used to be considered waste have to be considered non-waste. Such a change would mean that the legal and administrative controls available under waste law do not apply any longer. The following control possibilities for compost, emanating from waste law, would be affected:

   - permitting the application of compost on land and for other compost uses (e.g. for the preparation of growing media using compost);
   - inspecting compost users, collectors or transporters by the competent waste authorities;
   - obligation of compost users to keep records of the quantity, nature and origin of compost;
   - prior written notification and consent of shipment;
   - registration by the authorities of transporters, dealers and brokers of waste.

   The logic of the end-of-waste criteria requires that only compost for which waste law-based controls are not needed should qualify, either because the inherent risks and impacts of the materials are sufficiently low, or because there are other regulatory controls to deal with them independently of the status as waste. The use of the compost under different conditions should be possible without any danger to the environment and to health.

The inherent risks of the material are determined by the content of impurities and pollutants (hazardous substances) as well as the hygienic properties of the compost. The end-of-waste criteria can limit the environmental and health risks by including certain product quality requirements regarding pollutants and impurities, restrictions on the input materials used to produce the compost, and process requirements to eliminate pathogens from the material.

As stated above, composts should cease to be waste only if they are placed on the market for a purpose for which adequate rules on the use of compost apply. As complementary measures, such rules should be established where they do not yet exist. In several Member States, there are already soil protection and/or fertiliser laws that regulate the use of compost independently of the waste status. Often reference is made to good agricultural practices, or application recommendations for compost are provided. Compost should not cease to be waste if it does not meet the product quality requirements for the main use purposes or in most places. This should be considered when determining the product quality requirements (e.g. concentration limits on hazardous substances) for the end-of-waste criteria.

Private quality assurance schemes play an important role in risk management in a number of countries, and sometimes are made quasi-compulsory (statutory) by reference in the relevant legal (waste or other law) instruments.

Finally, there is also the possibility of introducing new complementary control instruments especially designed for non-waste compost. As an example, new requirements for ensuring the traceability of compost might be established independently of the waste laws in certain markets where this desirable. The key question for any new controls introduced together with end-of-waste criteria is if these specific controls are better suited to deal with the compost-specific risks than the general controls linked to the status as a waste, considering that disproportionate new burdens need to be avoided.

2.3.4 Set of end-of-waste criteria for compost

In the previous sections it was stated that establishing end-of-waste criteria for compost offers environmental and economic benefits as this improves harmonisation and legal certainty, promotes the production of compost with high and reliable quality and facilitates its use, by avoiding unnecessary regulatory burden. It was also shown which features the end-of-waste criteria for compost must have to ensure that the conditions for the end-of-waste criteria set in the draft revision of the Waste Framework Directive are met. These features include that end-of-waste criteria should require:

- reliable and high product quality (high usefulness and low levels of contamination and impurities);
- the elimination of hygienic risks;

- the exclusion of compost for which market demand is too low, does not fulfil the technical requirements for the most important use purposes, or does not, in most cases, meet existing legislation and standards for use;

- the provision of reliable and comparable information on product properties, allowing the use of compost in compliance with existing legislation and use specifications;

- the application of harmonised technical standards.

In this section, a set of end-of-waste criteria is proposed which includes all necessary elements for obtaining environmental and economic benefits of the end-of-waste criteria, while ensuring that all conditions for the end-of-waste criteria are met. The proposal is based on all the analyses and expert consultations carried out as part of this case study, and follows the structure of the general methodology developed in the JRC-IPTS end-of-waste project, i.e. criteria on the input materials, the processes and techniques, product quality, potential applications, quality control procedures and the application of end-of-waste criteria.

2.3.4.1 The input materials

The criteria	Explanations	Reasons
The input materials used for the production of end-of-waste compost must be clearly identified and fully declared when the compost is placed on the market. In particular it must be declared if animal by-products, sewage sludge or input from mixed municipal solid waste were used.	The waste classification of the European Waste Catalogue should be used, ideally together with additional specifications, such as in the waste list in Annex 2-9.	The information on the input material is needed to allow the use of compost in compliance with existing legislation. For example, the Community legislation of organic farming has specific rules for the use of compost from source-separated household waste. For example, there are Member States that do not allow the use of compost for certain purposes if sewage sludge or mixed municipal waste (MSW) were input. If sewage sludge was input, the provisions following from the directive ([31]) on the agricultural use of sewage sludge need to be applied. If animal by-products were

([31]) Council Directive 86/278/EEC of 12 June on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (OJ L 181, 4.7.1986, p. 6).

The criteria	Explanations	Reasons
		input, compliance with the Animal By-products Regulation ([32]) is required. Furthermore, users, for instance farmers, often wish to know the origins and source materials of compost. Transparency on the input materials is important for the confidence of users in compost quality and can therefore strengthen compost demand.
<u>Biodegradable wastes are the only wastes allowed to be used as input materials</u> for the production of end-of-waste compost. Annex 2-9 lists biodegradable wastes that are currently regarded as suitable for composting in one or more Member States.	Non-biodegradable components that are already associated with biodegradable waste streams at source, should, however, be allowed if they are not dominant in quantity, do not lead to exceeding the pollutant concentration limits (see product quality requirements) and do not impair the usefulness of the compost. Example: soil-like material attached to garden waste.	Composting is suitable as treatment only for biodegradable wastes. Dilution of other wastes with biodegradable waste needs to be avoided.
<u>Criterion regarding metal concentrations:</u> **The metal concentrations in each of the waste streams that enter the composting process must not exceed half (exact value of this factor to be discussed) of the concentration limits (based on dry matter) of the product quality requirements (Section 2.3.4.3). Dilution of more contaminated waste streams with less contaminated waste streams is not allowed.**	This criterion should be used by Member States (legislative and regulatory competent authorities) when deciding on the suitability of an input material for producing end-of-waste compost. The relevant concentrations are those after pretreatment of the waste. Note that the organic matter content is reduced during composting, and metal concentrations are increased accordingly.	Low heavy metal concentrations are needed for sustained demand and a good overall cost-benefit balance of compost use. For promoting high compost quality (keeping contamination as low as possible according to best practice), it is important to avoid mixing clean input materials with more contaminated input materials.
<u>Criterion regarding</u>	This criterion should be used	To be cost-effective in risk

([32]) Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption (OJ L 273, 10.10 2002, p. 1).

The criteria	Explanations	Reasons
<u>persistent organic pollutants:</u> **As a principle, the concentration of persistent organic pollutants in input materials should not be increased compared to background concentrations found in uncontaminated topsoil.**	by Member States (legislative and regulatory competent authorities) when deciding on the suitability of an input material for producing end-of-waste compost. The relevant concentrations are those after pretreatment of the waste.	management, it is preferable to exclude input materials with increased persistent organic pollutant concentrations, instead of relying on systematically testing for these substances in the product.
<u>Criterion regarding clean sources</u>: In the case of effective source segregation of the biodegradable fraction of garden and park waste and of kitchen waste, it is assumed that the conditions on metal concentrations and persistent organic pollutants are met.	The effectiveness of source segregation in excluding potentially contaminating waste fractions should be assessed by the competent authorities on a case-by-case basis.	The use of these types of waste (with effective source segregation) is considered current best practice in compost production. It has been demonstrated that concentrations of the relevant metals and of persistent organic pollutants in these waste types are robustly low enough for the production of high-quality composts (ORBIT/ECN, 2008).
<u>Additives</u> (material other than biodegradable waste) can be used as input to the composting process in minor quantities if they improve the compost quality or they have a clear function in the composting process and the metal concentrations (based on dry matter) do not exceed the concentration limits for end-of-waste compost.	A limit for additives may be set, for example, at up to 10 % of total inputs.	In practice, additives are sometimes needed to improve the composting process or the compost quality.
Suitable procedures for controlling the quality of input materials need to be followed by the operators of composting plants. See also section on criteria regarding quality control procedures.	It is expected that in many cases visual inspection and approval of origin will be suitable procedures.	Controlling the input materials is a key factor (probably the single most important) for assuring reliable quality of the compost.

2.3.4.2 The processes and techniques

The criteria	Explanations	Reasons
It must be demonstrated for each compost batch that a suitable <u>temperature-time profile</u> was followed during the composting process for all material contained in the batch. **Annex** 2-10 **lists temperature-time profiles required by the Animal By-products Regulation ([33]) and national legislation and standards.**	The desired risk control can be achieved, avoiding being overly descriptive, by allowing a number of alternative temperature-time profiles from existing standards or regulations. The producer must comply with at least one profile that has been approved as suitable for the type of composting process applied and is specified in the licence/permit by the competent authority. The list in Annex 2-10 could serve as a basis for a European reference list of accepted methods according to type and scale of the composting process. It must be ensured that all of the composted material undergoes appropriate conditions. Depending on the process type this may require, for example, suitable turning, oxygen supply, presence of enough structural material, homogenisation, etc.	As is common in existing regulations and standards, there should be process requirements to ensure that the processes yield composts without hygienic risk.

2.3.4.3 Product quality

The criteria	Explanations	Reasons
The <u>product properties</u> that determine the usefulness of compost and the environmental and health impacts and risks of compost use <u>must be declared</u>. See Annex 2-11	The parameters included in the annex found acceptance in the expert stakeholder workshops organised as part of the JRC-IPTS end-of-waste project.	Composts can be used as a safe and useful product only if the relevant properties of the material are known to the user and the corresponding regulatory authorities. This information is needed to

([33]) Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption (OJ L 273, 10.10.2002, p. 1).

The criteria	Explanations	Reasons
for the parameters that need to be covered.		adapt the use to the concrete application requirements and local use conditions as well as the corresponding legal regulations (e.g. the provisions on soil protection that apply to the areas where the compost is used). An adequate declaration of the material properties is therefore a prerequisite for placing compost on the market and for the waste status to be lifted.
<u>Certain product quality requirements</u> must be fulfilled. These include that compost must: • **have a minimum organic matter content** • **(have a minimum stability)** • **not contain pathogens to an extent that poses health risks (measured by the absence of certain indicator organisms such as salmonellae)** • **contain only a limited number of viable weeds and plant propagules** • **contain only limited macroscopic impurities** • **have only limited concentrations of pollutants (measured as the concentration of certain potentially toxic elements).** **Proposals for parameters and limit values of the product quality requirements are made in Annex 2-12.**	One set of product quality requirements is sufficient because it is not the role of the European end-of-waste criteria to regulate uses. Rules on compost use for specific purposes and in specific geographical areas may demand stricter product quality requirements than those included in the end-of-waste criteria, on the grounds of environmental protection and to ensure usefulness.	The product quality requirements serve to exclude composts from end-of-waste that: o have a low quality and therefore a too weak market demand o do not fulfil the technical requirements for the most important use purposes, or that in a dominating part of the compost market do not meet the existing legislation and standards applicable to products o are likely to have an overall adverse environmental or human health impact. More specifically: A minimum level of organic matter content is needed to ensure basic usefulness as well as to prevent dilution with inorganic materials. A minimum stability would help to avoid methane and odour emissions during uncontrolled anaerobic conditions after sales (e.g. during storage). Limitation of macroscopic impurities is needed to ensure

The criteria	Explanations	Reasons
		usefulness and to limit the risks of injuries. Limitation of pollutant concentrations is needed: o to ensure that the material's inherent risks are sufficiently low so that the environmental impacts in the case of misuse are within acceptable limits o to exclude composts from end-of-waste that cannot be used lawfully for the main purposes in a dominant part of the compost market o to promote higher compost quality and as a signal against relaxing quality targets for compost production.
<u>Requirements on product testing</u> (sampling and analysis): **Compost producers must demonstrate by external independent testing that there is a sufficiently high probability that any consignment of compost delivered to a customer complies with the minimum quality requirements and is at least as good as the properties declared.** **The details of the sampling programme may be adjusted to the concrete situation of each compost plant. The competent authorities will, however, have to check compliance with the following requirements:** • **The compliance testing has to be carried out within external quality**	In the case of metal concentrations, the probability that the mean value of the concentration in a sample exceeds the legal limit should be less than a certain percentage (a confidence level of 95 % is typically used). This implies that the mean concentration of the whole population of the compost sold plus the confidence interval needs to be below the legal limit. (Usually, it will be impractical to sample from the total population and a subset of the overall population that can be considered typical of the whole population will have to be defined as part of the quality assurance process. Usually, the population will correspond to all the compost sold from a composting plant	A high level of environmental protection can be achieved only if there is reliable and comparable information on the environmentally relevant product properties. Claims made on product properties must correspond closely to the 'real' properties, and the variability should be within known limits. To manage compost so that environmental impacts and risks are kept low, it must be possible for compost users and regulatory authorities to interpret the declared product properties in the right way and to trust in conformity. Therefore, standardisation of product parameters, sampling and testing is needed as well as quality assurance.

The criteria	Explanations	Reasons
assurance by laboratories that are accredited for that purpose • **The CEN/Horizontal standards for sampling and analysis have to be applied as far as available. See Annex 2-13 for a list of standards and sampling and testing methods.** • **Probabilistic sampling should be chosen as the sampling approach and appropriate statistical methods used in the evaluation of the testing.**	throughout a year or shorter periods of time). The scale of sampling needs to be chosen depending on the sales/dispatch structure of a composting plant. The scale should correspond to the minimum quantity of material below which variations are judged to be unimportant. The better the precision of the testing programme (the narrower the confidence interval), the closer the mean concentrations may be allowed to be to the legal limit values. The costs of a testing programme of compost with very good quality (parameter values far from the limits) can therefore be held lower than for compost with values that are closer to the limit. When a new compost plant is licensed there is usually an initial phase of intensive testing to achieve a basic characterisation (for example one year) of the compost qualities achieved. If this proves satisfactory, the further testing requirements are then usually reduced.	
<u>Traceability:</u> The information supplied to the user together with the compost should allow the producer of the compost, the batch and the input materials used to be identified.	Member States may require users to keep records of these data for certain uses so that the compost can be traced back to the origin when needed.	For the event of environmental or health problems that can potentially be linked to the use of compost, there is a need to provide traceability trails for any investigations into the cause of the problems.

2.3.4.4 Potential applications

The criteria	Explanations	Reasons
When placing compost on the market, the producer must declare at least one <u>recognised purpose</u> for which the product is fit to be used. **The producer must identify the legal norms that regulate the use according to the identified purposes in the markets on which the product is placed.** **The producer must declare compliance with all requirements for use insofar as they are determined by the product properties.**	Recognised uses of compost by Member States and also at Community level (eco-label) include, in principle, use: • as a soil improver (or conditioner) or organic fertiliser • for the production of growing media (including manufactured/artificial soil Designated market sectors are, for example: • land restoration and soft landscape operations • horticulture • agriculture and soil-grown horticulture. • hobby gardening/wholesalers. A use of compost can be considered as recognised only if there are suitable regulations or other rules in place that ensure the protection of health and of the environment. The applicability of such rules must not depend on the waste status of the compost (see also Section 2.3.5 on complementary measures). Landfill or incineration of compost is generally not considered a recognised use.	It is a condition for end-of-waste that the product fulfils the technical requirements for a specific purpose and meets the existing legislation and good practice standards applicable to products.
The product should be accompanied by <u>instructions on safe use and application recommendations.</u> **The instructions should also make reference to the need of compliance with any**	For example, instructions and recommendations may refer to the maximum amounts and recommended times, for spreading on agricultural land. Spreading and incorporation in soil e.g. have to follow good agricultural practice.	Application instructions and recommendations help to avoid bad use of the compost and the associated environmental and health risks and impacts. Reference to legal requirements and standards

The criteria	Explanations	Reasons
legal regulations, standards, and good practice applying to the recommended uses.		for use are intended to support legal compliance by the compost user.

2.3.4.5 Quality control procedures

The criteria	Explanations	Reasons
Compost producers are required to operate a <u>quality management system</u> in compliance with quality assurance standards that are recognised as suitable for compost production by Member States or the Community.	Recognised quality assurance standards are set out, for example, in the British publicly available specification BSI PAS 100, Austrian ÖNORM S 2206-Parts 1 & 2 (requirements for a quality assurance system for composts), the Belgian VLACO total quality control system based on ISO 9000, and the German BGK's RAL quality assurance system.	Users and the authorities that are in charge of controlling the use of the compost need to have reliable quality guarantees. Trust in the quality of the material is a precondition for a sustained market demand. The actual product properties must correspond well to what is declared and it must be guaranteed that the material minimum quality requirements as well as the requirements concerning the input materials and processes are actually met when a product is placed on the market.
The quality assurance system is audited externally by the competent authorities or by quality assurance organisations accredited by Member State authorities.		The reliability of product quality will be acceptable only if the quality assurance systems are audited by the authorities or an officially accredited third-party organisation.

2.3.4.6 Application of the end-of-waste criteria

The criteria	Explanations	Reasons
Compost ceases to be waste, provided all other end-of-waste criteria are fulfilled, when it is <u>placed on the market by the producer</u>. However, if no customer is found that will use the compost lawfully, compost will be considered waste.		The end-of-waste criteria are defined so that compliant compost can be traded freely as a product once it is placed on the market by the producer. The benefits of the end-of-waste criteria can be realised if compost users are not bound by waste

The criteria	Explanations	Reasons
		legislation. (This means, for example, that farmers or landscapers using compliant compost do not require waste permits nor do formulators of growing media that use compost as a component.) Users have, however, the obligation to use the product according to purpose and to comply with the other existing legislation and standards applicable to compost.
If the compost is mixed/blended with other material before being placed on the market, the product quality criteria apply to the compost before mixing/blending.		Meeting the limit values relevant for product quality by means of dilution with other materials should not be allowed.
The undertaking placing compost on the market must provide the national authorities with the information or documentation required by national law that can be used to control that the compost is actually used for a lawful purpose.	Today, for example, before compost producers and importers place composts on the market in Austria, they are required to submit the following information to the Ministry of Environment: • their name, address, and telephone number • categories of input materials • designation of the compost • declaration of compliance with the prohibition of mixing Furthermore, compost producers and importers have to keep records of the customers/recipients (name, address, amount, date) for five years.	The quality requirements of the end-of-waste criteria are so strict for compost that generally it can be expected that there will be a sufficiently strong market demand for its use according to purpose. However, there is the possibility of oversupply at certain places, which may lead to increased risk of misuse. Member States need to have the possibility of controlling this risk proportionally to its size and specific nature.

2.3.5 Complementary measures

The functioning of compost end-of-waste criteria can be optimised if a number of complementary measures are taken which establish well-suited framework conditions for the operation of the end-of-waste criteria. The complementary measures are about the existence of compost use rules throughout the EU, quality assurance schemes and market surveillance.

2.3.5.1 Existence of use rules throughout the EU

Rules for compost use should be in place in all Member States and at Community level when appropriate. These rules should specify for what purposes compost may be used and under what conditions. The conditions should provide the adequate levels of environmental and health protection. By putting such rules in place, the uses become recognised. Currently recognised uses of compost by certain Member States and also at Community level (eco-labels, use of compost in organic agriculture) include use as a soil improver (or conditioner) or organic fertiliser and for the production of growing media. Designated market sectors are, for example, land restoration and soft landscape operations; horticulture; hobby gardening and agriculture and soil-grown horticulture. From a formal point of view, it must be ensured that the applicability of use rules is not conditional to the waste status of the compost. Harmonised technical standards for parameter definition, sampling and analysis should be used to ensure compatibility with the end-of-waste criteria. Detailed crop and use specific application specifications should be made available.

2.3.5.2 Quality assurance schemes

The reliability of product quality should be supported by suitable third-party quality assurance systems. The reliability of quality assurance should be at the same level wherever in the EU the compost is produced.

Member States authorities should audit the quality management systems in place at compost production plants or accredit quality assurance organisations for carrying out such audits. Authorities should furthermore identify/develop and recognise suitable compost quality management standards.

To ensure that quality assurance has the same level of reliability throughout the EU, certain minimum quality assurance standards should be agreed and applied accordingly. Furthermore, it is advisable to carry out a benchmarking of quality assurance systems across the EU.

2.3.5.3 Compliance checks and market surveillance

Member States authorities should monitor that composts placed on the market comply with the end-of-waste criteria (or waste law if they do not) and the relevant product legislation. Market surveillance should also include monitoring (e.g. through spot checks) that composts are used according to purpose and in compliance with the corresponding use legislation.

In cases where there is a sizeable risk of compost oversupply, Member States should put appropriate means in place to have an overview of composts flows (amounts of composts placed on the market and of compost use).

Administrations of Member States should cooperate in the compliance checks and market surveillance.

2.4 Impact assessment

2.4.1 Environmental and health impact

Chapter 2.2.4.8 concluded that there were three main groups of environmental and health issues related to composting that needed to be managed.

1. Climate change impacts of methane and nitrous oxide (N_2O) emissions during the composting process, pretreatment and storage.
2. Local health and environmental impacts and risks at, and close to, the composting facility (linked to odour, gas emissions, leachate and pathogens in bioaerosols).
3. Soil, environment and health protection when using compost, especially when applying compost to land.

The proposed end-of-waste criteria affect the first two groups only indirectly because they do not imply any change of the legal situation during composting ([34]). Composting always has to be considered a waste treatment activity and as such is covered by waste regulatory controls.

As an indirect effect of end-of-waste criteria, there is a good chance that the requirement to operate a quality management system will have a positive effect also on the management of the process related environmental impacts. Furthermore, if end-of-waste criteria induce changes in composting capacities and the amount of compost produced, this will also affect the compost production related environmental impacts, and those of the alternative waste treatment activities.

The exact size of these indirect effects and their overall balance (positive or negative) can hardly be measured. In any case, the indirect effects of end-of-waste will not be decisive factors for the environmental impacts from composting facilities. A much more important legal development in this respect is the possible coverage of composting by a revised IPPC Directive.

The third group of environmental and health impacts, however, are affected directly by end-of-waste criteria because end-of-waste criteria will alter in most cases the regulatory controls applicable to compost use and are also very likely to affect the quality of compost produced and used.

The proposed end-of-waste criteria were designed in a way that rules out intolerable impact and risks to human health and the environment in absolute terms. The criteria include minimum compost quality requirements regarding sanitation, impurities and contents of hazardous substances and that compost may cease to be waste only if placed on the market for purposes for which suitable regulation on compost use is in place to ensure environmental and health protection. There is, however, the possibility of relative changes of environmental impacts when comparing a ‘no action scenario’ with a scenario where the proposed and of waste criteria are applied. Such relative changes, i.e. the marginal environmental impact, are

([34]) The only exception is methane emissions during storage of immature compost after sales. End-of-waste criteria in principle reduce the legal base on which the issue can be addressed. However, compared to the current situation, the proposed end-of-waste criteria would not make any significant difference, because methane emissions during storage of compost hardly receive attention by regulatory authorities today. In any case, if the issue were considered as crucial, a straightforward solution would be to include a minimum compost maturity/stability requirement in the end-of-waste criteria.

assessed in this chapter, in general terms directly in the following text, and in a specific way for the main compost producing/using countries in Annex 2-14.

Average contents of hazardous substances in compost

Hazardous substance concentration is a useful proxy indicator for the potential overall environmental impact of compost use because more benefit can be obtained from compost used at the same potential of negative toxicological and ecotoxicolgical impacts when concentrations of hazardous substances are reduced.

The overall environmental impact of compost use is determined by the balance of specific positive and negative impacts. The soil improving function of compost, for instance, has positive environmental impacts, such as reduced soil erosion and improved water retention. The main negative aspects are the potential toxicological and ecotoxicological impacts due to the contents of hazardous substances (mainly heavy metals and organic pollutants). A quantitative comparison of the positive and negative impacts of compost use in the different scenarios (with and without end-of-waste criteria) is not practicable. However, it can be assessed if end-of-waste criteria are likely to lead to a change of the average concentrations of hazardous substances in compost used and produced in a country.

As Annex 2-14 shows, the likely effects of end-of-waste criteria on hazardous substance concentrations were assessed at the level of Member States. The overall conclusion of this assessment is that in most countries the end-of-waste criteria would introduce new quality standards for compost production that are stricter than the current lead standards. This is expected to lead to a reduced average concentration of hazardous substances, in particular heavy metals, in compost. An effective relaxation of the lead quality standards regarding the allowed concentrations of hazardous substances would only occur in the Netherlands. This might theoretically open the door to tolerating higher hazardous substance concentrations in compost production for exports. Since quantitative restrictions of compost use in the Netherlands are set by fertiliser law and independent of the waste status, end-of-waste criteria should, however, not alter the contents of hazardous substances of compost used in the Netherlands.

Hazardous substance flows to soil

A second way to compare the environmental impact of compost use with and without end-of-waste criteria is to look at the size of the hazardous substance flows to soil associated with compost use. Hazardous substance flows are an indicator of the size of the potential ecotoxicological and toxicological impacts of compost use. They are determined by the combined effect of changes in concentrations and of amounts of compost used.

While, as argued above, average concentrations are likely to decrease, it is more difficult to foresee how the total amount of compost used (both compliant and non-compliant with end-of-waste criteria) would be affected by end-of-waste criteria. An overall conclusion on the combined effect on hazardous substance flows is therefore not possible. It is likely, however, that there will be increased hazardous substance flows at certain locations where the quality of compost used is approximately the same with and without end-of-waste criteria and more compost will be used due to increased availability. However, since the end-of-waste criteria include minimum compost quality requirements and demand that there must be suitable locally applicable use rules, it can be expected that the overall environmental balance of increased compost use is still positive.

Risks related to misuse of compost

A third aspect to assess is the risks of environmental impacts (likeliness and size) because of compost misuse (not for recognised purpose or not complying with quantitative use restrictions). These risks may change when end-of-waste criteria lead to a new market situation (alterations in compost supply and demand) and affect the regulatory controls applicable to compost trade and use.

Locally, there may be increased risks related to compost misuse if end-of-waste criteria lead to new situations of oversupply, because of facilitated imports, that the market cannot handle efficiently. This theoretical possibility appears most relevant close to the main compost producing countries and where little experience exists yet with compost use. However, the heavy metal limits of end-of-waste criteria are set at a level that keeps any potential environmental impacts low even in the case of misuse. As a complementary measure to end-of-waste criteria it may be indicated in some countries to put means in place for the monitoring of composts flows (e.g. registration and analysis of data of compost placed on the market) in order to detect and manage possible situations of oversupply.

Conclusion

Altogether, the overall environmental impact of compost use in the end-of-waste scenario is expected to be more positive or at least neutral than in the 'no action scenario', both at the EU level and at the level of individual Member States. There is the theoretical possibility of a locally less favourable balance at certain places but there are proportionate accompanying measures to detect and counter any undesired developments.

The existence and enforcement of adequate compost use rules is an important factor supporting the positive environmental balance of end-of-waste criteria, especially in countries where composting is not a common practice today.

2.4.2 Economic impact

Costs of compost production

The main potential cost factor of end-of-waste criteria for compost production is quality assurance in the case of composting plants where an upgrading of quality assurance is required. ORBIT/ECN (2008) produced an overview of quality assurance costs according to the main schemes in place in various countries. Table 6 shows that the quality assurance costs are mainly determined by the size of the composting plant and range from below EUR 0.20/tonne of input to more than EUR 3/tonne of input. The costs measured per tonne of compost produced are about double these values. The quality assurance costs in Table 6 reflect the external expenses in the renewal procedure of certificates or quality labels during the continuous operation of the plants. In the first application and validation period (first one to two years) costs are considerably higher on account of a first evaluation of the plants and the higher frequency of tests. Additional costs are incurred through the internal staff requirements for operating the quality management system.

The total compost production costs in a best practice composting plant with 20 000 tonnes capacity were estimated at EUR 45/tonne of input (Eunomia, 2002). A comparison with the average quality assurance costs for a plant of this size according to Table 6 shows that the external quality assurance costs represent less than 1 % of total costs.

For open-air windrow composting the cost can be less than EUR 20/tonne. In this type of plant the throughput is usually much smaller and, in the case of 500 tonnes/year, quality assurance can make up more than 10 % of total costs.

However, many composting plants have already suitable quality assurance systems in place (at least one fifth of all composting plants in the EU), and most others regularly carry out some form of compliance testing, so that not all of the quality assurance costs associated with end-of-waste would be additive.

Table 6: Cost of compost quality assurance in selected European countries. Source: ORBIT/ECN (2008).

Quality assurance costs/tonne input and year (EUR excluding VAT)										
Throughput/year (tonnes)	**AT (1) (ARGE) Agriculture plants**	**AT (2) (KGVÖ) Industrial plants**	**DE (3) (BGK)**	**IT (4) (CIC)**	**NL (5) (BVOR) (Green C. plants)**	**NL (6) (VA) (VFG plants)**	**SE (7) (SP)**	**UK (8) (TCA) Use in agriculture/ horticulture**	**UK (9) (TCA) Other uses**	**EU Mean value**
500	2.15	3.36	—	—	—	—	—	—	—	—
1 000	0.94	1.80	—	—	—	—	—	—	—	—
2 000	0.97	1.32	0.82	—	1.62	1.87	1.21	1.13	1.10	1.26
5 000	0.63	0.67	0.52	0.48	0.76	0.86	0.48	0.45	0.44	0.59
10 000	0.44	0.58	0.34	0.46	0.53	0.58	0.29	0.28	0.27	0.42
20 000	0.26	0.44	0.31	0.45	0.39	0.43	0.15	0.23	0.22	0.32
50 000	0.17	0.36	0.19	0.43	0.21	0.22	0.06	0.20	0.19	0.23

Sources: Personal information from:

(1) KGVÖ Compost Quality Society of Austria — operates mainly biowaste treatment plants. Costs include membership fees, laboratory costs and external sampling.

(2) ARGE Compost & Biogas Association Austria — decentralised composting of separately collected biowaste in cooperation with agriculture. Costs include membership fees, laboratory costs and external sampling.

(3) BGK German Compost Quality Assurance Organisation. Costs include membership fees, laboratory costs and external sampling.

(4) CIC Italian Compost Association CIC — including company fee according to turnover plus external sampling and laboratory costs

(5) BVOR Dutch Association of Compost Plants — costs at green waste plants which include membership fees, laboratory costs and the costs for yearly audits by external organisations — no external sampling.

(6) VA Dutch Waste Management Association — costs at biowaste (VFG) plants including membership fees, laboratory and external sampling costs, and the costs for yearly audits by external organisations. The expenses are slightly higher compared to BVOR because of additional analysis of sanitisation parameter and the external sampling.

(7) SP Swedish Standardisation Institute execute the QAS scheme — costs include membership fees, laboratory costs, and costs for yearly audits by SP — sampling is done by the plants besides the yearly audit.

(8) TCA the UK Compost Association certification for compost in agriculture and horticulture — total costs associated with certification scheme fees for all parameter and lab testing. Costs associated with testing the compost are higher compared to other application areas, as the compost producer is required to test parameters like total nutrients, water soluble nutrients and pH in addition sampling is done by the plants. For compost used in agriculture and field horticulture, the UK Quality Compost Protocol has introduced for the land manager/farmer the requirement to test the soil to which compost is applied. The costs associated with soil testing are not incorporated here because it is mostly not the compost producer, but the farmer or land manager who pays for.

(9) TCA the UK Compost Association certification for compost used outside agriculture and horticulture — total costs associated with certification scheme fees and lab testing. Sampling is done by the plants.

Cost of compost use

Users of end-of-waste compost need not comply with waste regulatory controls. Other legal obligations, for example based on fertiliser or soil protection law, are independent of waste status. There is also the possibility of new regulatory obligations being introduced as accompanying measures to end-of-waste criteria. The net difference of the cost of compost use in an ‘end-of-waste scenario’ compared to a ‘no action scenario’ depends therefore on the specific legal situation in each country and may even be different in sub-regions of one country. It was not possible to get a full picture of compliance costs of compost use within the scope of this case study. However, the case of the compost quality protocol in the United Kingdom can serve as an example. The Composting Association (2006) estimated that for agricultural use of compost under the quality protocol (equivalent to end-of-waste) the agricultural compliance costs are reduced by EUR 1.69 (GBP 1.29 ([35]))/tonne of compost.

Benefits

Where end-of-waste criteria lead to an upgraded quality assurance it can, in principle, be expected that the compost will be of improved quality, rendering additional benefits to users, for instance agronomic benefits in the case of agricultural use. The size of these benefits, however, cannot be reasonably quantified within this study.

Overall assessment

Where quality certified compost is used today under waste regulatory controls, end-of-waste criteria are likely to lead to a net cost reduction. The cost reductions accrue in the use sector, and may possibly be transferred back to some extent, through the acceptance of increased compost prices, to compost producers, and through reduced gate fees to municipalities or other relevant waste generators.

Where the quality certification of compost needs to be upgraded for complying with end-of-waste criteria, this creates increased costs for compost producers, which are not likely to be very significant in relative terms for large scale compost production, but may make up to 10 % of total costs in the case of very small-scale production. This may be compensated, at least partly, by increased revenues through higher prices in compost sale, if users accept that there is a sufficiently high benefit to them in terms of avoided compliance costs and better and more reliable product quality.

2.4.3 Market impact

The main direct impact to be expected from end-of-waste criteria is a strengthened market demand for compost through:

- facilitated exports
- better and more reliable product quality (improved perception by potential users)
- avoided compliance costs for compost use.

Facilitated exports are especially relevant in areas where the compost market is saturated because of use restrictions due to strong supply of competing materials for soil spreading,

([35]) 1 March 2008 exchange rate.

especially manure. According to ORBIT/ECN (2008), shortage in national demand because of competition of other cheap organic material (mainly manure) is the main reason for compost exports today in the cases of Belgium and the Netherlands. The Netherlands, for instance, combine a very high population density, one of the highest separate collection rates of kitchen and garden waste (ca 190 kg/inhabitant/y), a very large excess of animal manure on the one hand and a very restrictive nutrient/fertilising legislation on the other. Even if theoretically there could still be enough market potential for compost in the Netherlands, prices achieved for compost are low, often even negative, and the Dutch composting industry has already exported considerable amounts of compost under current framework conditions. On average 4.5 % of the annual compost production in Belgium and the Netherlands was exported in 2005 and 2006.

Dutch exports to Germany required the participation of Dutch composting plants in the German compost quality certification scheme and bilateral agreement with German *Länder* governments. Currently, Belgian exports to France need to demonstrate both compliance with the Belgian VLACO standard and the French NFU 44051 standard (analysis and certification by French laboratories). It is expected that export possibilities could more easily be developed with European end-of-waste criteria.

The strengthening of domestic compost markets is especially relevant in countries where composting is only incipient at the moment. By setting EU-wide quality standards for compost that ensure good and reliable product quality of compliant compost, end-of-waste criteria, together with accompanying measures to define the conditions for compost use, may give a boost to compost markets in these countries.

Avoiding compliance costs for compost use if waste regulatory controls are not required, is also a factor that favours the compost market demand. This has been an advantage, for instance, considered in the development of the compost quality protocol in the United Kingdom.

For composts that do not meet end-of-waste criteria it will be increasingly difficult to find market outlets, because their use will require waste regulatory compliance and they will be clearly differentiated as of lower quality. In some cases, this will lead to efforts to improve quality management and product quality in order to succeed in meeting the requirement. The key factor will be to obtain purer input materials, which will often require measures to introduce, expand or improve the effectiveness of source segregation of biological wastes. In other cases, the economics of composting will deteriorate (lower, i.e. often negative, compost prices), compost production may be abandoned and plants converted to mechanical-biological treatment with subsequent landfill or incineration.

In a similar way, the available choices will also be clearer shaped for decisions on new treatment capacities for biodegradable waste: either production of end-of-waste compliant compost or one of the non-compost alternatives (including MBT + landfill or incineration). Through strengthening the market demand, while changing the costs of high-quality compost production only marginally, it can be expected that at more places than today there will be favourable conditions for opting for compost production. It can also be expected that the establishment of new capacities for the production of non-end-of-waste-compliant compost will become rather unattractive because of difficulties to find an outlet for the compost.

2.4.4 Legislative impact

In a few Member States there exists specific compost legislation based on waste law, including explicit provisions on the status of compost as waste or not (e.g. biowaste and compost ordinances in Germany and Austria respectively). It can be foreseen that such legislation would have to be adapted when EU end-of-waste criteria are introduced for compost.

In other cases there are official rulings or practices by regulatory authorities that link end-of-waste to compliance with certain standards or protocols, as in France and the United Kingdom. An adaptation to end-of-waste criteria (for example concerning limit values or the need for quality assurance) would also be required in these cases, although these would probably not have to be of a legislative nature.

As an accompanying measure to end-of-waste criteria, there is a need to adapt existing legislation in Member States regulating the use of compost to harmonised technical standards on product parameters, sampling and analysis. Furthermore, the use of compost should be regulated also in those places where no such legislation exists yet.

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Annex 2-1: Overview of the management of biodegradable waste in EU Member States, based on ORBIT/ECN (2008)

Legend:

Bio and green waste composting B/GWC	Anaerobic digestion AD	Mixed municipal solid waste composting MSWC	Mechanical biological treatment MBT	Landfilling LAND	Incineration INCIN

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
AT	x	x	—	x	—	x

Biological waste treatment
Countrywide statutory separate collection of bio and green waste and the necessary composting capacity exist.

Landfilling and mechanical biological treatment
Austria has realised a national ban on landfilling of untreated and biodegradable waste in 2004 and meets the targets of the EU Landfill Directive. MBT plants with 0.5 million tonnes of treatment capacity stabilise the organic part of the residual MSW (after separate collection of biowaste) so it meets the Austrian acceptance and storage criteria for landfills.
Incineration
Incineration is well established in Austria but, besides sewage sludge, not for organic waste.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
BE	x	—	—	—	—	x

The Waste Management System in Belgium is assigned to the three regions. Each region has its own waste management legislation and policy. No information from the Brussels region is available.

Biological waste treatment
Separate collection of bio and green waste and the necessary composting capacity exist in Flanders supplemented by a waste prevention programme which reduces the waste amount for landfilling and incineration.

Landfilling and mechanical biological treatment
Landfilling of waste is intended to be reduced to the maximum level by waste prevention, recycling and mechanical biological treatment in Flanders. Only waste which can't be recycled or incinerated should be landfilled. Flanders meets already the reduction targets of the Landfill Directive after a ban on landfilling of organic waste in 2005.

Incineration
Incineration is well established in Flanders and Wallonia.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
CY	—	—	—	—	x	—

Biological waste treatment
In order to meet the EU diversion targets biological waste treatment capacities have to be built.

Landfilling
The full implementation of the Landfill Directive is planned for the year 2009. It requires a number of up to 100 existing landfill sites to be closed and replaced by four non-hazardous waste treatment and disposal centres plus one hazardous waste treatment centre. It also requires the establishment of a separate collection system for recyclable (packaging) waste and the promotion of composting of biodegradable waste.

Incineration
No essential capacities recorded.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
CZ	**x**	—	—	—	**x**	**x**

Biological waste treatment
The National Waste Management Plan 2002–13 in the Czech Republic includes challenging targets for separate collection and composting of biowaste in its implementation programme for biodegradable waste.

Landfilling
An implementation plan for the Landfill Directive has already been prepared (in 2000) to meet all the nine key requirements of the EU Landfill Directive.

Incineration
Incineration capacity is part of the Czech waste management.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
DE	**x**	**x**	—	**x**	—	**x**

Biological waste treatment
Countrywide separate collection of bio and green waste and the necessary composting and anaerobic digestion capacity of around 12 million tonnes annually exist.

Landfilling and mechanical biological treatment
Germany has realised a national ban on landfilling of untreated and biodegradable waste by June 2007 and surpassed the targets of the EU Landfill Directive already. Around 50 MBT plants with 5.5 million tonnes of treatment capacity stabilise the organic part of the residual MSW (after separate collection of biowaste) so it meets the German acceptance and storage criteria for landfills.

Incineration
Incineration is well established in Germany but, except for sewage sludge, not for organic waste. Additional capacity is under construction especially designed for the high calorific fraction from MBT.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
DK	**x** GWC	—	—	—	—	**x**

Biological waste treatment
Collection and composting of green waste is well developed and diffused in Denmark. Biowaste composting stays more or less on a pilot scale.

Landfilling
The number of landfill facilities in Denmark is expected to be reduced further. The requirements laid down in the Statutory Order on Landfill Facilities are expected to lead to the closure of 40–60 landfill facilities (out of the approximately 150 existing facilities) before 2009.

Incineration
Denmark largely relies on waste incineration. The general strategy is a ban on landfilling of waste that can be incinerated (is suitable for incineration).

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
EE	**x**	**—**	**—**	**—**	**—**	**—**

Biological waste treatment
The Estonian National Waste Plan suggests the collecting garden waste in cities and enhancing home composting in rural areas.

Landfilling
For biodegradable municipal waste, the Estonian National Waste Plan gives a general priority to separate biowaste from mixed MSW before landfilling. The plan proposes to increase biowaste recovery from 20 000 tonnes in 2000 to 290 000 to 350 000 tonnes in the year 2020 and to decrease landfilling of biodegradable waste from 390 000 to 450 000 tonnes in 2000 to 40 000 tonnes in 2020. This shift of capacities requires essential alternative treatment by composting or mechanical biological treatment.

Incineration
No essential capacities recorded.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
ES	**x**	**x**	**x**	**—**	**x**	**x**

Biological waste treatment
The National Waste Management Plan NWMP 2000–06 indicates a general target for BMW (mixed biological municipal solid waste including food and garden waste and paper) recycling by treating a minimum 40 % by 2001 and 50 % by 2006 of the total arising by composting and AD. The plan intends to enhance energetically valorisation by means of anaerobic digestion of 2 % of BMW by 2001 and 5 % by 2006.
The National Plan on Waste states a general target for green waste to be separately collected and recycled: 50 % by 2002 and 80 % by 2006. Food waste should be separately collected starting from big producers (restaurants, canteens, etc.). All municipalities > 5 000 should introduce separate collection. Source-separation of biowaste (mainly food waste) is only implemented mandatory in Catalonia.

Landfilling
All uncontrolled landfills should to be closed by 2006 according to the 2000 National Waste Management Plan. By 2006 all landfill sites will be managed according to the requirements of the EU directive, estimating that 33.1 % of MSW will be eliminated via landfilling.

Incineration
The National Waste Management Plan from 2000 foresees to incinerate 9 % of MSW by 2001 and 17.7 % by 2006.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
FI	**x**	**x**	**—**	**x**	**x**	**—**

Biological waste treatment
A most important policy document in relation to biodegradable waste management is the National Strategy on Reduction of Disposal of Biodegradable Waste on landfills according to the EU Landfill Directive requirements. This strategy also provides means and assistance in order to reach the objectives set out in the Landfill Directive. Scenarios of the strategy give statistics and forecasts for biodegradable waste production and treatment for the years 1994, 2000, 2006 and 2012. The strategy contains an assessment of present biodegradable waste quantities and a forecast and various technological (including composting, digestion, mechanical biological treatment) and infrastructural scenarios including waste prevention.

Landfilling
The Finish waste management strategy in the past was always quite effective in reducing biodegradable waste on landfills with less than 50 % of the volume compared to 10 years before.

Incineration
No essential capacities recorded.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
FR	**x**	**—**	**x**	**—**	**x**	**x**

Biological waste treatment and mechanical biological treatment MBT
Composting of selected biodegradable MSW is increasing but is still not consolidated (141 000 tonnes in 2002). MSW mixed bio-composting (called raw waste composting) is expected to increase essentially due to advanced technology screening and new lower national thresholds for the compost quality. In the last years the collection of green waste has strongly progressed through the setting up of collection points. Also, the French agency ADEME has supported numerous composting projects. The biological pretreatment of waste is not widespread in France, but the experiences of the existing sites are followed with interest.

Landfilling
Today waste landfilling still represents the most applied management options for MSW in France: 42 % of MSW are sent to landfills in 2002. From 2009 all landfills shall comply with the EU Landfill Directive requirements and diversion requirements. France already largely respects the targets of 2006 and 2009 set by EU Directive on landfills. However, the estimated amount of biodegradable municipal waste going to landfill in 2016 is 40 % of the total amount produced in 1995 but 35 % is required by the EU Landfill Directive for 2016. In

accordance with this requirement the waste management plans have been revised with a stronger orientation towards recycling.

Incineration
There are approximately 130 incinerators at present in France. Some waste management plans foresee the construction of new incineration plants, some of which are already under construction. It is estimated that the amount of waste going to incineration will increase by 1–2 % in the next years. The capacity allows biodegradable waste to be incinerated to a certain extent.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
GR	**—**	**—**	**—**	**x**	**x**	**—**

Biodegradable waste treatment
Legislation JMD 50910 repeats the dual commitment of the Greek government to close down all illegal landfills by the end of 2008 and to reduce the biodegradable municipal waste to 65 % by 2020. Intermediate targets are: 25 % (2010) and 50 % (2013). The targets will be achieved through the operation of recycling and composting facilities in almost all regions of the country as well as through the full operation of the separate collection systems for selected waste streams. At the moment, there are no facilities processing source-separated organic waste, although it would be fairly easy to do so with, at least, the green wastes; they are collected separately anyway and some municipalities have thought of so doing.

Mechanical biological treatment MBT
Various regional waste management plans foresee the construction of MBT plants as the main tool to meet the Landfill Directive targets. At present three such plants are in operation. Obviously, the option to revise the waste management plans to include other options such as thermal treatment or source separation is always open, but conditions for any of these options do not seem to be mature yet.

Landfilling
Until the early 1990s, the use of uncontrolled dumps was the ‘traditional’ method of solid waste disposal. Since then, the overall situation has dramatically improved: There are 45 sanitary landfills constructed in Greece (41 already operational) whereas 47 more sites are under construction including the expansion of existing ones. The latest data for the year 2003 reports that 1 032 dumping sites, mainly small, were still operating in various municipalities of the country. It is expected that by the end of 2008, uncontrolled waste dumping will cease to exist.

Incineration is not well diffused in Greece.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
HU	**x**	**—**	**—**	**x**	**x**	**—**

The National Waste Management Plan (NWMP) valid from 2003 till 2008 prescribes the general tasks of waste management in Hungary. Main goals and targets:

Biological waste treatment
50 % reduction of landfilled quantity of biodegradable waste of the volume generated in 1995 till 2007. The National Biowaste Programme (BIO-P, 2005–08) has the following preferences

to reduce BMW: recycling (paper), composting, anaerobic digestion (biogas generation), MBT, thermal utilisation. The needed capacity building until 2008 is 460 000 tonnes/year composting and 100 000 tonnes/year MBT (HU ([36])).

Landfilling
Revision and liquidation of the old landfill sites till 2009. At the end of 2008 approximately half of all waste not including biomass must be recovered or used in power engineering.

Incineration
The old waste incinerators will be renovated or closed by 2005 (accomplished).

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
IE	**x**	**x**	**—**	**x**	**x**	**—**

The Irish waste management policy includes a strategy for a dramatic reduction in reliance on landfilling, in favour of an integrated waste management approach which utilises a range of waste treatment options to deliver effective and efficient waste services and ambitious recycling and recovery targets. Alternative waste treatment options like composting, digestion, MBT or incineration more or less doesn’t exist.

National Strategy on Biodegradable Waste (2004) sets the following targets for 2013:

- diversion of 50 % of overall household waste away from landfill;
- a minimum 65 % reduction in biodegradable municipal waste (BMW) sent to landfill;
- developing biological treatment capacity (composting, MBT or AD) of up to 300 000 tonnes/year;
- recycling of 35 % of municipal waste;
- rationalisation of municipal waste landfills to a network of 20 state-of-the art sites;
- reduction of methane emissions from landfill by 80 %.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
IT	**x**	**—**	**—**	**x**	**—**	**x**

Integrated biodegradable waste management with composting, MBT and incineration
Italy has established waste management in an integrated way according to the specific properties of the different material flows using separate collection and recycling and the treatment options incineration (including energy recovery), mechanical biological treatment (12 million tonnes annual capacity — to segregate the high calorific faction and to stabilise the organic part before landfill) and composting of source-separated bio and green waste (2.8 million tonnes/year).

([36]) Strategic evaluation on environment and risk prevention under Structural and Cohesion Funds for the period 2007–13 — Contract No 2005.CE.16.0.AT.016. ‘National Evaluation Report for Hungary — Main Report’, Directorate-General for Regional Policy. A report submitted by GHK Brussels, November 2006, p. 217 (http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/strategic_environ.pdf) (downloaded 15 October 2007).

Landfilling and biological mechanical treatment MBT

In Italy the implementation of the Landfill Directive includes strict limits as regards organic matter (TOC) and the calorific value of the waste to be landfilled. So pretreatment of the waste by means mechanical biological treatment to allow to stabilisation or energy recovery is necessary. Coherently with decree 36/03 the regions shall plan a strategy in order to decrease the amount of biodegradable waste going to landfills. Before 27 March 2008 biodegradable municipal waste must be reduced to less than 173 kg/inhabitant/year, before 27 March 2011 to less than 115 kg and before 27 March 2018 to be reduced to less than 81 kg/inhabitant/year. The waste management strategy identifies the following instruments to be implemented in order to achieve the targets:

- economic instruments to discourage landfill disposal;
- separate collection of organic, wooden and textiles fractions;
- mechanical/biological treatment;
- biological treatment;
- incineration with energy recovery;
- a ban on landfilling of certain waste streams.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
LT	**x**	**x**	**—**	**x**	**x**	**—**

Biological waste treatment

The development of the overall waste management system in Lithuania from 2006 aims at meeting the targets of diverting biodegradable waste from landfills set in the Landfill Directive. It is assumed that set targets will be met by increasing the efficiency of separate collection of biodegradable waste and recyclables and implementation of facilities for treatment and recovery of biodegradable waste, i.e. composting. In regional waste management projects currently under implementation, construction of green waste composting facilities is foreseen in most of the municipalities. However, in order to meet the stringent requirements of the Landfill Directive it is also envisaged that in future some form of additional waste treatment will be required, i.e. incineration (with energy recovery), mechanical-biological treatment, anaerobic digestion, etc. In Lithuania many waste management companies have started composting activities due to a ban on the disposal in landfills of biodegradable waste from gardens, parks and greeneries.

Landfilling

The lack of environmentally safe waste disposal sites is a key problem of waste management in Lithuania. Special efforts have to be invested into the development of new landfills which meet all environmental requirements included in EC Directive 1999/31/EC. Lithuania has indicated that no landfilling will take place in non-complying landfills after 16 July 2009.

Incineration

There are no waste incinerators in Lithuania designed specifically for the combustion of waste.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
LU	**x**	**x**	**—**	**—**	**x**	**—**

National and local Waste Management Plans from 2005 include the following quantitative objectives (% by weight) which should be attained for domestic waste, bulky waste and similar wastes (reference year: 1999):

- organic wastes: rate of recycling of 75 %;
- rate of recycling of 45 %;
- other recoverable wastes: rate of recycling of 45 %.

No further detailed information on landfilling and incineration is available.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
LV	**x**	**—**	**—**	**—**	**x**	**x**

Biological waste treatment
No biological treatment besides pilot projects.

Landfilling
Latvia relies on landfilling.

Incineration
No incineration capacity for MSW.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
MT	**—**	**—**	**—**	**—**	**x**	**—**

Biological waste treatment
No biological treatment; only one pilot project on composting. Activities for separate collection and composting were intended for 2006 with no real progress until now.

Landfilling
Malta relies on landfilling.

Incineration
No incineration capacity for MSW.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
NL	**x**	**—**	**—**	**—**	**—**	**x**

The Ministry of Environment has issued a National Waste Management Plan for the period 2002 to 2012 with the essential provision to promote waste recovery, particularly by encouraging waste separation at source and subsequent separation of waste streams. Waste separation allows for product reuse, material reuse and use as fuel. The level of waste recovery must accordingly increase from 81 % in 2000 to 86 % in 2012.

Biological waste treatment
The Netherlands have, with 3.3 million tonnes/year, the highest recovery rate for source-separated bio and green waste in Europe.

Landfilling
Landfilling of the surplus combustible waste, as currently happens, must be finished within five years. The Waste (Landfill Ban) Decree came into force in 1995 and prohibits landfilling of waste if there is a possibility for reusing, recycling or incinerating the waste. According to the waste management plan the quantity of waste to be disposed of in 2012 should be limited to a maximum (rounded) of 9.5 million tonnes — mainly non-combustible waste, incineration residues and sewage sludge.

Incineration
Incineration should optimise the use of the energy content of waste that cannot be reused by high energy efficiency waste incineration plants.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
PL	**x**	**—**	**x**	**x**	**x**	**—**

Biological waste treatment
Biological waste should be collected separately by a two-bin system mainly in the cities. Before July 2013 not less than 1.7 million tonnes/year, before 2020 not less than 2.2 million tonnes capacity should be installed which means the construction of 50 composting plants from 10 000 tonnes to 50 000 tonnes capacity. In practice, today, there is only mixed waste composting with low qualities mainly used as landfill cover. Referring to garden waste in the national waste management programme it is implied that 35 % of this waste category will undergo the process of composting in 2006, and 50 % in 2010.

Landfilling
Poland has been granted a transition until 2012 for the implementation of the Landfill Directive. According to the Treaty of Accession, intermediate targets until 2012 were set out for each year, detailing how much waste may be deposited in landfills.

Incineration
No essential capacities recorded.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
PT	**x**	**x**	**x**	**x**	**x**	**x**

Biological waste treatment
In order to reduce biological waste going to landfills the 2003 national Portuguese strategy promotes separate collection and composting or anaerobic digestion. An increased capacity from 285 000 tonnes for organic waste in 2005 up to 861 000 tonnes in 2016 should be constructed with 10 large and several small organic waste treatment plants.

Landfilling
In 2003 the National Strategy for the reduction of biodegradable urban waste from landfills came into force in order to meet the EU Landfill Directive requirements. Additional recycling and incineration capacities should help to fulfil the diversion targets. Lately, mechanical biological treatment is prioritised instead of recycling via composting or digestion of separately collected organic waste.

Incineration
A third incineration plant and extension of the existing incinerators is intended.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
SE	**x**	**x**	**—**	**—**	**—**	**x**

Biological waste treatment

- By 2010 at least 50 % of household waste will be recycled, including biological treatment.
- By 2010 at least 35 % of food waste from households, restaurants, institutions and shops will be recycled through separate collection and biological treatment.
- By 2010 food waste from food industry will be recycled through biological treatment.
- Biological treatment will be mainly — besides green waste composting — based on anaerobic digestion.

Landfilling
Ban on combustible waste was 1 January 2002 and on compostable waste, 1 January 2005. Inadequate statistics on how much combustible and organic waste is landfilled make it difficult to assess the need for increased capacity to comply with the prohibitions. No essential activities on mechanical biological treatment MBT.

Waste incineration is well accepted and diffused.

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
SI	**x**	**—**	**—**	**x**	**x**	**—**

Based on the criteria of the Waste Framework Directive and Directive on Landfill of Waste, combined with other directives in municipal waste sector, the Cohesion Fund priority projects in waste sector were identified on the basis of the National Waste Management Strategy and the Action Plan of Municipal Waste Management 2000 to 2006, and are focused on the construction of new infrastructure facilities in the scope of regional waste management centres.
Implementation of legislation on incineration, and biowaste collection started in 2001 but with nearly no real transformation in treatment plants especially for bio and green waste.

Biological waste treatment
The Slovenian report about the needs for the next Cohesion Funds (SI ([1])) period estimate in Figure 9.13 for 2013 the need of 270 000 tonnes of MBT treatment and 147 000 tonnes composting capacity for separately collected biowaste.

No references to landfills and incineration capacities are given.

SI ([1]) STRATEGIC EVALUATION ON ENVIRONMENT AND RISK PREVENTION UNDER STRUCTURAL AND COHESION FUNDS FOR THE PERIOD 2007–13 — Contract No 2005.CE.16.0.AT.016. '**National Evaluation Report for Slovenia — Main Report',** Directorate-General for Regional Policy. A report submitted by GHK Brussels, November 2006 (http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/strategic_environ.pdf) (downloaded 15 October 2007).

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
SK	**x**	**—**	**—**	**—**	**x**	**—**

Waste Act No 223/2001 Coll. regulates the whole waste management. The waste management plan WMP SR for 2006–10 was approved by the Government in 2006. Municipalities prepare waste management plans and are responsible for all waste generated within.

Biological waste treatment

Article 18(3m) of Act No 223/2001 does not allow to landfill green waste and also entails an obligation of separate collection of biodegradable municipal wastes to municipalities. The WMP defines the target for 2010 as decrease of biodegradable municipal waste landfilling on 20 % of 2005. The municipalities are responsible for recovery of green waste. Usually they operate (or cooperate with agricultural farms) composting or biogas plant.

Landfilling and incineration

Targets for 2010 for waste management for non-hazardous wastes are the following 70 % recovery, 0 % incineration and 19 % landfilling.
The Slovak report about the needs for the next Cohesion Funds period estimates until 2013 the need of 400 to 900 small municipal compost plants and 6 to 10 large ones ([37]).

OPTIONS	B/GWC	AD	MSWC	MBT	LAND	INCIN
UK	**x**	**x**	**—**	**x**	**x**	**—**

Biological waste treatment

The United Kingdom government and the National Assembly have set challenging targets to increase the recycling of municipal waste: to recycle or compost at least 25 % of household waste by 2005, at least 30 % of household waste by 2010 and at least 33 % of household waste by 2015. No further provisions are made as to what extent alternative treatments like MBT or AD are part of the strategy. Green waste composting is well developed and diffused in the United Kingdom. AD shows growing interest. Regions in the United Kingdom have different specific targets recycling and treatment target exceeding the national requirements.

Landfilling

Landfilling allowances can be traded within the municipalities by the LATS Landfill Allowance and Trading Scheme.

Incineration

Incentives exist to shift waste treatment from incineration which is not very well diffused in the United Kingdom.

([37]) Strategic evaluation on environment and risk prevention under Structural and Cohesion Funds for the period 2007–13 — Contract No 2005.CE.16.0.AT.016. 'National Evaluation Report for Slovakia — Main Report', Directorate-General for Regional Policy. A report submitted by GHK Brussels, November 2006 (http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/strategic_environ.pdf) (downloaded 15 October 2007).

Annex 2-2: National approaches and criteria to determine whether compost produced from waste may be marketed as product or is still within the waste regime
Source: ORBIT/ECN (2008)

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime
AT	PRODUCT	Compost Ordinance BGBl. I 291/2001	Central registration of compost plant Positive list of input materials Comprehensive documentation of waste reception Process management and material movement Compost quality criteria Product designation, declaration, labelling and selling of compost External sampling and product certification by acknowledged institute If all criteria are met and approved by the external certification system all types of compost can be marketed as PRODUCT.
BE Flanders	WASTE (secondary material)	VLAREA Flemish Regulation on waste prevention and management (BS 1998-4-16)	Total quality control of the VLACO certificate includes: input criteria, process parameters, standards for end product, correct use; compost remains WASTE in any case ([38]). User certificate by OVAM is necessary only for the application of sewage sludge compost
BG	—	—	—
CY	—	—	—
CZ	PRODUCT	Act on fertilisers 156/1998 Sb. by the Public Ministry of Agriculture ČSN 46 5735 Průmyslové komposty Czech Compost Standard	Fertiliser Registration System: Central Institute for Supervising and Testing in Agriculture, the Czech Environmental Inspectorate. One compost class: quality requirements correspond to Class 1 of the Czech Compost Standard but with less quality parameter compared to the waste composts. The use is not restricted to agriculture. Compost has only to be registered for this group and the inspection/control of samples is done by the control and test institute for agriculture which is the Central Institute for Supervising and Testing in Agriculture.
	PRODUCT	Biowaste Ordinance (in preparation)	All three classes foreseen in the new draft compost ordinance are defined as end-of-waste criteria.
DE	WASTE	Fertiliser	Compost also from source-separated organic

([38]) There are different interpretations of the situation in Belgium (Flanders). According to comments from VLACO, compost is not traded as waste but as a secondary raw material when it gets a VLACO certificate.

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime
		Ordinance (26 November 2003) Closed-loop Management and Waste Act (KrW-/AbfG); Biowaste Ordinance (BioAbfV, 1998)	waste is seen as WASTE due to its waste properties and its potential to pose negative impacts to the environment (risk of contamination). Positive list for input materials Hygienically harmless Limit value for heavy metals Requirements for environmentally sound application Soil investigation Official control of application by the waste authority Documented evidence of approved utilisation All classes and types of compost, which are produced from defined source materials under the Biowaste Ordinance remain WASTE.
	WASTE product	RAL Gütesicherung RALGZ 251	When participating in a voluntary QA scheme relaxations are applied with respect to the regular control and approval protocols under the waste regime. Though, legally speaking, compost remains WASTE, quality assured and labelled compost can be extensively treated and handled like a product. The relaxations are: no soil investigation; no official control of application by the waste authority; no documented evidence of approved utilisation. In principle all classes and types of compost, which are produced from defined source materials under the biowaste ordinance remain WASTE, but, in practice, if certified under QAS of the RALGZ 251 compost can be marketed and used as a quasi-PRODUCT.
DK	WASTE	Statutory Order 1650 of 13.12.2006 on the use of waste (and sludge) for agriculture	The use of compost based on waste is under strict regulation (maximum of 30 kg P/ha/y etc. and the concentration of heavy metals in the soil where applied must not exceed certain levels. For this reason the authorities want to know exactly where the compost ends up which is only possible if handled as waste and not as a product (for free distribution). Garden and park waste compost is exempted from this waste regulation and is therefore handled like a product.
EE	WASTE	Environment	Heavy metal limits in compost (sludge compost)

	Compost = PRODUCT or WASTE	**Legal basis or standard**	**Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime**
		al Ministry regulations 30.12.2003 No 78 and in Environmental Ministry Regulation 1.1.2002 No 269	No specific regulation on compost from biowaste and green waste.
ES	PRODUCT	Real Decree 824/2005 on Fertilisers Products	Input-List (Annex IV of Decree on Fertilisers Products) Documentation (Article 16) Declaration of raw materials and proportion Description of process Certification to declare the fulfilment of all requirements Declaration and labelling: nutrient content and other technical requirements (limitation of impurities, size of particles, limitation for micro-organisms, maximum content on heavy metals, limitation of use, use recommendations, etc.) External quality approval by acknowledged laboratory Quality parameter for final compost (Annex V of Decree on Fertilisers Products) Heavy metal content Nitrogen % Water content Granulometry Maximum micro-organisms content (sanitation)
FI	WASTE PRODUCT	Jätelaki (Waste Law) Fertiliser Regulation 12/07	WASTE status changes to PRODUCT if compost fulfils the criteria of fertiliser regulation and is spread to land or mixed into substrate. But there is no external approval or inspection scheme. Samples can be taken by compost producer
FR	PRODUCT	NFU 44051 Standard	Mixed waste compost — no positive list Four Product types 'Organic soil improvers — organic amendments and supports of culture' 'Organic soil improvers — composts containing substances essential to agriculture, stemming from water treatment (sludge compost)' 'Organic amendments with fertiliser' 'supports of culture' Further following quality criteria:

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime
			Limit values for: trace metal concentrations and loads (g/ha/y), impurities, pathogens, organic micro-pollutants Labelling requirements There is no regular external approval or inspection scheme. Samples can be taken by compost producer. However, there is a legal inspection by the competent authority based on the IPPC procedure which, in FR, is also applied to composting facilities. Compost which is not produced according to the standard is WASTE and has to follow a spreading plan and may apply for a temporary product authorisation. By this way the standard can easily be bypassed.
GR	PRODUCT	Common Ministerial Decision 114218, 1016/B/17-11-97. Fertiliser law (Law 2326/27-6-1995, regulating the types of licences for selling fertilisers)	Compost is considered as product and may be sold, provided it complies with the restrictions of the framework of Specifications and General Programs for Solid Waste Management. No sampling protocol and analysis obligations/organisations are defined. Composts produced from materials of agricultural origin (olive-mill press cake, fruit stones, tree trimmings, manures, etc.) are considered products and sold under the fertilisers law
HU	PRODUCT	36/2006 (V.18.) Statutory rule about licensing, storing, marketing and application of fertiliser products	Composts are in waste status as long as they are not licensed under the Statutory rule No 36/2006 (V.18.). After the licensing composts may become a PRODUCT. To achieve the product status needs to be in accordance with the Statutory rule No 36/2006 (V.18.). Criteria: Input-List, External quality approval by acknowledged laboratories, physical, chemical and biological quality parameter for final compost.
IE	PRODUCT	EPA Waste Licence	Product status is based on individual waste licence; compliance with all operational and product requirements laid down in the consent

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime
			document must be shown by producer. There is NO legal standard or QAS or quality protocol in Ireland at the moment which says when waste becomes a product.
IT	PRODUCT	L. 748/84 (law on fertilisers); D.M. 5.2.1998 (Technical Regulation on simplified authorisation procedures for waste recovery)	Criteria for product status are based on National Law on Fertilisers, which comprises: qualitative input list (source segregated organic waste; quality parameters for final compost; criteria for product labelling. Compost from MBT/mixed waste composting plants may still be used under the old Decree DPR 915/82 — DCI 27/7/84 as WASTE for restricted applications (brown fields, landfill reclamation, etc.).
LT	PRODUCT	Decree of the Ministry for Environment (D1-57/Jan 2007)	According to environmental requirements for composting of biowaste the compost producer must provide a certificate on the compost quality Compost sampling is done by the PRODUCER NO external approval or plant inspection
LU	PRODUCT	Waste licence	The product status is achieved only when a QAS is applied. QAS is an obligatory element of the waste licensing of composting plants. The further criteria are: positive list for input materials; hygienically harmless (process requirements and indicator pathogens); limit value for heavy metals; requirements for environmentally sound application (labelling).
LV	PRODUCT	Licensing as organic fertiliser (Cabinet Regulation No 530, Regulations on identification, quality, conformity and sale of fertilisers 25.6.2006)	Quality of the compost, its composition. The product status is achieved only when it is registered and tested by certificated laboratory. The further criteria are: hygienically harmless; limit value for pollutants.
MT	WASTE	—	NO provisions for compost.

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime
NL	PRODUCT	Decree of the quality and use of organic fertilisers other than manure (1991)	One or more organic components, but no animal manure, broken down by micro-organisms into such a stable end product that the composting process is slowed down considerably. Key criteria: the composting process (hygienisation) and its documentation; stability (no value); the absence of animal manure; heavy metal limits; minimum organic matter content; declaration & labelling.
PL	WASTE	Fertiliser law	Ministerial Approval by Ministry of Agriculture and Rural Development Criteria: limit values for heavy metals (three classes, also coarse and fine compost); test on Pathogens.
PT	PRODUCT	NP 1048 — Standard for fertilisers Portaria 672002 pg 436	Compost is interpreted as organic soil amendment '*Correctivo organic*'. There are no specific regulations available.
RO	—	—	NO provisions for compost
SE	WASTE	Private QAS and SPRC 152 (compost standard)	Waste Criteria: definition according to European Court of Justice. The compost standard is managed by the Swedish Standardisation Institute (SP).
SI	PRODUCT	Decree on the input of dangerous substances in fertilisers into soil (1996 as amended in 2001)	If compost meets the requirements of this fertiliser ordinance compost is a PRODUCT. If limit values are not met the compost can be used as WASTE provided a risk assessment is carried out by an accredited laboratory. Criteria: limit values for heavy metals (three classes) and AOX, PCBs; maximum levels for glass, plastics, metals.
SK	PRODUCT	Act No 223/2001 Col. on waste as amended Slovak technical standard	After biowaste has gone through recovering process it is considered as compost, but such product cannot be marketed. Compost may be marketed in cases when it is certified by an authorised person according to Act No 264/1999 Col. Key criteria for the PRODUCT status:

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime
		(STS) 46 57 35 Industry composts Act No 136/2000 Col. on fertilisers Act No 264/1999 Col. about technical requests for products Regulation of the Government No 400/1999 Col. which lays down details about technically requirements for products	quality parameter for final compost — STS 46 57 35; process parameter (sanitisation) — STS 46 57 35; quality approval by acknowledged laboratory or quality assurance organisation — Act No 264/1999 Col.
UK	WASTE	Waste Management Licensing Regulations Animal By-Products Regulations	England, Wales, Scotland and Northern Ireland: Compost must be sold/supplied in accordance with the Waste Management Licensing Regulation rules for storing and spreading of compost on land (these rules apply whether or not the compost is derived from any animal by-products). There are no quality criteria/classes but in the application form and evidence (test results for the waste) sent to the regulator, 'agricultural benefit' or 'ecological improvement' must be justified. The regulator makes an evaluation taking account of the characteristics of the soil/land that is intended to receive the waste, the intended application rate and any other relevant issues. Compost derived in whole or in part from animal by-products must be placed on the market and used in accordance with the animal by-products regulations.
	PRODUCT	BSI PAS 100 :2005	Scotland: requires certification to PAS 100 (or an equivalent standard), that the compost has certainty of market, is used without further recovery, is not be subjected to a disposal activity

	Compost = PRODUCT or WASTE	Legal basis or standard	Main criteria for compost ceasing to be waste and/or placing on the market and use of compost even under the WASTE regime
		BSI PAS 100 :2005 + Quality Compost Protocol	and is not be mixed with other wastes, materials, composts, products or additives. Northern Ireland: similar position as Scotland. England & Wales: both, the standard and the Protocol have to be fulfilled to sell/supply/use 'Quality Compost' as a PRODUCT. Key criteria: positive list of allowed input types and source types; QM system including HACCP assessment; standard process including hygienisation; full documentation and record keeping; contract of supply per consignment; external quality approval; soil testing on key parameters; records of compost spreading by land manager who receives the compost (agriculture and land based horticulture. NB: In each country of the United Kingdom, if compost 'product' is derived in whole or in part from animal by-products, it must be placed on the market, stored, used and recorded as required by the animal by-products regulations.

Annex 2-3: Heavy metal limits in existing compost regulations and standards
Source: ORBIT/ECN (2008)

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
			mg/kg dm								
AT	Compost Ordinance Class A+ (organic farming)	Statutory ordinance	0.7	70	—	70	0.4	25	45	200	—
	Compost Ordinance Class A (agriculture; hobby gardening)		1	70	—	150	0.7	60	120	500	—
	Compost Ordinance Class B limit value (landscaping; reclamation) (guide value)*		3	250	—	500 (400)	3	100	200	1 800 (1 200)	—
BE	Royal Decree 7.1.1998	Statutory decree	1.5	70	—	90	1	20	120	300	—
BG	No regulation	—	—	—	—	—	—	—	—	—	—
CY	No regulation	—	—	—	—	—	—	—	—	—	—
CZ	Use for agricultural land (Group 1)	Statutory	2	100	—	100	1	50	100	300	10
	Landscaping, reclamation (draft Biowaste Ordinance) (Group 2)	Statutory Class 1	2	100	—	170	1	65	200	500	10
		Class 2	3	250	—	400	1.5	100	300	1 200	20
		Class 3	4	300	—	500	2	120	400	1 500	30
DE	Quality assurance RAL GZ — compost/digestate products	Voluntary QAS	1.5	100	—	100	1	50	150	400	—
	Biowaste Ordinance	Statutory decree (Class I)	1	70	—	70	0.7	35	100	300	—
		(Class II)	1.5	100	—	100	1	50	150	400	—
DK	Statutory Order No 1650; Compost after 13 December 2006	Statutory decree	0.8	—	—	1 000	0.8	30	120/60 for private gardens	4 000	25

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
			mg/kg dm								
EE	Environment Ministry Re. (30.12.2002; No 87) Sludge Regulation	Statutory	—	1 000	—	1 000	16	300	750	2 500	—
ES	Real decree 824/2005 on fertilisers Class A	Statutory	0.7	70	0	70	0.4	25	45	200	—
	Class B		2	250	0	300	1.5	90	150	500	—
	Class C		3	300	0	400	2.5	100	200	1 000	—
FI	Fertiliser Regulation (12/07)	Statutory decree	1.5	300	—	600	1	100	150	1 500	25
FR	NFU 44 051	Standard	3	120		300	2	60	180	600	
GR	KYA 114218, Hellenic Government Gazette, 1016/B/17-11-97 (Specifications framework and general programmes for solid waste management)	Statutory decree	10	510	10	500	5	200	500	2 000	15
HU	Statutory Rule 36/2006 (V.18)	Statutory Co: 50; Se: 5	2	100	—	100	1	50	100	—	10
IE	Licensing of treatment plants (EPA) stabilised MBT compost compost not meeting Class I or II	Statutory	5	600	—	600	5	150	500	1 500	—
	(Compost — Class I)	Statutory	0.7	100	—	100	0.5	50	100	200	—
	(Compost — Class II)	Statutory	1.5	150	—	150	1	75	150	400	—
IT	Law on fertilisers (L 748/84; 03/98 and 217/06) for BWC/GC/SSC	Statutory decree	1.5	—	0.5	230	1.5	100	140	500	—
LU	Licensing for plants		1.5	100	—	100	1	50	150	400	—
LT	Regulation on sewage sludge Category I (LAND 20/2005)	Statutory	1.5	140		75	1	50	140	300	—

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
			mg/kg dm								
LV	Regulation on licensing of waste treatment plants (No 413/23.5.2006) — no specific compost regulation	Statutory = threshold between waste/product	3			600	2	100	150	1 500	50
NL	BOOM Compost	Terminated on 31.12.2007	*1*	*50*	—	*60*	*0.3*	*20*	*100*	*200*	*15*
	BOOM Very clean Compost		*0.7*	*50*	—	*25*	*0.2*	*10*	*65*	*75*	*5*
	Amended National Fertiliser Act from 2008	Statutory	1	50		90	0.3	20	100	290	15
PL	Organic fertilisers	Statutory	3	100		400	2	30	100	1 500	—
PT	Standard for compost is in preparation	—	—	—	—	—	—	—	—	—	—
SE	Guideline values of QAS	Voluntary	1	100	—	100	1	50	100	300	
SI	Three classes of heavy metals were not delivered	Statutory	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SK	Industrial Standard STN 46 5735 Cl. 1	Voluntary (Mo: 5)	2	100		100	1	50	100	300	10
	Cl. 2	Voluntary (Mo: 20)	4	300		400	1.5	70	300	600	20
UK	UKROFS fertil.org.farming, 'Composted household waste'	Statutory Regulation (EEC) No 2092/91	0.7	70	0	70	0.4	25	45	200	—
	Standard: PAS 100	Voluntary	1.5	100	—	200	1	50	200	400	—
EU Eco-label	Commission Decision 2007/64/EC of 15 December 2006, eco-label to growing media Commission Decision 2006/799/EC of 3 November 2006, eco-label to soil improvers	Voluntary (Mo: 2; As: 10; Se: 1.5; F: 200 (only if materials of industrial processes are included)	1	100	—	100	1	50	100	300	10

Country	Regulation	Type of standard	Cd	Crtot	CrVI	Cu	Hg	Ni	Pb	Zn	As
			mg/kg dm								
EU regulation on organic agriculture	Regulation (EEC) No 2092/91 of 24 June 1991, compliance with limits required for compost from source-separated biowaste only	Statutory	0.7	70	—	70	0.4	25	45	200	—

Annex 2-4: Limits on the content of impurities in compost in existing compost regulations and standards
Source: ORBIT/ECN (2008)

Country	Impurities	∅ Mesh size	Limit values % dm (m/m)
AT *Compost Ordinance*	Total: agriculture Total: land reclamation Total: technical use Plastics: agriculture Plastics: land reclamation Plastics: technical use Plastics: agriculture excluding arable land Plastics: technical use Metals: agriculture	2 mm > 2 mm > 2 mm > 2 mm > 2 mm > 2 mm > 20 mm > 20 mm —	≤ 0.5 < 1 < 2 < 0.2 < 0.4 < 1 < 0.02 < 0.2 < 0.2
BE *Royal Decree for fertilisers, soil improvers and substrates*	Total: Stones:	> 2 mm > 5 mm	< 0.5 < 2
CZ *Act on fertilisers* *Biowaste Ordinance*	Total: agriculture Total: land reclamation	> 2 mm > 2 mm	< 2 < 2
DE *Biowaste Ordinance*	Glass, plastics, metal: Stones:	> 2 mm > 5 mm	< 0.5 < 5
ES	Total impurities (glass, metals, plastic):	> 2 mm	< 3
FI *Fertiliser legislation*	Total:	—	< 0.5
FR *NFU 44-051*	Plastic films: Other plastics: Metals:	> 5 mm > 5 mm > 2 mm	< 0.3 < 0.8 < 2.0
HU	No restrictions	—	—
IE *EPA waste licence*	Total: compost Class 1 & 2 Total: low grade compost/MBT Stones:	> 2 mm > 2 mm > 5 mm	≤ 0.5 ≤ 3 ≤ 5
IT *DPR 915/82* *Fertiliser law*	Total: Glass: Metals: Plastics: Plastics: Other inert material:	--- --- --- --- < 3.33 mm > 3.33 < 10 mm < 3.33 mm	≤ 3 ≤ 3 ≤ 1 ≤ 0.5 < 0.45 < 0.05 < 0.9
LV *Cabinet Regulation*	Total (glass, metal, plastics):	> 4 mm	< 0.5

Country		Impurities	∅ Mesh size	Limit values % dm (m/m)
	No 530, 25.6.2006			
NL ([39])	*BOOM*	Total:	> 2 mm	< 0.5
	KIWA-QAS	Glass:	> 2 mm	< 0.2
		Glass:	> 16 mm	0
		Stones:	> 5 mm	< 2
UK	*PAS 100*	Total:	> 2 mm	< 0.5
	voluntary standard	Herein included plastic:		< 0.25
		Stones: other than ‘*mulch*’	> 4 mm	< 8
		Stones: in ‘*mulch compost*’	> 4 mm	< 6

([39]) As of 1 January 2008, the Dutch ‘Other Organic Fertiliser Decree’ (BOOM) has been replaced by the Fertiliser Regulation (Uitvoeringsregeling Meststoffenwet).

Annex 2-5: Provisions for the exclusion of pathogens, germinating weeds and plant propagules

Source: ORBIT/ECN (2008)

	Indirect **TIME-TEMPERATURE regime**				**Direct methods**		
	°C	**% H_2O**	**particle size/ mm**	**time**	**application area**	**pathogens/ weeds**	**product (P)/ approval of technology (AT)**
ABP Regulation *(Regulation (EC) No 1774/2002)*	70		12	1h	Cat. 3 material	*Escherichia coli OR Enterococcae* *Salmonella*	**Process validation**: < 1 000/g in 4 of 5 samples *1 000–5 000*/g in 1 of 5 samples **Final Compost:** Absent in 5 of 5 samples
EC Eco-label *(Decisions 2006/799/EC, 2007/64/EC)*					Soil improver growing media	*Salmonella* sp. *E. Coli* ([40]) *Helminth Ova* ([40]) **Weeds/ propagules**	Absent in 25 g < 1 000 MPN *(most probable number)*/g Absent in 1.5 g Germinated plants: ≤ 2 plants/l
AT *Statutory 'Guideline — State of the Art of Composting'*	55 – 65 Flexible time/temp. regimes are described at min. 55 °C, 1 to 5 turnings during a 10–14 days thermophilic process			10 d	Land reclam. Agriculture Sacked, sport/ playground Technical use Horticulture/ substrates	*Salmonella* sp. *Salmonella* sp. *E. coli* *Salmonella* sp. *E. coli*, *Campylobacter*, *Listeria sp.* — **Weeds/propagules**	Absent Absent If positive result recommendation for the safe use Absent Absent Absent Absent No requirements Germination ≤ 3 plants/l
BE *VLACO*	60 55			4 d 12 d		*Process control* **Weeds**	Time-temperature relation Absent
CZ *Biowaste Ordinance*	55 65			21 d 5 d		*Salmonella* spp. *E. coli* *Enterococcae*	Absent < 10^3 CFU/g < 10^3 CFU/g

([40]) For those products whose organic content is not exclusively derived from green, garden and park waste.

	Indirect TIME-TEMPERATURE regime				Direct methods		
	°C	% H_2O	particle size/ mm	time	application area	pathogens/ weeds	product (P)/ approval of technology (AT)
DE *Biowaste Ordinance*	55 60 ([1]) 65 ([2])	40 40 40		14 d 7 d 7 d		*Salmonella senft.* *Plasmodoph. Brass.* *Nicotiana virus 1* *Tomato seeds* *Salmonella senft.* **Weeds/ propagules**	**Process validation** ([3]): Absent Infection index: ≤ 0.5 Guide value bio-test: ≤ 8/plant Germination rate/sample: ≤ 2 % **Compost production**: Absent in 50 g sample Germination ≤ 2 plants/l
DK	55			14 d	Controlled sanitised compost	*Salmonella* sp. *E. coli*, *Enterococcae*	Absent < 100 CFU/g FM < 100 CFU/g FM
ES						*Salmonella* sp. *E. coli*	Absent in 25 g < 1 000 MPN *(most probable number)*/g
FI						No harmful micro-organisms to such an extent that it may endanger man, animals or the environment.	
FR	60			4 d	Gardening/ retailer Other uses	*Salmonella* sp. *Helminth Ova* *Salmonella* sp. *Helminth Ova*	Absent in 1 g Absent in 1 g Absent in 25 g Absent in 1.5 g
IE *Green waste*	—	—	—	—	Individual licence 2004	*Salmonella* sp. *Faecal coliforms*	Absent (≤ 3 MPN/4g) ≤ 1.0 x 10^3 MPN/g
Catering waste *Cat. 3 ABP*	60 70		400 12	2 x 2 d 1 h	Individual licence 2007	*Salmonella* sp. *Faecal coliforms*	Absent (≤ 3 MPN/4g) ≤ 1.0 x 10^3 MPN/g
IT *Fertiliser Law*	55			3 d		*Salmonella* sp. *Entero-*	Absent in 25 g sample ≤ 1.0 x 10^3 CFU/g

	Indirect TIME-TEMPERATURE regime				Direct methods		
	°C	**% H_2O**	**particle size/ mm**	**time**	**application area**	**pathogens/ weeds**	**product (P)/ approval of technology (AT)**
						bacteriaceae *Faecal Streptococcus* *Nematodes* *Trematodes* *Cestodes*	$\leq 1.0 \times 10^3$ MPN/g Absent in 50 g sample Absent in 50 g sample Absent in 50 g sample
LV *Cabinet Regulation No 530 25.6.2006*					Fertilisers	*Salmonella* sp. *E. coli*	Absent in 25 g sample < 2 500 CFU/g
NL ([41]) *BRL K256/02*	55			4 d		*Eelworms* *Rhizomania virus* *Plasmodoph. Brass.* **Weeds**	Absent Absent Absent Germinating plants: ≤ 2 plants/l
PL					All applications	*Ascaris* *Trichuris* *Toxocara* *Salmonella* sp.	Absent Absent Absent Absent
UK *PAS 100 voluntary standard*	65	50	min. 2 turnings	7 d ([4])	All applications	*Salmonella* ssp. *E. coli* **Weeds/ propagules**	Absent in 25 g < 1 000 CFU *(colony forming units)*/g Germinating weed plants: 0/l

([1]) In vessel composting.
([2]) Open windrow composting.
([3]) Two approvals (one in winter) for windrow composting.
([4]) Not necessarily consecutive days.

([41]) There are additional direct method requirements to obtain compost certification (regarding E. coli and enterococcae).

Annex 2-6: Regulation of the use of compost
Source: ORBIT/ECN (2008)

	Regulation	Requirements or restriction for the use of compost
AT	Compost Ordinance	• Agriculture: 8 tonnes dm/ha/y on a five-year basis • Land reclamation: 400 or 200 tonnes dm/ha/y within 10 years depending on quality class • Non-food regular application: 20 or 40 tonnes dm/ha/y within three years depending on quality class • Electrical conductivity > 3 mS/cm: excluded from marketing in bags and for private gardening
	Water Act	• Specific application requirements pursuant to the Action Programme following the EU Nitrate Directive (e.g. limitation to 210 or 170 kg total N/ha/year)
BE *Flanders*	Royal decree for fertilisers, soil improvers and substrates Fertiliser Regulation (Nitrate Directive) VLAREA waste regulation	• An accompanying document with user information is obligatory • Fertiliser Regulation limits N and P, partly more compost use possible because of beneficial soil effects compared to manure • VLAREA require VLACO Certificate for use and limits max. level of pollutants and show conditions for max application rates
BG	No data available	n.d.
CY	No data available	n.d.
CZ	Biowaste Ordinance, Waste Act (2008)	• According to the coming Biowaste Ordinance (2008) for the first class there are restrictions according to ordinance on hygienic requirements for sport areas, the second best can be used with 200 tonnes dm/ha/10 years
	Fertiliser law	• Fertiliser law requires application according good practice
DE	Biowaste Ordinance (BioAbfV 1998) Soil Protection Ordinance (BbodSchV 1999) Fertiliser Ordinance (DÜMV, 2003)	• The Biowaste Ordinance regulates agricultural use with compost • Class I 20 tonnes dm in three years, Class II 30 tonnes dm in three years • Soil Protection Ordinance for non-agricultural areas from 10 to 65 tonnes dm compost depending on use • Fertilising with compost according to good practice
DK	Stat. Order 1650 0f 13.12.2006 of the use of waste (and sludge) in agriculture	• 7 tonnes dm/ha/y on a 10-year basis • Restriction of nitrogen to 170 kg/ha/y • Restriction of phosphorus to 30 kg/ha/y average over three years • The levels for heavy metals and organic compounds are restricted in the INPUT material for the composting

	Regulation	Requirements or restriction for the use of compost
		process
EE	No compost restrictions	• Only restrictions for the use of stabilised sludge 'sludge compost'
ES	Real Decree 824/2005 on Fertiliser Products	• Class C compost (mixed waste compost) 5t dm/ha/y
FI	Fertilising Regulation 12/07 Lannoiteasetus	• Maximum Cd load/ha 6 g over four years (crop growing area), 15 g over 10 years (landscape gardening), 60 g over 40 years (forestry) • Soluble phosphorus load per five years 400 kg (farming), 600 (horticulture) and 750 (landscape gardening); soluble nitrogen load over five years in landscape gardening max. 1 250 kg
FR	Organic soil improvers — Organic amendments and supports of culture NFU 44-051	From the moment compost meets the standard NFU 44-051 there is no rule for the use. In the standard, flows in heavy metals, and elements are restricted to the maximum loading limits: • Per year g/ha: As 270, Cd 45, Cr 1.800, Cu 3.000, Hg 30, Ni 900, Pb 2.700, Se 180, Zn 6.000 • Over 10 years g/ha: As 900, Cd 150, Cr 6.000, Cu 10.000, Hg 100, Ni 3.000, Pb 9.000, Se 600, Zn 30.000 • Application should follow of good agrarian practices and agronomical needs which are taken into account for the use of composts.
GR	Common National Ministerial Decision 114218/1997 Hellenic Ministerial Decision	Upper limits for amounts of heavy metals disposed of annually in agricultural land Cd 0.15, Cu 12, Ni 3, Pb 15, Zn 30, Cr 5, Hg 0.1 kg/ha/y
HU	49/2001 Statutory Rule about the protection of the waters and groundwaters being affected by agricultural activities 10/2000. (VI. 2.) KöM-EüM-FVM-KHVM — Water protection rule	• Compost application on agricultural land is limited by the amount of nutrient with 170 kg/ha nitrogen. • Dosage levels depending on background contamination and nutrient content level in the soil laid down in the National Statutory Rule about the threshold values for the protection of the ground and subsurface waters and soils.
IE	Statutory	• IE Nitrate Regulation: compost has to be included in the

	Regulation	Requirements or restriction for the use of compost
	Instruments SI No 378/2006, Good agricultural practice for protection of waters: Statutory Instrument No 612/2006	nutrient management plan. Availability of nutrients calculated like cattle manure • There are specific waiting periods to consider for animal access to land fertilised with biowaste compost based on the Animal By-Product Regulations; o catering waste: 21 d for ruminant animals; 60 d for pigs; o former foodstuff & fish waste compost: three years (under revision)
IT	National law on fertilisers L. 748/84 (revised in 2006 with the new law on fertilisers, D.lgs. 217/06) Regional provisions	• Compost has to be considered a product to be used according only to good agricultural practice as long as it meets the standards. No restriction is set on loads for unit area • Some regions have codified approaches for low grade materials applications and landfill reclamation, building on the old regulation on 'mixed MSW compost' (DCI 27/7/84)
LT	Environmental Requirements for Composting of biowaste, approved by the Ministry of the Environment on 25 January 2007, No D1-57 Standards for sewage sludge use for fertilising and redevelopment LAND 20-2005 (Gazette 2005, No 142-5135)	• When compost used for improve the quality of the soil, the annual quantity of the heavy metals cannot exceed norms according LAND 20-2005 • Compost application in agriculture and or soil reclamation purposes, is restricted by contamination with pathogenic micro-organisms, organic micro-pollutants and heavy metals (according to LAND 20-2005) • Compost application on agricultural land is limited by the amount of nutrient with 170 kg/ha nitrogen and 40 kg/ha phosphorous per year
LU	EU Nitrate Directive	• No specific regulations; advise (voluntary): 15 tonnes dm/ha/y • Only record keeping about the compost use and sent to the Ministry
LV	No regulations	Only for sewage sludge compost
MT	No data available	—
NL	New national fertiliser regulation after 1.2008	• Compost has to meet the national standard (heavy metals) • In the new fertiliser legislation limitations for application are only based on the nutrient content for agriculture max. 80 kg P_2O_5/ha/y and 120 to 250 kg N/ha/y

	Regulation	Requirements or restriction for the use of compost
		depending on the crop consumption • For some crops which grow in the soil (e.g. potatoes) compost needs certification and a low glass content < 0.2 %
PL	The National Law on Fertilisers and Fertilisation, 26.7.2000. Dz. U. No 89, poz. 991	There are limits specified in regulations for amounts of composts applied to soil. There are no limits for nitrogen but only for manures. Composts shall be applied according to good agricultural practice
PT	No regulations available	—
RO	No data available	n.d.
SE	The Swedish Board of Agriculture: SJV 1998:915 (sewage sludge regulation)	• Fixed maximum heavy metal load Maximum heavy metal load (g/ha/y): Pb 25; Cd 0.75; Cu 300; Cr 40; Hg 1.5; Ni 25; Zn 600
	Nitrate Directive	Agriculture: nitrogen: 150 kg/ha/y and phosphorus: 22–35 kg/ha/y
SI	Decree on input of dangerous substances and plant nutrients into the soil (OJ RS 68/96 and 35/01) Instructions for implementing good farming practices (OJ RS 34/00)	• Class I (low heavy metal content) can be used without any restrictions. Class II (medium heavy metal content) can be spread with special permission with a limited application rate considering the heavy metal content and load after an evaluation and risk assessment by the laboratory • How many nutrients e.g. nitrogen and phosphorous can be spread in Agriculture
SK	Act No 220/2004 Col. on protection and using of agricultural soils	• Lays down limit concentrations of risk elements in agricultural soils
	Ministry of Agriculture Decree No 26/2000, on fertilisers.	• Lays down fertiliser types, max. concentration of risk elements in organic fertilisers, substrates and commercial fertilisers, storage and take-off conditions, and methods of fertiliser testing
UK	Each country of the United Kingdom has different requirements. Here is an example	• Use in agriculture and applications to soil other than land restoration**:** an environmental permit exemption, paragraph 7, must be obtained by the land owner/manager before accepting and storing then spreading compost. The compost must be made from source segregated biowaste. Per paragraph 7 exemption • ‘Benefit to agriculture’ or ‘ecological improvement’ must

	Regulation	Requirements or restriction for the use of compost
	of parts of the regulations applicable for England and Wales.	be demonstrated, which is done by spreading compost as per Nitrate Vulnerable Zone regulations if within a NVZ, and following the codes of good agricultural practice for the protection of soils and water. Given the typical total nitrogen content of 'Green compost', the application rate would be approximately: o 30–35 fresh tonnes/ha/y where a field NVZ limit of 250 kg total nitrogen per hectare applies; o 30 fresh tonnes/ha/y if 'Not NVZ' but as per good agricultural practice; o 60–70 fresh tonnes/ha/y once per two years if 'Not NVZ' but as per good agricultural practice
		• Voluntary code of good agricultural practice for the protection: limitation of nitrogen of 250 kg/ha/y (for all types of 'organic manure' used, including composts); compost can also be applied at a rate of 500 kg/ha once per two years.

Annex 2-7: Admissible maximum dosage of heavy metals to the soil in national legislation and standards (g/ha/y)
Source: ORBIT/ECN (2008)

Country		Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As	Se
		[g/ha/y]									
EC	**'Sewage sludge'** ([1]) 10-year basis	150	3.000	—	12.000	100	3.000	15.000	30.000	—	—
AT	Sewage sludge ([2]) Fertiliser Ord. Two-year basis	20 5	1.250 300	— —	1.250 350	20 5	250 200	1.000 300	5.000 1.500	— —	— —
BE	VLAREA (comp.) Yearly	12	500	—	750	10	100	600	1.800	300	—
CY	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
CZ	Sewage sludge Yearly *max. 5 tonnes dm/3y in agriculture*	5	200		500	4	100	200	2.500	30	
DE ([1])	Sewage sludge	16	1.500	—	1 300	13	300	1.500	4.100	—	—
DK	7 tonnes dm basis/calculated related to 30 kg P_2O_5/ha/calculated	5.6 3	700 —	—	7.000 —	5.6 6	210 75	840 300	28.000 —	— —	— —
EE	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
ES	Decr. 877/1991 (SS) 10-year basis	150	4.500		12.000	100	3.000	15.000	30.000	—	—
FI	Sewage sludge Goal for 1998	3 1.5	300		600	2 1	150 100	150	1.500	—	—
FR	NF U 44 51 (comp.) 10- years basis NF U 44 51 (comp.) Yearly	15 45	600 1.800		1.000 3.000	10 30	300 900	900 2.700	3.000 6.000	90 270	60 180
GR	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Country		Cd	Cr_{tot}	Cr^{VI}	Cu	Hg	Ni	Pb	Zn	As	Se
		[g/ha/y]									
HU	Sewage sludge (under No 50/2001)	150	10.000	—	10.000	100	2.000	10.000	30.000	500	1.000
IE	SI 148/1998 (use of sewage sludge in agriculture)	10	1 000	—	1 000	10	300	750	2 500	—	—
IT	DCI 27/07/84 — MWC from mixed waste	15	2.000	15	3.000	15	1.000	500	10.000	100	—
LT	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
LU	No regulation	—	—	—	—	—	—	—	—	—	—
LV	Sewage sludge	30	600		1.000	8	250	300	5.000		
MT	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
NL ([4])	No regulation	—	—	—	—	—	—	—	—	—	—
PL	Sewage sludge	20	1.000		1.600	10	200	1.000	5.000	—	—
PT ([1])	Sewage sludge 10-year basis	150	4.500		12.000	100	3.000	15.000	30.000	—	—
RO	No data available	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SE	SNFS 1992:2 (sewage sludge)	0.75	40		300	1.5	25	25	600	—	—
SI	No regulation	—	—	—	—	—	—	—	—	—	—
SK	No regulation	—	—	—	—	—	—	—	—	—	—
UK	Sludge (use in agriculture) Regulations ([3]) sewage sludge average annual loading over 10 years	150	?	—	7.500	100	3.000	15.000	15.000	—	—

([1]) Directive 86/276/EEC; average within 10 years.
([2]) Sew. Sludge Ordinance, Lower Austria (Class III).
([3]) S (UiA) Regulations: Statutory Instrument 1989 No 1263, The Sludge (Use in Agriculture) Regulations 1989. The QCP (England and Wales) sets maximum allowable concentrations for PTEs in soils that receive Quality Composts, as specified in the Sludge (Use in Agriculture) Code; these are more stringent than the soil PTE maximum allowable concentrations allowed in the regulations.
([4]) Nutrient loads (phosphate and nitrogen) are considered to be the dosage limiting factors.
(SS = sewage sludge).

Annex 2-8: Compost quality assurance schemes in EU Member States
Source: ORBIT/ECN (2008)

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
AT	Fully established quality assurance system based on Austrian Standards ÖNORM S2206 Part 1 and 2 and Technical Report ONR 192206 published by the Austrian ÖNORM Standardisation Institute. Up to now two non-profit associations have adopted these standards for granting a compliance certification with the QAS: • the Compost Quality Society of Austria KGVÖ (Kompostgüteverband Österreich); • the Compost & Biogas Association — Austria (ARGE Kompost & Biogas — Österreich). The certification schemes comprise both operational process and quality management and final product approval. Thereby the most important references are the requirements set by the Austrian Compost Ordinance which provides for a comprehensive documentation and monitoring programme. Compost can get product status if it meets one of the three classes based on precautionary requirements (Class A+ (top quality for organic farming), Class A 'Quality compost' (suitable for use in agriculture, horticulture, hobby gardening and Class B (minimum quality for 'compost' restricted use in non-agricultural areas).
	Under the roof of **Compost Quality Society of Austria (KGVÖ)** large-scale compost producers supplemented by experts, grant an additional quality seal for the marketing of high-quality composts on the basis of the officially acknowledged quality assurance system. External laboratories collect the samples and analyses. Evaluation of the results, documentation and granting of the label is carried out by an independent quality committee with expert members of the KGVÖ (16 members — 300 000 tonnes capacity). **Compost & Biogas Association Austria (ARGE** Kompost & Biogas) was founded to establish the decentralised composting of separately collected biowaste in cooperation with agriculture (on-farm composting). Nowadays the association has grown to a full-scale quality assurance organisation on the basis of the common Austrian standards. ARGE uses external auditors for sample taking, plant inspection, evaluation, documentation and certification of the plants. (370 members — 300 000 tonnes capacity).
BE	Fully established statutory quality assurance system for compost in the Flanders region operated by the non-profit **Flemish compost organisation VLACO vzw** with its members from municipalities, government and composting plants (around 40 green and biowaste plants with 840 000 tonnes capacity). Based on the Flemish Regulation on Waste Prevention and Management VLAREA act VLACO vzw show a very unique but effective integrated approach and a broad range of tasks. The organisation executes: (a) waste prevention and home-composting programmes; (b) consultation and advice for process management including co-composting and co-digestion; (c) sampling, organisation of the analysis and evaluation of the results;

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
	(d) organisation of field trials and development of application information; (e) marketing and public relations for organic waste recycling and, primarily, for the compost. So, by means of this integrated approach, the whole organic loop from source material to the use of the final product is in one hand. Nevertheless, some modifications have been made lately in order to include elements of ISO 9000 and Total Quality Management (TQM) of the quality assurance of anaerobic digestion residuals and of manure into the system. Not only is the end product controlled but the whole process is followed up. In TQM the input (the bio or green waste), the process and the output are monitored and analysed. The reason for standards on the input is that this prohibits dilution. Depending on source materials and product characteristics up to 15 different products can be certified (statutory) and labelled (voluntarily) by VLACO vzw.
CZ	Voluntary quality assurance scheme proposed by the regional **Environmental and Agricultural Agency ZERA** is in preparation for a quality assurance scheme for 2008 after new biowaste Ordinance is in force. Main task is to create a compost market by certifying compost products and organise a practical inspection and control of compost. The certification scheme is based on requirements of the Czech institute of accreditation in the agreement with international norm CSN EN ISO/IEC 45011:1998.
DE	Fully established voluntary quality assurance system for compost and anaerobic digestion residuals in which the **Compost Quality Assurance Organisation (Bundesgütegemeinschaft Kompost BGK)** organisation is the carrier of the RAL compost quality label. It is recognised by RAL, the German Institute for Quality Assurance and Certification, as being the organisation to handle monitoring and controlling of the quality of compost in Germany. The BGK was founded as a non-profit organisation in order to monitor the quality of compost. Through consistent quality control and support of the compost producers in the marketing and application sectors, the organisation promotes composting as a key element of modern recycling management. Four hundred and twenty-five composting and 67 digestion plants with 5.9 million tonnes capacity plants take part in the quality assurance system and have applied for the RAL quality label. Besides the central office, a quality committee works as the main supervision and expert body in the quality assurance system. In addition BGK runs a database with all indicators of the composting plants and analyses results of the products. Meanwhile it includes more than 35 000 data sets. The BGK has defined a general product criteria quality standard (the RAL quality label GZ 251 for fresh and mature compost as well as for compost for potting soil compost and for different types of digestion residuals RAL GZ 245 (new since 2007 RAL GZ 246 for digestion products residuals from treatment renewable resources (e.g. energy crops)) and established a nationwide system for external monitoring of plants and of compost and digestion products.

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
	The quality assurance system comprises the following elements: ▪ definition of suitable input in accordance with biowaste and fertiliser regulation; ▪ operation control by plant visits of independent quality managers; ▪ external and internal monitoring; ▪ quality criteria and quality label to demonstrate the product quality; ▪ compulsory declaration and information on correct application; ▪ documentation for the competent authorities. The successful work is respected by the authorities in Germany by exempting member plants from some control requirements which are subject to the waste legislation. By means of that procedure quality assured compost show a 'quasi-product' status in Germany.
DK	A quality assurance system for compost (quality criteria, standardised product definition, analysing methods) is prepared by **DAKOFA (Danish Association on waste management)** but is not applied. No further progress expected for the moment because separate collection of kitchen waste will not increase before the present legal background. Green waste collection and composting is very well diffused but not subject to any waste and quality standards regulation in Denmark.
ES	Draft statutory Spanish standard on compost legislation, laying down standardised, nationwide rules concerning the production, marketing and labelling of compost as a product prepared by the Ministry of Environment. A lot of studies confirmed the need for Spain to improve the compost quality in order to open up markets. This was in the outcome of a LIFE Project too deemed to investigate the production and use of quality compost in Andalusia. Based on the results the **Andalusia´s Regional Ministry of Environment** has designed and registered a trademark '*Environmental Accreditation of Compost'* that allows — on a voluntary basis — companies producing compost to show its quality**.** The Order 20.7.2007 Environmental Accreditation of Compost Quality. BOJA No 156 8.8.2007 explains how to get and use it .Compost should fulfil some limits according to the Real Decree 824/2005, 8.7.2005, about fertilisers. The Andalusia´s Regional Ministry of Environment will control the label use and define accredited laboratories to analyse compost samples. There is no independent sample taking.
HU	Voluntary Hungarian Compost Quality Assurance System is prepared (but not implemented) by the Hungarian Compost Association — waiting for the revision of the existing regulations which are intended for sewage sludge and fertilisers and are not applicable for composting. The **Hungarian Compost Association** completed in 2006 the framework of the assurance system (similar to the German BGK and Austrian KGVÖ examples) and is now waiting for the new Hungarian statutory rule about production, nominating, marketing and quality assurance for composts. Basic elements of the future Compost Quality Assurance Systems (implementation in 2009) are:

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
	(a) raw material list (permissive list); (b) compost classes: the ordinance will define three different quality classes for compost based on the contaminant content and will also define ways of utilisation; the classes (similar to the Austrian ones) will be: Class A — top quality (suitable for organic farming use) Class B — high quality (suitable for agricultural use) Class C — minimum quality (not suitable for agricultural use); (c) quality control, end product controlling and process controlling, independent sample taking and analysis is intended.
IE	A first draft for a voluntary compost quality standard was presented in Ireland (2007). This task and the follow up establishment of a quality assurance system are elements of the national Market Development Plan — intended to create market for recyclables — have recently started. The **Irish Composting Association CRE supports** is involved in these developments.
IT	Voluntary quality assurance operated by the **Italian Compost Association CIC,** the Italian National Association for the compost industry. It started as a certification system for compost products in order to show compliance with the national fertiliser regulation and the statutory quality standards for green and mixed compost are laid down there. No monitoring of the standard is proposed. Basically, the quality label ensures the fulfilment of statutory standards (assessment of compliance is usually an issue due to the rather poor performance of controlling authorities; hence CIC aims to reinforce the 'declaration of compliance'). Within the scheme samplings are made by certificated personnel from the Italian Composting Association (CIC) and analysed at a single accredited laboratory. Now the scheme is turning step-by-step into a quality assurance system e.g. the preparation of certifying the entire production process and, above all (as requested by consumers), the traceability of compost. The CIC quality label considers this to be a very important initiative for the industry because it provides an independent element of security upon which consumers and operators can make their choices. Currently, the quantities of compost that can be certified amount to approximately 250 000 tonnes/year, which represents approximately 20 % of the Italian production.
LU	Statutory system which relies on the German Quality Assurance System and on the German Organisation **(Bundesgütegemeinschaft Kompost e.V. BGK).** The request to execute a 'quality assurance system like the BGK system or similar' is part of the licensing procedure for every composting plant. Missing alternatives have established the BGK system in Luxembourg as the one and only. All independent sampling, control functions and documentation functions will be executed by the BGK representatives (five compost plants with around 50 000 tonnes/year total capacity are part of the scheme).
LV	At the starting stage (from November 2006), quality assurance organisation Environmental Agency.

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
NL	After 10 years of experience, the Dutch Government decided that not the quality but the nutrients are the primary precautionary problems with compost. Less strict heavy metal thresholds and no obligations for control in the future is one result. In addition, the applied amount of compost is no longer limited but the nutrient load instead. All compost which is used for crops which grow in the soil must be independently certified with a very strict threshold for glass. Because the sales area of compost is not predictable while the production, more or less all biowaste composts, will be certified in future and compost certification will become quasi-statutory. For vegetable, fruit and garden VFG waste the certification is operated by independent institutes/auditors with independent sample takers in cooperation with the Dutch Waste Management Association DWMA/VA. The around 20 VA members treat 1.5 million tonnes VFG waste from separate collection. This new scheme will replace the former costly KEUR certification system operated by the Dutch certification system KIWA. The BVOR Dutch Association of Compost Plants manages the certification system in both the green waste and VFG sectors which doesn't require external sampling but independent institutes/auditors for the evaluation of the process and the analysis results. Fifty green waste composting plants with 1.8 million tonnes of capacity are members of the BVOR.
PL	Quality Assurance refers only to the final product. The Ministry of Agriculture and Rural Development gives the certificate of organic fertiliser based on its chemical properties and pathogen status after the compost receives a positive expertise from the designated institution (depending on planned application area).
SE	A voluntary quality assurance system for compost and digestion products is operated by the **Swedish Waste Management Association Avfall Sverige** together with Swedish Standardisation Institute SP. For the moment, Sweden has no statutory standard but the necessity of standards is seen clearly by involved parties and the government. Producers and users are of the opinion that sustainable recycling of organic wastes demands clear regulations regarding as to what is suitable to be recycled and how it should be managed and controlled. A well-founded quality assurance programme definitely increases sustainable recycling of organic wastes. The regulations for the voluntary Swedish certification of compost and digestion residues are based on purely source-separated organic waste, with special emphasis on the acceptability of raw materials for input, the suppliers, the collection and transportation, the intake, treatment processes, and the end product, together with the declaration of the products and recommendations for use. Six digestion and one composting plant are included in the certification system and have applied for the certificate.
UK	Voluntary standard BSI PAS 100 and the supplementing Quality Compost

Country (Quality label)	Status of quality assurance activities and certification/quality assurance organisation
COMPOSTING ASSOCIATION CERTIFIED	Protocol (QCP) set criteria for the production and minimum quality of quality composts. The **UK Composting Association** owns a certification scheme aligned to BSI PAS 100, which has been upgraded to incorporate the additional requirements of the QCP. Composting plants and compost particle size grades that meet all the requirements can get their composts certified and use the Composting Association's quality mark. Around 150 composting producers are under assessment, treating more than 2 million tonnes of source segregated bio and green waste, and 40 % of the compost they produce is already certified. BSI PAS 100:2005 specifies the minimum requirements for the process of composting, the selection of materials from which compost is made, minimum compost quality, how compost is labelled and requires that it is traceable. It also requires Hazard Analysis and Critical Control Point assessment, the implementation of a compost quality management system and correct compost labelling and marking. Compliance with requirements of the QCP is considered sufficient to ensure that the recovered biowaste may be used without risk to the environment or harm to human health and therefore without the need for waste regulatory control. In addition, the Quality Compost Protocol requires compost certification to PAS 100 and also imposes restrictions on materials from which quality composts can be made and in which markets they can be used as 'product'. The QCP also requires the producer to supply customers with contracts of supply, and if quality compost is stored and used in agriculture or field horticulture, this must be done in accordance with the codes of good agricultural practice and that soil PTE concentrations do not exceed the Sludge Use in Agriculture Code's limits. The quality protocol further aims to provide increased market confidence in the quality of products made from biowaste and so encourage greater recovery of source-segregated biowaste. In England and Wales, compost must be independently certified compliant with both PAS 100 and the Quality Compost Protocol for it to be supplied to the designated market sectors as a 'product'. <u>In Scotland, for compost to be supplied as a 'product' it must be certified to PAS 100 (or an equivalent standard), have certainty of market, be used without further recovery, not be subjected to a disposal activity and not be mixed with other wastes, materials, composts, products or additives. Northern Ireland's position is currently similar to Scotland's.</u> Compost can be placed on the market as a recovered waste material in any of the countries of the United Kingdom; in this circumstance, waste management licensing regulation requirements must be adhered to. A number of local authorities have required PAS 100 certification in contracts with compost producers, and in England and Wales in particular, may start requiring certification to the Quality Compost Protocol as well.

Annex 2-9: Biodegradable wastes that are currently regarded as suitable for composting in one or more Member States

Country codes in […] indicate that the use of this waste as input material for composting is connected with certain restrictions for marketing and use or that specific quality requirements must be met. See also footnotes.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
1	Waste for biological treatment from exclusively vegetable origin (*NO animal by-products or meat*)				
1.1	Organic vegetable waste from garden & parks and other greens				
1.1.01	Mixtures from organic wastes according to 1.1	corresponds to VFG = vegetable, fruit & garden waste; source-separated	n.s.	n.s.	AT, BE, BG, CZ, DE, FR, HU, IE, IT ([42]), NL, PL, SE, UK
1.1.02	Grass cuttings, hay, leaves	Only slightly contaminated cuttings (not along highly frequented streets and highways)	20 02 01	Compostable waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LT, LU, LV, NL, PL, SE, SK, UK
1.1.03	Leaves	Only slightly contaminated (not along highly frequented streets and highways)	20 02 01	Compostable waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, LV, NL, PL, SE, SK, UK
1.1.04	Vegetable waste, flower waste, windfalls	Also cut flowers from florist markets and households	20 02 01 02 01 03	Compostable waste Waste from vegetable tissue	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, LV, NL, PL, SE, SK, UK
1.1.05	Bark	Only bark not treated with lindane	03 01 01 ([43]) 03 03 01	Bark and cork waste Waste from wood preparation and the production of cellulose, paper and cardboard	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LT,LU, NL, PL, SE, SK, UK
1.1.06	Wood, not specified	Only untreated wood	03 01 05	Sawdust, wood shavings, cuttings, wood, chipboard, veneer	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, [IT] ([44]), LT, PL, SE, SK,

([42]) As far as this waste corresponds to EWC code 20 02 01.
([43]) Waste from wood processing and the production of plates and furniture.
([44]) To be specifically approved for each plant.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
				with the exception of those which belongs to 03 01 04	UK
1.1.07	Wood, tree and bush cuttings	Complete or shredded	20 01 38 20 02 01	Wood with the exception of those which belong to 20 01 37 Biodegradable waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, [IT] ([45]), LT, LU, NL, PL, SE, SK, UK
1.1.08	Wood, from the processing of untreated wood	Only untreated wood	03 01 05	Sawdust, wood shavings, cuttings, wood, chipboard, veneer with the exception of those which belong to 03 01 04	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, [IT] ([45]), LT, LU, NL, PL, SE, SK, UK
1.1.09	Cemetery waste — source-separated		20 02 01	Biodegradable waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.2	Vegetable waste, from the preparation and consumption of food, luxury food & beverages				
1.2.01	Cereals, fruit & vegetables		20 02 01 02 01 03	Compostable waste Waste from vegetable tissue	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.2.02	Tea leaves, coffee grounds		20 02 01 02 01 03	Compostable waste Waste from vegetable tissue	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.2.03	Dough, yeast		20 02 01 02 01 03	Compostable waste Waste from vegetable tissue	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.2.04	Residues from spices and herbs		20 02 01 02 01 03	Compostable waste Waste from vegetable tissue	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK

([45]) To be specifically approved for each plant.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
1.2.05	Wooden oversize fraction from screening compost for reuse in composting		n.s.	n.s.	AT, BE, BG, CZ, DE, ES ([46]), FI, FR, HU, IE, IT, LU, NL, PL, SE, UK
1.2.06	Former foodstuff	Of vegetable origin only	02 01 03 02 03 04 ([47])	Waste from vegetable tissue Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, UK
1.2.07	Vegetable catering waste and used cooking oil	Of vegetable origin only (plant tissue) source-separated from central as well as household kitchens as well as catering services	02 01 03 02 03 04 ([48])	Waste from vegetable tissue Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, UK
1.3	Organic residues from commercial, agricultural and industrial production, processing and marketing of agricultural and forestry products — purely of vegetable origin				
1.3.01	Harvest residues, hay and silage		02 01 03 ([49])	Plant-tissue waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LT, LU, NL, PL, SE, SK, UK
1.3.02	Bark		02 01 03 ([49])	Plant-tissue waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.03	Grain/Cereal dust		02 01 03 ([49])	Plant-tissue waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.04	Straw		02 01 03 ([49])	Plant-tissue waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.05	Vines		02 03 04	Materials not suitable for consumption or	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL,

([46]) Not considered because it not appears in European waste list, but presumably it would not be of any problem to include it.
([47]) Waste from the preparation and processing of fruit, vegetables, grain, cooking oil, cacao, coffee, tea and tobacco, from canned food production, yeast production and preparation of molasses.
([48]) Waste from the preparation and processing of fruit, vegetables, grain, cooking oil, cacao, coffee, tea and tobacco, from canned food production, yeast production and preparation of molasses.
([49]) 02 01: Waste form agriculture, horticulture, fish farming, forestry, hunting and fishing.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
				processing	PL, SE, SK, UK
1.3.06	Tobacco waste		02 03 04	Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.07	Beet chips, tails		02 01 03 ([49]) 02 03 04	Plant-tissue waste Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.08	Residues from canned and deep freeze food processing		02 03 04	Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.09	Residues from fruit juice and jam production		02 03 04	Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.11	Residues from starch production		02 03 04	Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.12	Vinasse, molasses residues		02 03 04	Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.13	Feed and feed residues not fit for use	Of vegetable origin only	02 01 03 ([49])	Plant-tissue waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.14	Residues of tea and coffee production		02 03 04	Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LU, NL, PL, SE, SK, UK
1.3.15	Marc, seeds, shells, grist, press cake	e.g. from oil mills, spent barley, draff of hop, marc of medicinal plants, copra, only materials which have not been treated with organic extraction	02 03 01	Sludge from washing, cleaning, peeling, centrifuging and segregation processes	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LT, LU, NL, PL, SE, UK ([50])

([50]) Allowed in PAS 100 (BSI, 2005) but not yet in Quality Compost Protocol (Environment Agency, 2007).

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
		agents			
1.3.16	Crushed grain or process residues		02 03 01	Sludge from washing, cleaning, peeling, centrifuging and segregation processes	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, IT, LT, LU, NL, PL, SE, UK ([50])
1.3.17	Fruit, cereal and potato draff	From breweries and distilleries	02 03 01	Sludge from washing, cleaning, peeling, centrifuging and segregation processes	AT, BE, BG, CZ, DE, ES, FI, FR, IE, IT, LT, LU, NL, PL, SE, SK, UK ([50])
1.3.18	Filtration diatomite		n.s.	n.s.	AT, PL
1.3.19	Uncontaminated sludge or residues of press filters from separately collected process water of the food, beverage, tobacco and animal feed industry	From vegetable, fruit and plant tissue processing only		Sludge from washing, cleaning, peeling, centrifuging and segregation processes	AT, PL, UK ([50])
1.3.20	Eventually slightly polluted sludge from the food and fodder industry exclusively of vegetable origin		02 03 01 02 03 05	Sludge from washing, cleaning, peeling, centrifuging and segregation processes Sludge from company owned waste treatment	AT, BE, BG, CZ, DE, ES, HU, IE, IT, NL, PL, [SE], UK ([50])
1.3.21	Eventually slightly polluted pressfilter, extraction and oil seed residues from the food and fodder industry exclusively of vegetable origin		02 03 04	Materials not suitable for consumption or processing	AT, BE, BG, CZ, DE, ES, FR, HU, IE, IT, NL, PL, [SE], UK ([61])
1.3.22	Wastes from the production of alcoholic and non-alcoholic beverages (except		02 07 01	Wastes from washing, cleaning and mechanical reduction of raw materials	CZ, ES, PL, UK,

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
1.3.23	coffee, tea and cocoa'		02 07 02	Wastes from spirits distillation	CZ, ES, PL, UK
1.3.24			02 07 04	Materials unsuitable for consumption or processing	CZ, ES, PL, UK
1.3.25			02 07 99	Wastes not otherwise specified	UK
1.3.26	Spoilt seeds		02 01 03	Plant-tissue waste	AT, BE ([51]), BG, CZ, DE, ES, FI, FR, HU, IE?, IT, LU, NL, PL, SE, UK
1.3.27	Wood, tree and bush cuttings	Complete or shredded	20 01 38 20 02 01	Wood with the exception of those which belong to 20 01 37 Biodegradable waste	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, [IT] ([52]), LU, NL, SE, SK, UK
1.3.28	Wood, from the processing of untreated wood	Only untreated wood	03 01 05	Sawdust, wood shavings, cuttings, wood, chipboard, veneer with the exception of those which belong to 03 01 04	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, [IT] ([45]), LU, NL, PL, SE, SK, UK
1.3.29	Wood — sawdust	Only untreated wood	03 01 05	Sawdust, wood shavings, cuttings, wood, chipboard, veneer with the exception of those which belong to 03 01 04	AT, BE, BG, CZ, DE, ES, FI, FR, HU, IE, [IT] ([45]), LU, NL, PL, SE, SK, UK
1.4	Other Organic residues — purely of vegetable origin				
1.4.01	Sub-aqua plants; sea weed		02 01 03	Plant-tissue waste	AT, BE ([51]), BG, CZ, DE, ES, FI, FR, HU, IE?, IT, LT, LU, NL, PL, SE, UK

([51]) Approved on a case-by-case basis.
([52]) To be specifically approved for each plant.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
1.4.02	Micelles from antibiotics production (53)		16 03 06	Organic waste with the exception of those listed under 16 03 05	AT, BE (54), CZ, DE, NL, PL, SE,
1.4.03	Biodegradable packaging and bioplastics		07 02 13 15 01 02 15 01 05	Waste plastic Plastic packaging, Composite packaging	AT (55), BG, DE, ES, FI, FR, HU, IE, IT, LT, LU, NL, PL, SE, UK (56)
1.4.04	Wastes from packaging; absorbents, filter materials, wiping cloths and protective clothing		15 01 01 15 01 03	Paper and cardboard packaging, Wooden packaging	AT (57), CZ, UK (58)
1.4.05			15 01 09	Textile packaging	AT, UK (59)
1.4.06	Municipal Wastes (household waste and similar commercial, industrial and institutional waste) including separately collected fractions		20 01 01	Paper and cardboard	AT (57), CZ, UK (58)
1.4.07			20 01 99	Other fractions not otherwise specified	UK
1.4.08	Cooking oil and fats, grease trap residues of vegetable origin		02 03 04 20 01 25	Materials unsuitable for consumption or processing Edible oil and fat	AT, [BE] (60), CZ, DE, ES, FI, FR, HU, IE, IT, NL, PL, SE, UK (61)
1.4.09	Silage leachate water		02 01 99	Waste not further specified	AT, BE, FR, NL, PL, SE,
1.4.10	Waste from forestry		02 01 07	Waste from forestry	AT, CZ, LU, PL, UK

(53) Italy has commented that micelles from antibiotics production should not be comprised in the input waste streams suitable for compost production because their effects on composting process and soil properties could be negative.
(54) In accordance with the regulation on GMOs (genetically modified organisms).
(55) Non-bio-based source materials max. 5 %; conventional plastic polymers are excluded.
(56) Compostable packaging: allowed only if independently certified in compliance with one or more of the following:
- BS EN 13432 Packaging — requirements for packaging recoverable through composting and biodegradation;
- EN 13432 or EN 14995 in national standard form in any other EU Member State with independent compliance verification by a nationally recognised competent authority or certification body;
- German standard DIN V54900 Testing of the compostability of plastics;
- American standard ASTM D6400 Standard specifications for compostable plastics;
- any variation upon the standards referred to above for 'home compostable' packaging agreed between the regulator, WRAP, the Composting Association, the organisation is responsible for standards and the certification bodies associated with them'.

(57) Only paper which has been in contact with food and foodstuff (e.g. food packaging).
(58) Not allowed if any non-biodegradable coating or preserving substance is present.
(59) Allowed only if entirely natural fibres.
(60) Separately collected; in practice not destined for composting.
(61) If no chemical agents added and no toxin residues.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
1.4.11	Fibre rejects	Waste from pulp, paper and cardboard production and processing	03 03 10	Fibre rejects	ES, CZ, PL, UK,
1.4.12	Waste bark and wood	Waste from pulp, paper and cardboard production and processing	03 03 01	Waste bark and wood	ES, CZ, PL, UK
1.4.13	Organic matter from natural products	Wastes from the textile industry	04 02 10	Organic matter from natural products	CZ, ES, UK
1.4.14	Wood	Wastes from construction and demolition wastes	17 02 01	Wood	CZ, UK ([62])
1.4.15	Off-specification compost	Only if the compost is derived from input types allowed by this Quality Protocol, this category includes oversize material resulting from screening such compost.	19 05 03	Off-specification compost	CZ, UK
1.4.16	Liquor/leachate from a composting process	From vegetable waste treatment only	19 05 99	Liquor/leachate from a composting process	CZ, PL, UK
1.5	Digestion residues from anaerobic digestion of waste materials — pure vegetable origin				
1.5.01	Digestion residues from the anaerobic treatment of the waste classes 1.1 and 1.2		19 06 06	Digestion residues/sludge from the anaerobic treatment of animal and vegetable waste	AT, BE, BG, CZ, DE, ES ([63]), FI, FR, HU, IE, IT, LT, NL, PL, SE, UK
1.5.02	Liquor from anaerobic treatment of municipal waste		19 06 03	Liquor from anaerobic treatment of municipal waste	CZ, ES, UK
1.5.03	Liquor from		19 06 05	Liquor from	CZ, ES, PL, UK

([62]) Not allowed if any non-biodegradable coating or preserving substance is present.
([63]) Except for constraints reflected in Regulation (EC) No 1774/2002.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
	anaerobic treatment of vegetable waste			anaerobic treatment of animal and vegetable waste	
1.5.04	Sludge from cooking fat and oil production, solely vegetable origin	Also centrifugal sludge	02 03 04	Materials unsuitable for consumption or processing (?)	AT, CZ, PL, ES, UK
1.5.05	Glycerine phase	e.g. from rape seed and waste cooking oil esterification (rape seed oil methylester — RME, waste cooking fat methylester)	n.s.	n.s.	AT
1.5.06	Distillation residues from production of rape seed oil methyl ester		02 03 04	Materials unsuitable for consumption or processing (?)	AT, CZ, LV, PL, UK
2	Waste for biological treatment with parts of animal origin				
2.1	Animal waste, especially waste from the preparation of foodstuffs				
2.1.01	Kitchen and food waste from private households with animal residues	Catering waste from source-separated organic household waste	20 01 08	Biologically degradable catering waste (to be utilised only if compatible with the provisions of the Animal By-products Regulation)	AT, BE ([64]), CZ, DE, ES, FI, FR, HU, IE, IT, LT, LU, NL, PL ([65]), SE, UK ([66])
2.1.02	Kitchen and food waste from central kitchens and catering services with animal residues		20 01 08	Biologically degradable catering waste (to be utilised only if compatible with the provisions of the Animal By-products Regulation)	AT, BE ([64]), CZ, DE, ES, FI, FR, HU, IE, IT, LT, LU, NL, PL ([65]), SE, UK ([66])
2.1.03	Former foodstuffs		02 02 02	Animal tissue	AT, BE ([64]), DE,

([64]) Only with individual approval.
([65]) Organic fertilisers produced using animal wastes by composting or more preferentially biogas method can get approval but they have to be assessed by veterinary institute.
([66]) Only if composted in accordance with national rules at a facility registered by the animal health vets.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
	of animal origin		02 03 04	waste Materials unsuitable for consumption or processing	ES (?), FI, FR, HU, IE, IT ([67]), LU, LV, PL ([65]), SE, UK ([68])
2.1.04	Eggshells		02 02 02 02 03 04	Animal tissue waste Materials unsuitable for consumption or processing	AT, BE ([64]), DE, ES, FI, FR, HU, IT ([67]), LU, PL ([65]), SE, UK ([68])
2.2	Organic residues from commercial, agricultural and industrial production, processing and marketing of agricultural and forestry products — with parts of animal origin				
2.2.01	Sludge from the food and fodder industry with parts of animal origin		02 02 03	Materials unsuitable for consumption or processing (?)	AT, BE ([64]), BG, CZ ([67]), DE, ES ([63]), FR, HU, IT ([67]), NL, PL ([65]), SE, UK
2.2.02	Pressfilter, extraction and oil seed residues from the food and fodder industry with parts of animal origin		02 02 03	Materials unsuitable for consumption or processing (?)	AT, BE ([64]), CZ ([67]), DE, ES ([63]), FR, HU, IT ([67]), NL, SE, UK
2.2.03	Spoilt feeding stuff of animal origin from fodder producing industry		02 02 03	Materials unsuitable for consumption or processing (?)	AT, BE ([64]), BG, CZ ([67]), DE, ES (?), FR, HU, IT ([67]), NL, PL ([65]), SE, UK
2.2.04	Residues from horn, hoof, hair, wool, feathers		02 02 02	Animal tissue waste	AT, BE ([64]), DE, ES ([67]), FR, HU, IT ([67]), NL, PL ([65]), SE, UK
2.2.05	Sludge and pressfilter residues from slaughter houses and fattening industries		02 02 02	Animal tissue waste	AT, BE ([64]), DE, ES ([67]), FR, HU, IT ([67]), PL ([65]), SE, UK ([50])
2.2.06	Paunch waste	Belongs to ABPR Category 2 Material	02 02 02	Animal tissue waste	AT, BE ([64]), DE, ES ([67]), FR, IE, IT ([67]), NL, PL ([65]), SE, UK

([67]) If approved by the veterinary service, according to Animal By-productions Regulation (EC) No 1774/2002.
([68]) Only if composted in accordance with 'national rules' requirements at a facility registered by the animal health vets.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
2.2.07	Solid and liquid manure	Belongs to ABPR Category 2 Material	02 01 06	Animal faeces, urine and manure	AT, BE ([64]), BG, CZ ([67]), DE, ES (?), FI, FR, HU, IE, IT ([67]), LU, LV, PL ([65]), SE, UK ([69])
2.2.08	Gelatine waste		02 02 03 02 02 09	Material unsuitable for consumption or processing Waste not otherwise specified	AT, BE ([64]), BG, CZ ([67]), DE, ES ([67]), FR, IT ([67]), PL ([65]), SE, UK
2.2.09	Wastes from aerobic treatment of solid wastes	Only allowed if compost was derived from input materials specified in this list	19 05 03	Off-specification compost	CZ ([67]), UK ([69])
2.2.10	Wastes from aerobic treatment of solid wastes	Liquor/leachate from compost processing	19 05 99	Wastes not otherwise specified	UK ([70])
2.3	Digestion residues from anaerobic treatment of waste materials which may contain parts of animal origin				
2.3.01	Digestion residue of anaerobic digestion of materials of waste Group 2 rendered fat and cooking oil of animal origin		19 06 06	Digestion residues/sludge from the anaerobic treatment of animal and vegetable waste	AT, BE[64], BG, CZ[67], DE, ES[67], FI, FR, HU, IT[67], PL[65], SE, UK
2.3.02	Digestion residue of anaerobic digestion of dairy residues	e.g. whey, cheese residues and dairy sludge	19 06 06	Digestion residues/sludge from the anaerobic treatment of animal and vegetable waste	AT, BE ([64]), BG, CZ ([67]), DE, ES ([67]), FI, FR, HU, IE, PL ([65]), SE, UK
2.3.03	Digestion residue of anaerobic digestion of raw milk	Material according to Article 6(1)(g) of Regulation (EC) No 1774/2002	19 06 06	Digestion residues/sludge from the anaerobic treatment of animal and	AT, BE ([64]), BG, CZ ([67]), DE, ES ([67]), FI, FR, HU, IE, PL ([65]), SE, UK

([69]) Slurry and used animal bedding of the following types are allowed; straw; shredded paper; paper pulp; sawdust; wood shavings and chipped wood.

([70]) Liquor/leachate from a process operated according to 'PAS 100 only' or 'PAS 100 and Quality Compost Protocol' requirements (includes restrictions in input material types and sources).

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
				vegetable waste	
2.3.04	Digestion residue of anaerobic digestion of slaughter house waste and by-products		19 06 06	Digestion residues/sludge from the anaerobic treatment of animal and vegetable waste	AT, BE ([64]), CZ ([67]), DE, ES ([67]), FR, HU, PL ([65]), SE, UK
2.3.05	Digestion residue of anaerobic digestion of skins, hides and furs		19 06 06	Digestion residues/sludge from the anaerobic treatment of animal and vegetable waste	AT, BE ([64]), CZ ([67]), DE, ES ([67]), HU, PL ([65]), SE, UK
2.3.06	Wastes from anaerobic treatment of wastes	Only allowed if compost was derived from input materials specified in this list	19 06 03	Liquor from anaerobic treatment of municipal waste	ES ([67]), UK
2.3.07	Wastes from anaerobic treatment of wastes		19 06 05	Liquor from anaerobic treatment of animal and vegetable waste	CZ ([67]), ES ([67]), UK
2.3.08	Wastes from the preparation and processing of meat, fish and other foods of animal origin		02 02 02	Animal tissue waste	ES ([67]), PL ([65]), UK[71]
2.3.09	Wastes from the preparation and processing of meat, fish and other foods of animal origin		02 02 03	Material unsuitable for consumption or processing	CZ ([67]), ES ([67]), PL ([65]), UK ([72])
2.3.10	Wastes from the preparation and processing of meat, fish and other foods of animal origin		02 02 09	Wastes not otherwise specified	UK ([73])

([71]) EWC code 02 02 02 may include animal blood.
([72]) May include gut contents, shells and shellfish wastes.
([73]) Allowed only if animal manure, slurry or bedding of types which are listed in the UK quality protocol.

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
2.3.11	Wastes from the dairy products industry		02 05 01	Materials unsuitable for consumption or processing	CZ ([67]), ES ([67]), PL ([65]), UK ([74])
2.3.12	Wastes from the baking and confectionery industry		02 06 01	Materials unsuitable for consumption or processing	CZ ([67]), UK ([75])
3	Further waste for biological treatment with (these wastes might need additional approval of origin and involved processes)				
3.01	Municipal sewage sludge	Sludge which is used for compost production must be acknowledged for the direct use in agriculture	19 08 05	Sludge from treatment of urban waste water	[AT], BG, CZ, ES ([63]), FI, FR, HU, IE, IT ([76]), LT, LU ([77]), LV, SK, PL, [SE] ([78]), [UK] ([79])
3.02	Wastes from the leather and fur industry'		04 01 01	Fleshings and lime split wastes [leather shavings]	CZ, ES, UK
3.03	Municipal solid waste — not source-separated				[AT] ([80]), BG, ES, FR, HU, [IE] ([81]), LT, PL, [SE] ([78]),
4	Additives for composting (added in minor quantities (10–15 % maximum) in order to improve the composting process, humification and maturation)				
4.01	Rock dust		01 03 08 01 04 09	Dusty and powdery waste except those belonging to 01 03 07 Waste from sand and clay	AT ([82]), HU, NL, PL ([65]), SE?
4.02	Lime stone dust		02 04 02	Calcium carbonate sludge not according to specification	AT ([82]), BG, DE, FI, FR, HU, LV, NL, SK, PL ([65]), SE,
4.03	Bentonite		—	—	AT ([82]), DE, HU, PL ([65]), SE?,

([74]) May include raw milk.
([75]) May consist of, or include former foodstuffs (Category 3 animal by-products).
([76]) Sewage sludge is allowed if it complies with Italian enforcement of the European Directive 86/278/EEC.
([77]) Only sewage sludge not mixed with kitchen waste.
([78]) Not allowed within the QAS Certification scheme of SPRC 152 (compost) and SPCE 120 (digestate); otherwise this might be used.
([79]) BSI PAS 100, but only if HACCP assessment indicates acceptable risk and compost sample test results show sufficient quality → not allowed under CQP.
([80]) Compost from mixed MSW is restricted to the use in reclamation of landfill sites and may only be delivered directly to the landfill.
([81]) Not for quality compost. There are dedicated facilities which process mixed waste which is used in landfills.
([82]) Sum of all mineral additives for the process optimisation max 10 % (m/m); dredged soil: max 15 % (m/m).

	Type of waste material	Further specifications	EWC Code	Corresponding EWC waste type	Input materials accepted by Member State
4.04	Ash from combustion of plant tissue (e.g. wood, straw)		10 01 01	Bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)	AT ([83]), BG, DE, FI, HU, PL ([65]), SE?,
4.05	Excavated soil	Not contaminated	17 05 04	Soil and stones other than those mentioned in 17 05 03	AT ([82]) ([83]), HU, SK PL ([65]), SE?, UK ([84])
4.06	Washing soil from sugar beet and potato processing		02 04 01	Soil from cleaning and washing beet	AT ([82]) ([83]), CZ, DE, PL ([65]), UK ([50])

(n.s. — not specified)

([83]) Limit values for heavy metals must be respected.
([84]) Allowed only if Hazard Analysis and Critical Control Point (HACCP) assessment determines that adequate pollutant risk control is feasible.

Annex 2-10: Temperature-time profiles required during the composting process in existing regulations and standards

	Indirect TIME-TEMPERATURE Regime °C	% H_2O	particle size mm	time
ABP *(Regulation (EC) No 1774/2002)*	70		12	1 h
AT *Statutory 'Guideline — State of the Art of Composting'*	55–65			10 d
	Flexible time/temperature regimes are described at min. 55 °C, 1–5 turnings during 10–14 days thermophilic process			
BE *VLACO*	60			4 d
	55			12 d
CZ *Biowaste Ordinance*	55 65			21 d 5 d
DE *Biowaste Ordinance*	55	40		14 d
	60 ([1])	40		7 d
	65 ([2])	40		7 d
DK	55			14 d
FR	60			4 d
IE *Green waste*	—	—	—	—
Catering waste	60		400	2 x 2 d
Category 3 ABP	70		12	1 h
IT *Fertilisation Law*	55			3 d
NL *BRL K256/02*	55			4 d
UK *PAS 100, voluntary standard*	65	50		7 d ([4])
	min. 2 turnings			

Annex 2-11: Product property parameters that need to be declared when placing compost on the market

Usefulness concerning soil improving function:

- organic matter content
- alkaline effective matter (CaO content).

Usefulness concerning fertilising function:

- nutrient content (N, P, K, Mg)
- mineralisable nitrogen content (NH_4-N, NO_3-N).

Biological properties:

- stability/maturity
- plant response
- contents of germinatable seeds and plant propagules.

General material properties:

- water or dry matter content
- bulk density/volume weight
- grain size
- pH
- electrical conductivity (salinity).

Hygienic aspects relevant for environmental and health protection:

- presence of salmonellae
- presence of E. Coli.

Pollutants and impurities relevant for environmental and health protection:

- contents of macroscopic impurities (such as glass, metals, plastics)
- contents of Pb, Cd, Cr, Cu, Ni, Hg, Zn.

Annex 2-12: Parameters and limit values of product quality requirements

(a) Minimum organic matter content

The minimum organic matter content of the final product, after the composting phase and prior to any mixing with other materials shall be 20 % ([85]) (this is intended to prevent dilution of compost with mineral components such as sand or soil).

(b) Minimum stability

[Propose a requirement?]

(c) Effective sanitation

Absence of pathogen indicator organism: no S*almonella* sp. in 50 g sample.
Viable seeds and plant propagules: maximum 2/litre.

(d) Limitation of macroscopic impurities

Total impurities (plastics, metals and glass) > 2 mm shall be < 0.5 % (dry matter).

(e) Limitation of potentially toxic elements (heavy metals)

In the final product, just after the composting phase and prior to any mixing with other materials, the content of the following elements shall be lower than the values shown below, measured in terms of dry weight:

Element	mg/kg (dry weight)	*Times the limit in the EU eco-label criteria for soil improvers and growing media (Decisions 2007/64/EC and 2006/799/EC)*
Zn	400	*4/3*
Cu	100	*1*
Ni	50	*1*
Cd	1.5	*3/2*
Pb	120	*6/5*
Hg	1	*1*
Cr	100	*1*

The limits apply to the compost just after the composting phase and prior to any mixing with other materials.

<u>Rationale for the limit values:</u>

There a number of factors to be considered for finding the most suitable limit values. Some factors are best addressed by very low (i.e. strict) limits; for others there are reasons for not being too strict. Therefore, a solution is needed that best reconciles the different demands in an acceptable way.

([85]) The ECN recommends the limit to be set at 15 %.

On the one hand, strict limits are needed to meet the following demands:

- there should be no overall adverse environmental or human health impact from the use of end-of-waste compost;
- environmental impacts in the case of misuse of compost should be within acceptable limits;
- the limits should promote the production of higher compost qualities and prevent a relaxation of quality targets (end-of-waste criteria should not lead to higher contamination levels of composts than today);
- the limits should be an effective barrier to diluting more contaminated wastes with compost;
- the limits should exclude compost from end-of-waste if it cannot be used in a dominant part of the market because it does not meet the existing standards and legislation on use.

On the other hand:

- the benefits of compost use should not be sacrificed because of disproportionate risk aversion;
- limits should not be so strict that they disrupt current best practice of compost production from the biodegradable fractions of municipal solid waste;
- composting as a recycling route for biodegradable wastes should not be blocked by demanding unrealistic and unnecessarily strict limits.

Well-balanced limit values can be found by the following considerations.

1. The limits in the EU eco-label criteria for soil improvers and growing media are the lower boundaries of what can reasonably be demanded as limits.

The Community eco-label criteria for soil improvers and growing media include limits for hazardous substances. The eco-label criteria were decided by the European Commission in accordance with the corresponding Committee of Member State representatives. They introduced harmonised limit values at Community level ([86]).

These limits apply to the growing media constituents in the case of growing media and to the final product in the case of soil improvers. The explicit aim of these eco-label criteria is to promote 'the use of renewable materials and/or recycling of organic matter derived from the collection and/or processing of waste material and therefore contributing to a minimisation of solid waste at the final disposal (e.g. at landfill)'. For soil improvers, the criteria aim at promoting 'the reduction of environmental damage or risks from heavy metals and other hazardous compounds due to application of the product.' In the case of growing media, the eco-label criteria 'are set at levels that promote the labelling of growing media that have a lower environmental impact during the whole life cycle of the product.'

The eco-labels were established with compost in mind as the prime organic constituent of the eligible growing media and soil improvers and it is apparent that the eco-label criteria have

([86]) Note that the eco-label limit values are valid unless national legislation is stricter. Correspondingly, this paper argues that limits in rules on certain compost uses may be stricter than end-of-waste criteria if justified.

the same aim as the end-of-waste criteria: to promote the recycling of organic waste while reducing environmental impacts throughout the life cycle and avoiding environmental damage or risks when using the product on land.

The study by ORBIT/ECN (2008) shows that when composts comply with the eco-label limits even continued yearly applications of compost on land would not lead to any unacceptable accumulation of metals in soil within 100 years. This underlines that the eco-label criteria are sufficiently strict to protect the environment.

It also needs to be considered that it would make European legislation inconsistent if end-of-waste limits were stricter than the eco-label limits. This would lead to paradoxical cases where composts labelled as soil improver with the EU flower label could not cease to be waste.

It can be concluded that the eco-label criteria are sufficiently strict also as end-of-waste criteria.

2. The eco-label limits would exclude a considerable part of current and potential compost production from the source segregated biodegradable fractions of household, garden and park waste.

End-of-waste criteria should not disrupt the successful existing national approaches to composting. Limits for hazardous substances should be oriented at the compost qualities that have proven feasible (i.e. can be reliably produced) in the existing best practice compost systems. Best practice currently includes compost production with reliable quality assurance systems and the use of source-segregated biodegradable wastes as input materials.

A study for UBA (Reinhold, 2008) made a statistical evaluation of the compost quality achieved by composting plants that participate in the German quality assurance and certification scheme (which allows the use of source-segregated input materials only). From the study it can be shown that with current testing practice about 60 of 367 composting plants would not be able to warrant compliance with limits for Zn. For each Pb and Cd there are 36 plants that would not be able to guarantee compliance, and for Cu 18 ([87]). For Ni, Hg and Cr almost all plants would comply. See also Table 7.

([87]) It should be noted that by increasing the precision of the testing (more samples) further plants would be in a position to demonstrate compliance. This would come, however, at higher testing costs.

Table 7: Possibility to guarantee compliance with individual limit vales of German composting plants participating in the German compost quality assurance scheme.
Source: Reinhold (2004) Anlage 5.

Element	Eco-label limits (g/kg (dry weight))	Percentage of 367 composting plants that can warrant concentrations below the limit at a 95 % level of confidence
Cu	100	95.2
Zn	300	83.5
Pb	100	90.2
Cd	1	90.2
Ni	50	98.2
Hg	1	99.7
Cr	100	100

The study by ORBIT/ECN shows that other countries with advanced source separation and composting systems (Belgium (Flanders), the Netherlands, Austria) show a very similar level and distribution of heavy metals in both biowaste compost and green waste compost as Germany. In Italy and the United Kingdom, concentrations of metals in composts from biowaste and green waste compost are comparatively higher (approximately by a factor of two for most of the metals in the case of Italy, and for Pb in biowaste compost in the case of United Kingdom).

For compost producers in 'newcomer' countries it is expected to be very hard to meet limits with the ambitious eco-label criteria in the early phase of setting up suitable waste collection systems. A certain relaxation of the most critical limits (Zn, Pb, Cd) would open the door to newcomers by allowing them to have a more realistic perspective of being able to meet end-of-waste criteria. One also has to keep in mind that the eco-label is a voluntary instrument that is intended to be selective. Article 4-2(c) of the Eco-label Regulation ([88]) sets out that 'the selectivity of the criteria shall be determined with a view to achieving the maximum potential for environmental improvement.' End-of-waste criteria also aim at an environmental improvement, but not necessarily for a maximum potential because also other aspects of waste management, such as economic cost need to be taken into account.

There are, therefore, good reasons for end-of-waste criteria to include higher limits for the most critical elements than the EU eco-label criteria.

3. It is possible to meet the conditions of end-of-waste criteria even if the critical metal concentration limits are increased to a certain extent compared to the eco-label criteria

ORBIT/ECN (2008) estimates that even with metal concentrations corresponding to the limits of the relatively tolerant French NFU 44051 standard and continued yearly compost applications to soil, critical soil threshold values of the German Soil Protection Ordinance

([88]) Regulation (EC) No 1980/2000 of the European Parliament and of the Council of 17 July 2000 on a revised Community eco-label award scheme (OJ L 237, 21.9.2000, p. 1).

would not be exceeded within more than 50 years in the case of Zn and more than 100 years in the cases of Pb and Cd. The limits of that standard at least triple the eco-label limits for Zn, Pb, and Cd. Also misuse by applying to soil higher amounts than phosphate limited application rates are unlikely to lead to critical impacts unless extremely high amounts or repeated over prolonged periods (several years).

However, applying the limits of the NFU 44051 standard would relax the quality targets that are currently used in most places where compost is being produced in significant amounts. Furthermore, agricultural use, as main outlet for compost, would not be allowed by current use rules in most of the main compost using countries.

Table 8 shows that end-of-waste limits would still be within the use limit in all but two of the main compost using countries if they are were derived from the eco-label limits increased by a factor of 3/2 for Cd, 6/5 for Pb, and 4/3 for Zn.

Table 8: Limits for use of compost in agriculture compared to EU eco-label limits, all values g/kg (dry weight).

	Cd	**Pb**	**Zn**
AT	1	120	500
BE	1.5	120	300
NL	1	100	290
DE	1.5	150	400
IT	1.5	140	500
ES (Class B, without limitation of use)	2	150	500
FR (NFU 44051)	3	180	600
UK (PAS 100 ([89]))	1.5	200	400
EU eco-label	*1*	*100*	*300*
Times the eco-label value that complies with the use limit in all but two of the countries	***3/2***	***6/5***	***4/3***

Such an increase would allow best practice compost production in these countries to be sustained better as more composting plants would be able to meet the limits. Furthermore the values are still ambitious but more realistic to achieve for compost producers in ‘newcomer’ countries.

For the other elements (Cu, Ni, Hg, Cr) an increase compared to the eco-label limits is not needed because most composting plants following best practice are able to meet the eco-label limits.

([89]) Compliance not formally a requirement for use, but de facto the dominant standard.

Annex 2-13: Sampling and testing methods

Until horizontal standards elaborated under the guidance of CEN Task Force 151 become available, testing and sampling shall be carried out in accordance with test methods developed by Technical committee CEN 223 ‘Soil improvers and growing media’ ([90]).

Other test methods may be used if their equivalence is accepted by National Member states. For instance, if other consolidated and approved test methods for soil improvers and fertilisers are used in Member States or third countries, they may substitute some of those set by CEN. Where required testing is not covered by CEN standards or CEN standards in progress of approval, other test methods are pointed out in the annex. These methods are indicative by nature and, as stated above, may be substituted by other methods in use.

Analysis should be carried out by reliable laboratories that are preferably accredited for the performance of the required tests in an acknowledged quality assurance scheme.

Terms and definitions

The glossary is intended to be useful for a uniform comprehension and in order to keep univocal interpretation on test methods.

‘Alkaline effective matter’: calcium and magnesium in basifying form (e.g. as oxide, hydroxide and carbonate).

‘Bulk density’: ratio of the dry mass and volume of the sample in grams per litre measured under standard suction conditions (suction pressure: 10 cm); it is sometimes referred to as ‘apparent density’.

‘Dry matter’: the portion of substance that is not comprised of water. The dry matter content (%) is equal to 100 % minus the moisture content %.

‘Electrical conductivity’: measure of a solution’s capacity to carry an electrical current; it varies both with the number and type of ions contained in the solution; it is an indirect measure of salinity.

‘Heavy metals’: elements whose specific gravity is approximately 5 or higher. They include lead, copper, cadmium, zinc, mercury, nickel, chromium.

‘Impurities’: physical impurities are defined as all non-biodegradable materials (glass, metals, plastics) with a size > 2 mm.

‘Maturity’: maturity (see also ‘stability’) can be defined as the point at which the end product is stable and the process of rapid degradation is finished, or, a biodegraded product that can be used in horticultural situations without any adverse effects. The term maturity can also be interpreted in a wide sense, and also includes the term stability. An attempt to define maturity could be that it is a measure of the compost’s readiness for use that is related to the composting process. This readiness depends upon several factors, e.g. high

([90]) Contact: http://www.cenorm.be/cenorm/index.htm degree of decomposition, low levels of phototoxic compounds like ammonia and volatile organic acids.

‘Moisture content’: the liquid fraction (%) that evaporates at 103 ± 2 °C (EN 13040).

‘Organic matter’ (OM): the carbon fraction of a sample of compost which is free from water and inorganic substances, clarified in EN 12829 (Horizontal WI CSS99023) as ‘loss on ignition’ at 550 ± 10 °C.

‘Plant response’: (Pre-normative Work item of CEN/TC 223 for soil improvers and growing media).

‘Stability/stabilisation’: refers to a stage in the decomposition of organic matter during composting. The stability is measured as residual biological activity like the oxygen uptake rate (Pre-normative Work item of CEN/TC 223 for soil improvers and growing media), Self-heating test (DIN V 11539; Pre-normative work item of CEN/TC 223 for compost). Material that is not stable, but still putrescent, gives rise to nuisance odours and may contain organic phytotoxins.

‘Test methods’: analytical methods approved by Member States, institutions, standardising bodies (CEN, UNI, DIN, BSI, AFNOR, OENORM, etc.) or by reliable manufacturers’ associations (BGK in Germany, TCA in the United Kingdom, etc.).

‘Weed seeds’: all viable seeds (and propagules) of undesired plant species found in end products.

Testing parameters	Methods (e.g. EN etc.)	Short description	EU-Project HORIZONTAL Draft Standards BT/TF 151
General material properties			
pH value	EN 13037	A sample is extracted with water at 22 ± 3.0 °C in an extraction ratio of 1 + 5 (V/V). The pH of the suspension is measured using a pH meter.	WI CSS99017 Extraction with $CaCl_2$
Electrical conductivity	EN 13038	A sample is extracted with water at 22 ± 3.0 °C in an extraction ratio of 1 + 5 (V/V). The specific electrical conductivity of the extract is measured and the result is adjusted to a measurement temperature of 25 °C.	WI CSS99037
Water content	EN 13040	Dry the sample (50 g) at 103 ± °C in an oven and cool in a desiccator.	WI CSS99022
Dry matter content	EN 13040	Dry the sample (50 g) at 103 ± 2 °C in an oven and cool in a desiccator.	WI CSS99022
Organic matter content (Loss on ignition)	EN 13039/ EN 12829	The test portion is dried at 103 °C, than ashed at 450/550 °C. The residue on ignition (loss on ignition) is a functional dimension for the organic matter content in composts.	WI CSS99023 Determination at 550 °C
Alkaline effective matter (CaO content)	BGK 2006 ([91]) BGBl 1992 ([92]) Teil 1 S. 912 VDLUFA , 1995 ([93])	The method is based on the determination of basifying substances in fertilisers and sludges. The method is applicable on treated biowaste like compost containing calcium and magnesium in basifying form (e.g. as oxide, hydroxide and carbonate). The substance shall be rendered soluble with acid and the excess of acid back-titrated. The basifying substances shall be specified as % CaO.	No

([91]) BGK, 2006:Methodenbuch zur Analyse organischer Düngmittel, Bodenverbesserungsmittel und Kultursubstrate, ISBN 3-939790-00-1.
([92]) Federal Law Gazette BGBl I, p. 912, 1992: Sewage Sludge Ordinance (AbfklärV).
([93]) VDLUFA, 1995: Methodenbuch Band II. Die Untersuchung von Düngemitteln, Kap. 6.3 Bestimmung der Basisch wirksamen Bestandteile in Kalkdüngemitteln, 4. Auflage, VDLUFA-Verlag.Darmstadt.

Testing parameters	Methods (e.g. EN etc.)	Short description	EU-Project HORIZONTAL Draft Standards BT/TF 151
Particle size distribution	EN 15428	The standard describes a method to determine the particle size distribution in growing media and soil improver by sieving (Sieve size: 31.5 mm, 16 mm, 8 mm, 4 mm, 2 mm, 1 mm).	No
Nutrients			
N (total) (Kjeldahl N)	EN 13654-1	The moisture sample is extracted with a sulphuric acid, is distilled in boric acid. To titrate the ammonia with sulphuric acid 0.1 N.	WI CSS99021
P (total)	EN 13650	The sample is finely ground and extracted with a hydrochloric/nitric acid mixture by standing for 12 hours at room temperature, followed by boiling under reflux for two hours, the extract is clarified and extracted element determined by ICP.	WI CSS99025B
K (total)	EN 13650	Idem	WI CSS99025B
Mg (total)	EN 13650	Idem	WI CSS99025B
$N0_3$-N (dissolved)	EN 13651	The moisture sample is extracted with 0.0125 $CaCl_2$, ration 1:10. The extract is clarified and analysed by spectrophotometric method.	WI CSS99019 Extraction with 1mol/l potassium chloride, ratio 1:20
NH_4-N (dissolved)	EN 13651 DIN 38405 E5	The moisture sample is extracted with 0.0125 $CaCl_2$, ration 1:10. The extract is clarified and analysed by spectrophotometric method.	WI CSS99019 Extraction with 1mol/l potassium chloride, ratio 1:20

Testing parameters	Methods (e.g. EN etc.)	Short description	EU-Project HORIZONTAL Draft Standards BT/TF 151
Biological parameters			
Stability	CEN/TC 223 prWI Aerobic Biological Activity	This parameter refers to a stage in the decomposition of organic matter during composting. The stability is measured as residual biological activity like the Oxygen uptake rate (Pre-normative Work item of CEN/TC 223 for soil improvers and growing media), Self-heating test (DIN V 11539; Pre-normative work item of CEN/TC 223 for compost). Material that is not stable, but still putrescent, gives rise to nuisance odours and may contain organic phytotoxins.	No
	Part I Oxygen uptake rate	This pre-standard describes a method for determination of the determination of aerobic biological activity by measuring the oxygen uptake rate (OUR). The method may be applied to growing media and growing media constituents. The oxygen uptake rate is an indicator of the extent to which biodegradable organic substance has been broken down.	No
	Part II Self-heating	This pre-standard describes a method for determination of the degree of decomposition in a self-heating test. The method is applicable to biodegradable materials and composts. The degree of decomposition of the test materials is an indicator of the extent to which highly biodegradable organic substances has been broken down. It is used to distinguish between compost types (fresh, mature and substrate compost).	No

Testing parameters	Methods (e.g. EN etc.)	Short description	EU-Project HORIZONTAL Draft Standards BT/TF 151
Viable seeds and reproductive parts of plants		This standard specifies a test procedure for the assessment of contamination by viable plant seeds and propagules on soil, treated biowaste and sludge. Test sample material is filled into seed trays. The trays are kept at temperature suitable for plant germination for 21 days. The germinated plants have to be counted.	WI CSS99048
Plant response	CEN/TC 223 prWI plant response	This pre-standard specifies procedure to test the plant response on the following materials used as growing media, growing media constituents or soil improvers: compost, peat, wood fibres, rice hulls, coir, cocoa hulls, clay, clay minerals, expanded clay, pearlite, vermiculite, rock wool, sand, pumice, lava, bark and readily mixed growing media. To test the plant response directly using the test material, the test sample is filled into plant containers. Seeds of the respective species are evenly distributed on the surface of the test material. For Chinese cabbage, 15 seeds, for barley, 20 seeds per container have to be used. Then the plots are kept at a temperature suitable for plant germination. The plant response of the material can be evaluated by the germination rate and growth of the plants.	No

Testing parameters	Methods (e.g. EN etc.)	Short description	EU-Project HORIZONTAL Draft Standards BT/TF 151
Physical contaminants			
Impurities	BGK 2006 ([91])	Determination of impurities and stones. This standard describes a method to determine the physical impurities > 2 mm and stones > 5 mm in soils, sludges and treated biowastes. The test material is dry sieved and the fractions of stones > 5 mm and differentiated impurities > 2 mm are determined by weight or, for plastics, by weight and area.	WI CSS99049
Chemical contaminants — Heavy metals			
Pb	EN 13650	The dried sample is finely ground and extracted with a hydrochloric/nitric acid mixture by standing for 12 hours at room temperature, followed by boiling under reflux for two hours, the extract is clarified and extracted element determined by ICP.	WI CSS99025B
Cd	EN 13650	Idem	WI CSS99025B
Cr	EN 13650	Idem	WI CSS99025B
Cu	EN 13650	Idem	WI CSS99025B
Ni	EN 13650	Idem	WI CSS99025B
Hg	EN 13650	Idem	WI CSS99025B
Zn	EN 13650	Idem	WI CSS99025B
Hygienic aspects			
Salmonellae	CEN/TC 308 WI (prEN 15215-1, prEN 15215-2, prEN 15215-3)	The *Salmonella* procedure in sludges, soils and treated biowastes comprises three methods (prEN 15215-1, prEN 15215-2, prEN 15215-3). The absence of salmonellae in treated biowaste is an indicator that the process requirements in respect to hygienic aspects are fulfilled and that the material is sanitised.	Still under validation, deadline for validation phase 30.11.2007

Testing parameters	Methods (e.g. EN etc.)	Short description	EU-Project HORIZONTAL Draft Standards BT/TF 151
Sampling			
Sampling	EN 12079	Soil Improver and growing media — sampling	This has been elaborated by CEN TC 223
Framework on sampling		Framework for the preparation and application of a sampling plan: this standard specifies the procedural steps to be taken in the preparation and application of the sampling plan. The sampling plan describes the method of collection of the laboratory sample necessary for meeting the objective of the testing programme.	CSS99031
Selection and application of criteria for sampling		Sampling Part 1: Guidance on selection and application of criteria for sampling under various conditions	CSS99058
Sampling techniques		Sampling Part 2: Guidance on sampling techniques	CSS99057
Sub-sampling in the field		Sampling Part 3: Guidance on subsampling in the field	CSS99032
Sample packaging, storage, etc.		Sampling Part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery	CSS99059
Sampling plan		Sampling Part 5: Guidance on the process of defining the sampling plan	CSS99060
Sample pretreatment		Guidance for sample pretreatment	CSS99034

The reports include the following documents:

PART 1: Sampling of sewage sludge, treated biowastes and soils in the landscape — Framework for the preparation and application of a Sampling plan.

PART 2: Report on sampling draft standards.

Sampling of sludges and treated biowastes:

A. Technical Report on Sampling — Guidance on selection and application of criteria for sampling under various conditions.

B. Technical Report on Sampling — Guidance on sub-sampling in the field.

C. Technical Report on sampling — Guidance on procedures for sample packaging, storage, preservation, transport and delivery.

Sampling of sewage sludge and treated biowastes — Guidance on sampling techniques 30.3.2006.

Sampling of sewage sludge and treated biowastes — Definition of the sampling plan 27.4.2006

Annex 2-14: Country-specific environmental impacts of the end-of-waste criteria

DE

	Without complementary measures	*Complementary measures*
Average contents of hazardous substances in compost produced	**No change expected** The lead quality target for compost produced in Germany would not change. End-of-waste heavy metal limits are almost identical to German biowaste Ordinance Class II compost limits and limits for RAL GZ quality certification.	
Average contents of hazardous substances in compost used	**No change expected** End-of-waste limits almost identical to German biowaste Ordinance Class II compost limits, which under existing law restrict the contents of heavy metals for agricultural use.	
Hazardous substance flow to soil	**May theoretically increase** In case end-of-waste criteria lead to a legal void because restrictions on application rates in agricultural use are currently regulated under waste law.	Regulate agricultural compost application rates for Germany independent of waste status. However, the existing application limitations based on nutrients might be an effective limitation also regarding hazardous substances.
Risks related to misuse of compost	**No substantial change expected** Today, quality-certified compost is already traded ‘quasi like a product’ (according to ORBIT/ECN, 2008) and its use is exempted from waste regulatory controls to a large extent. The effect of end-of-waste on risk management would therefore	Regarding potential risks of facilitated exports: Member States may put means into place to monitor compost flows (e.g. registration and analysis of data of compost placed on the market) in order to detect and manage possible situations of

	be rather limited, even without new complementary measures. Compost supply pressure in Germany may increase in certain areas (because of facilitated imports) and decrease in others (because of facilitated exports). The overall effect is hard to foresee.	oversupply. All Member States should have proportionate rules and regulatory controls on compost use in place. (In any case, the heavy metal limits of end-of-waste criteria are set at a level that keeps any potential environmental impacts low also in the case of misuse.)

NL

	Without complementary measures	*Complementary measures*
Average contents of hazardous substances in compost produced	**Likely to increase** The heavy metal limits in the proposed end-of-waste criteria are less strict than the current Dutch limits for compost production and use. This might lead to a relaxation of compost quality targets, for example, for exports.	Potential receiving Member States of Dutch compost should have rules on compost use in place that limit heavy metal concentration and/or loads according to the needs of environmental protection.
Average contents of hazardous substances in compost used	**No change** Heavy metal concentration limits for use are regulated by national fertiliser regulation and are independent of waste status	
Hazardous substance flow to soil	**No change in the Netherlands — possible increase in countries importing compost from the Netherlands** In the Netherlands: both application rates and heavy metal concentrations are regulated by national fertiliser regulation, independently of waste status;	

	more compost may be used in neighbouring countries because of imports from the Netherlands which is then likely to lead to increased hazardous substance flows (unless compensated through substitution of lower quality composts). In any case, the heavy metal limits of end-of-waste criteria are set at a level to ensure a high benefit/impact ratio of compost use.	
Risks related to misuse of compost	**No increase in the Netherlands — limited risk increase related to compost exports** Regulatory controls on compost use and trade in the Netherlands are independent of waste status today. Furthermore, it is unlikely that end-of-waste will lead to higher risks through a stronger compost supply in the NL. On the contrary, it is likely that the domestic supply pressure of compost will decrease because of facilitated exports. End-of-waste may, however, induce increased supply of Dutch end-of-waste compost outside the Netherlands, with the possibility of elevated compost supply pressure at certain places.	Member States may put means into place to monitor composts flows (e.g. registration and analysis of data of compost placed on the market) in order to detect and manage possible situations of oversupply. (In any case, the heavy metal limits of end-of-waste criteria are set at a level that keeps any potential environmental impacts low also in the case of misuse.)

AT

	Without complementary measures	*Complementary measures*
Average contents of hazardous substances in compost produced	**Slight decrease expected** The lead quality target for compost produced in Austria is Class A according to national compost ordinance. End-of-waste would not change this quality target substantially (of the critical heavy metals, current compost Class A limits in Austria are stricter on Cd and less strict on Cu and Zn, but differences are not bigger than factor 1.5). However, EU end-of-waste criteria may be a disincentive for the production of compost of quality Class B (lower quality), which currently also qualifies for national end-of-waste (for non-agricultural purposes).	
Average contents of hazardous substances in compost used	**No substantial change for agricultural use** **Decreased** heavy metal concentrations likely **for certain non-agricultural uses**, where composts with higher heavy metal concentrations can be used outside waste regime today (national end-of-waste provisions) but not in the future according to the proposals for EU end-of-waste criteria.	
Hazardous substance flow to soil	**Unchanged in agricultural use, likely to decrease in certain non-agricultural uses** The conditions for compost use in agriculture (amounts	

	and pollutant concentrations) will not change substantially; however, in non-agricultural uses, fewer composts with heavy metal concentrations that do not meet the end-of-waste criteria can be expected to be used.	
Risks related to misuse of compost	**Unchanged or even reduced in Austria — limited risk increase related to compost exports** Current national end-of-waste provision is largely equivalent for main compost uses (agricultural). Certain non-agricultural uses of lower quality compost will not be possible anymore outside waste regulatory controls. Compost supply pressures in the domestic market may decrease because of facilitated exports. Correspondingly, supply pressures in neighbouring countries may increase.	Member States may put means into place to monitor composts flows (e.g. registration and analysis of data of compost placed on the market) in order to detect and manage possible situations of oversupply. All Member States should have rules and regulatory controls on compost use in place. (In any case, the heavy metal limits of end-of-waste criteria are set at a level that keeps any potential environmental impacts low also in the case of misuse.)

UK

With specific reference to England and Wales

	Without complementary measures	*Complementary measures*
Average contents of hazardous substances in compost produced	**Likely to decrease** The proposed heavy metal limits within end-of-waste criteria are stricter than the limits of PAS 100, which are the lead compost quality target in the UK today.	

Average contents of hazardous substances in compost used	**Likely to decrease** Pollutant concentrations in compost used are a matter of rules at country level and are independent of waste status. However, if users prefer end-of-waste compost, then the tightened limit values will let average heavy metal concentrations of compost used go down.	
Hazardous substance flow to soil	**Likely to decrease** Both application rates and pollutant concentrations are a matter of rules at country level and are independent of waste status. The most likely effect of the proposed end-of-waste criteria is that heavy metal loads will go down along with concentrations because the compost use will not increase as much so as to offset the positive concentration effect.	
Risks related to misuse of compost	**No substantial change** In England and Wales a quality protocol allows the use of compliant compost as non-waste already, with criteria similar to proposed end-of-waste criteria. Stricter thresholds on heavy metal concentrations limit the potential environmental impact in case of misuse. It is not expected that end-of-waste criteria would increase the supply pressure of compost (no additional promotion of compost production compared to	

	existing national provisions, no substantial net import expected).	

FR

	Without complementary measures	*Complementary measures*
Average contents of hazardous substances in compost produced	**Likely to decrease** Heavy metal limits in the end-of-waste proposal are lower than current lead standard NFU 44051.	
Average contents of hazardous substances in compost used	**Likely to decrease** Pollutant concentration limit in composed used are independent of waste status; standard NFU 44051 will still apply. However, it is likely that users will prefer end-of-waste composts, with lower heavy metal concentration limits.	
Hazardous substance flow to soil	**Likely to decrease** Current limits on pollutant load per hectare (NFU 44051) will still apply (for both heavy metal and organic pollutants). The most likely effect of the proposed end-of-waste criteria is that heavy metal loads will go down along with concentrations because the compost use will not increase as much as to offset the positive concentration effect.	
Risks related to misuse of compost	**Likely to decrease** NFU 44051 compliant compost is considered a ‘normal’ product today and waste law-derived regulatory	 Regarding potential risks of facilitated exports: Member States may put means into place to monitor composts

	controls are not applied; end-of-waste criteria are stricter concerning heavy metal limits and quality assurance and waste-law derived regulatory controls may be applied to non-compliant composts. Compost supply pressure in France may increase in certain areas (because of facilitated imports) and decrease in others (because of facilitated exports). The overall effect is hard to foresee.	flows (e.g. registration and analysis of data of compost placed on the market) in order to detect and manage possible situations of oversupply. All Member States should have rules and regulatory controls on compost use in place. (In any case, the heavy metal limits of end-of-waste criteria are set at a level that keeps any potential environmental impacts low also in the case of misuse.)

IT

	Without complementary measures	*Complementary measures*
Average contents of hazardous substances in compost produced	**Likely to decrease** Heavy metal limits for end-of-waste are lower than the Italian lead standards in the national law on fertilisers.	
Average contents of hazardous substances in compost used	**Likely to decrease** Heavy metal concentration limits in compost used are independent of waste status; fertiliser law will still apply. However, it is likely that users will prefer end-of-waste composts, with lower heavy metal concentration limits.	
Hazardous substance flow to soil	**Likely to decrease** Good agricultural practice will continue to be the guiding principle for amount of compost used. With increased compost quality the hazardous substance flow	

	should decrease.	
Risks related to misuse of compost	**Likely to decrease** Compost in compliance with the national law on fertilisers is considered a 'normal' product today and waste law-derived regulatory controls are not applied; end-of-waste criteria are stricter concerning heavy metal limits and quality assurance and waste law-derived regulatory controls may be applied to compost that does not meet the end-of-waste criteria. It is unclear how supply pressures would develop, for example as a consequence of facilitated imports and exports.	

ES

	Without complementary measures	*Complementary measures*
Average contents of hazardous substances in compost produced	**Likely to decrease** Heavy metal limits for end-of-waste are lower than the lead standards in the national law on fertilisers (except the highest quality class for use in organic agriculture).	
Average contents of hazardous substances in compost used	**Likely to decrease** Heavy metal concentration limits in compost used are independent of waste status; fertiliser law will still apply. However, it is likely that users will prefer end-of-waste composts, with lower heavy metal concentration limits.	

Hazardous substance flow to soil	**Unclear** It cannot reasonably be foreseen how the level of compost use will change. Current limitations on amounts of compost used apply only to compost that would not comply with the end-of-waste criteria. There may be substantial differences between regions within ES.	
Risks related to misuse of compost	**Likely to decrease** Because the waste status for low quality compost would be more clearly established than currently the case and the regulatory controls are expected to be reinforced in this case.	

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CHAPTER 3 Aggregates case study

3.1 Introduction

3.1.1 Objectives

This part of the report presents the case study on aggregates within the JRC-IPTS end-of-waste project.

The objective of this case study was to support the development of the end-of-waste methodology. Together with two studies, it aimed at defining possible end-of-waste criteria by applying and testing the general end-of-waste methodology.

The development of the three case studies was closely linked and interacted with the development of the general end-of-waste methodology. It provided feedback and allowed a further improvement of the methodology so it can be applied consistently to other waste stream.

This case study did not intend to define end-of-waste criteria for aggregates per se. The purpose was to carry out a scientific and technical study to test the feasibility of possible end-of-waste criteria for recycled aggregates from construction and demolition waste and for secondary aggregates from material generated in parallel to industrial processes that could provide feedback on the general end-of-waste methodology.

The proposals developed in this case study are merely research-based, and do not necessarily represent the position of the European Commission.

3.1.2 Scope and methodology used

The case study on aggregates aimed at defining end-of-waste criteria for potential materials to be used as substitutes for aggregates. In particular, it focused on a number of representative waste streams with the potential to be used as recycled and secondary aggregates, construction and demolition waste, slags from ferrous metal production and ashes from coal combustion.

Initially a literature review and assessment was done aimed at identifying current practices within the EU associated with the recycling of these materials and the general views of the various stakeholders on the end-of-waste concept. Contacts were made with relevant industry associations to understand how the industry sector is organised. In addition, contacts with experts and some Member States gave a national-level perspective on the management of these three waste streams.

In parallel, an external contract for gathering data on aggregates was launched to compile quantitative data on the waste streams. It gathered information on the arisings at the European level, and qualitative data on the environmental issues associated with the materials. Information was also gathered on the market and on existing legislation and standards associated with their use as aggregates.

Two expert workshops were organised in March and November 2007. Participants were invited on the basis of their capacity and expertise. The panel included industry representatives, users of the recovered materials and national experts. Technical experts and members of the waste management committee were also invited.

The first expert workshop focused on the environmental issues associated with the processing, handling and use of the three waste streams. The technical limitations of the recovered materials were debated as well as relevant legislation for each particular waste. The debate also focused on the role of standards in the definition of end-of-waste criteria.

The second focused on the main features of end-of-waste criteria for each of the waste streams. The debate was centred on essential and operational elements that should be part of the criteria in order to fulfil the end-of-waste principles. The workshop provided feedback on stakeholders' positions on the proposed end-of-waste criteria.

In order to understand the generation, processing and recycling sectors, several visits were organised to construction and demolition waste recycling centres in different countries. The objective was to understand the processing and use of recycled aggregates in different countries. The project team also visited two iron and steelworks in order to understand the generation, treatment and processing of steel slags.

3.1.3 Case study structure

Sub-chapter 3.2 characterises the three waste streams, from the generation of the waste through the processing and to the marketing of recycled and secondary aggregates. It addresses the technical limitations of the materials and the main environmental issues associated with the use of secondary and recycled aggregates. Quantitative data is presented to illustrate the European situation. The chapter also presents the relevant legal framework associated with these waste streams and the legislation associated with aggregates as construction materials.

Sub-chapter 3.3 identifies the rationales for defining end-of-waste criteria for recycled and secondary aggregates, and explains the fulfilment of end-of-waste conditions within the scope of the three waste streams. It identifies the relevant issues for defining end-of-waste criteria for recycled aggregates from construction and demolition waste and for secondary aggregates from material generated in parallel to industrial processes, explaining the requirements and the rationales behind such conditions.

Sub-chapter 3.4 assesses the impact of end-of-waste criteria compared with the current waste status of recycled and secondary aggregates. It also examines the economic, market, legislative and environmental impacts associated with the removal of waste status from recycled and secondary aggregates according to the end-of-waste criteria defined in Sub-chapter 3.3.

The case study concludes with some considerations regarding the areas identified for further analysis to determine European end-of-waste criteria.

3.2 Analysis

3.2.1 Introduction to aggregates

Aggregates are a granular material used in construction. The most common natural aggregates of mineral origin are sand, gravel and crushed rock. A product by itself when used as railway ballast or armour stones, aggregates are also a raw material used in the manufacture of other vital construction products such as ready-mixed concrete (made of 80 % aggregates), precast products, asphalt (made of 95 % aggregates), lime and cement (UEPG, 2006). According to the source material aggregates can be classified as:

natural aggregates, produced from mineral sources; sand and gravel are natural aggregates resulting from rock erosion; crushed rock is extracted from quarries;

secondary aggregates, secondary materials arising from industrial processes;

recycled aggregates, produced from processing material previously used in construction.

Natural aggregates come from rock of which there are three broad geological classifications — igneous, sedimentary and metamorphic. They are extracted from natural deposits by quarrying and mining. Rock is blasted or dug and then reduced in size by a series of crushers and screens to prepare it for use as aggregate. Sand and gravel are extracted from alluvial or marine deposits.

3.2.1.1 Production volumes

The production of aggregates is strongly linked with the geological conditions and the growth of the construction sector. Table 9 shows the overall production of natural, recycled and secondary aggregates.

In 2006, a total of 3 600 million tonnes in 2006 were produced in 21 European countries, compared with 3 000 million tonnes were produced in 18 European countries in 2005. The average annual aggregates production represents about 7 tonnes/EU citizen (Umweltbundesamt (2008)).

Table 9: Production of aggregates in 2006 (million tonnes).

Country	Com-panies	Sites	Em-ployees ([1])	Sand and gravel ([2])	Crushed rocks ([3])	Marine aggre-gates ([4])	Recycled aggregates 2006 ([5]) (2005)	Secondary aggregates 2006 (2005) ([6])	Total 2006 (2005)
Germany	1 800	5 396	92 625	277	186.5	0.4	48 (46.0)	30 (30.0)	541.9 (513.0)
Spain	1 600	1 950	86 000	170	314	0	1.5 (1.3)	0 (0.0)	485.5 (460.3)
France	1 680	2 700	17 300	167	233	7	14 (10.0)	9 (7.0)	430.0 (410.0)
Italy	1 700	2 360	24 000	210	135	0	5.5 (4.5)	3.5 (3.0)	354.0 (377.5)
United Kingdom	350	1 300	46 000	68	123	13	58 (56.0)	12 (12.0)	274.0 (277.0)
Poland	2 200	2 550	53 600	115	43	n.a.	8 (7.2)	3 (1.6)	169.0 (150.8)
Ireland ([8])	250	450	5 100	54	79	n.a.	(1)	(0)	(134)
Netherlands	60	185 ([8])	400	44.5	4 ([8])	50	25 (20.2)	n.a.	123.5 (48.2)
Austria	950	1 260	21 400	66	32	0	3.5 (3.5)	(3.0)	104.5 (104.5)
Finland	400	3 550	3 000	54	46	0	0.5 (0.5)	0 (n.a.)	100.5 (98.5)
Portugal	331 ([7])	379	4 560 ([8])	97.5		0	n.a.	n.a.	97.5 (88.3 ([7]))
Sweden	120	2 410	3 500	23	62	0	1.8 (7.9)	0.2 (0.2)	87.0 (80.1)
Belgium	184	253	15 919	10.07	55.5	3.5	13 (12.0)	1.3 (1.2)	83.4 (65.1)
Czech Republic	208	490	3 368	27.1	41.5	0	3.8 (3.4)	0.3 (0.3)	72.7 (67.2)
Denmark ([8])	350	400	3 000	58.0	0.3	13.6 ([9])	n.a.	n.a.	(72)
Croatia	500	330	7 000	6.2	21.8	0	3.4 (n.s.)	0.3 (n.s.)	67.2 (n.s.)
Norway	1 500	2 000	1 839	13.4	45.0	0	n.a. (0.2)	n.a. (n.a.)	58.4 (53.2)
Slovakia	175	213	3 700	10	16.5	0	0.2 (0.2)	0.3 (0.3)	27.0 (26.3)
Romania		440	11 600	15.5	6.5	0	0.5 (n.s.)	0.5 (n.s.)	23.0
Switzerland	350	480	3 200	50	5.7	0	5.7 (5.3)	n.a.	61.4 (57.1)
Turkey	770	770	20 240	24	260	0	0 (n.s.)	0 (n.s.)	284.0 (n.s.)
Total	**15 478**	**29 866**	**427 351**	**1 560.27**	**1 710.3**	**87.5**	**190 (179.2)**	**63.1 (58.6)**	**3 611.2 (3 069.4)**

(n.s. = not specified; n.a. = not available)

Source: UEPG 2006; UEPG 2008; Umweltbundesamt, 2008.

(1) Number of people directly employed (i.e. under the payroll of the companies), comprising full-time employees and part-time employees as well as people indirectly employed including all on-site contractors (e.g. truck operators, cleaners, etc.) unless indicated otherwise.

(2) Sand and Gravel: sold production including marine aggregates and crushed gravel.

(3) Crushed rock: sold production (excluding crushed gravel).

(4) Aggregates produced from sea-dredged materials.

(5) Recycled aggregates: materials coming from construction and demolition waste used in the aggregates market.

(6) Secondary aggregates include blast-furnace-slag, electric-arc-furnace-slag, incinerator bottom ash (IBA), pulverised fuel ash (PFA) and other industrial and extraction by-products for construction and civil engineering.

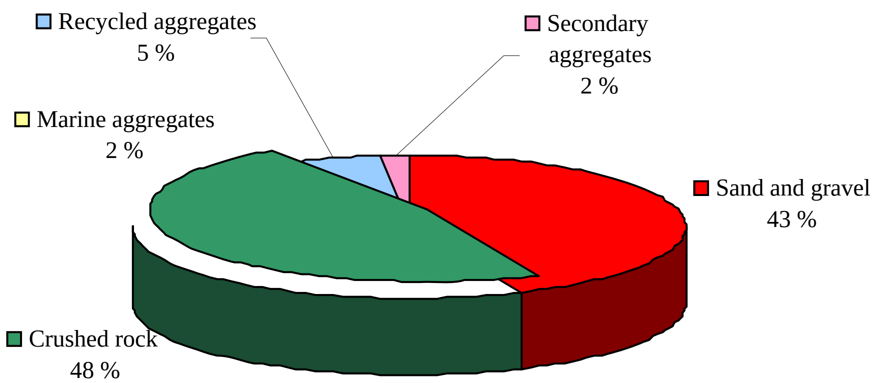
(7) Data 2003.

(8) Data 2005.

(9) Data 2004.

Figure 6 shows the distribution of the total production of aggregates between the different categories, data 2006. Recycled and secondary aggregates account for about 7 %.

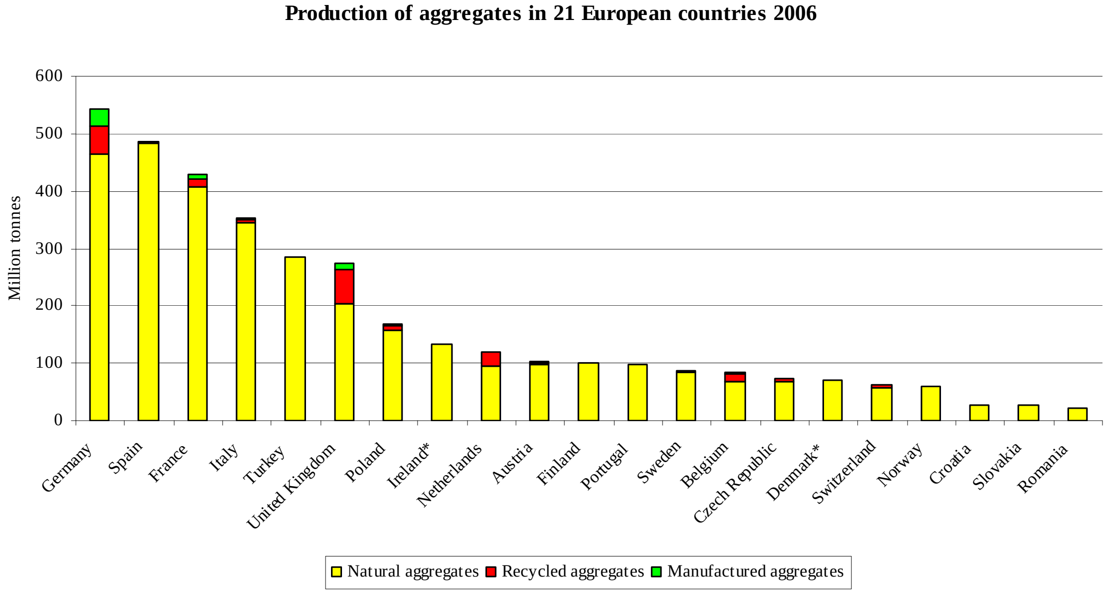
Figure 6: Production of aggregates in 21 European countries in 2006



Source: UEPG 2008.

From Figure 7, it is clear that the share of recycled and secondary aggregates is small compared with overall production of aggregates. In Germany, Belgium, the Netherlands and United Kingdom the share of recycled and secondary aggregates is 14 %, 17 %, 20 % and 26 % respectively. Spain was the largest producer of primary aggregates in 2006.

Figure 7: Production of recycled and secondary aggregates in European countries in 2006



(*) No data available for secondary aggregates.
(**) Data 2005.

Source: UEPG 2008.

3.2.1.2 Type of applications

The field of application of aggregates can be divided into two main types:

unbound applications, where the aggregate is not bound;

bound applications, where the mixture contains a binding agent, such as cement, bitumen or a substance that has binding properties, in contact with water, similar to cement.

Concrete may be defined as a mixture of water, cement or binder and aggregates. The water and the cement/binder form the paste and the aggregate forms the filler, not intervening in the chemical reaction of the mixture. Concrete is used in many types of applications for the construction of buildings and structures including the production of precast structures and masonry units.

Aggregates are also used in the production of mortar. Fine aggregates are mixed together with one or more binders and possibly additives and/or admixtures. There are many different types of mortar and, correspondingly, many different types of applications such as floor/screed mortar, surfacing of internal walls (plastering mortar), rendering external walls, masonry mortar to join ceramic tiles and masonry units, and grout mortar to fill in cavities or empty junctions between materials.

For aggregates to be used in concrete and mortar applications, they must remain stable within the concrete/mortar and in the particular environment throughout the design life of the application. Their characteristics must not affect adversely the performance of the concrete/mortar in either the fresh or hardened state.

In road construction, aggregates are used in bound and unbound types of applications. For bound applications, they must be strong, durable and resistant to abrasion. A good adhesion to bitumen is also essential for a good lifetime of a road surface. The road surface of a road can be bound or unbound depending on the foreseen load. One unbound application for aggregates is in river engineering for protection of river banks against erosion and for water flow control.

Lightweight aggregates are used to produce lightweight concrete and masonry, and as a filler. In general, concrete made with lightweight aggregates has good fire resistance and good thermal properties. Its low density gives some benefits in transport and handling the precast structures made with lightweight aggregate and additionally there is a reduction in loads in foundations and reinforcement.

Aggregates are typically used for the construction of new homes and other buildings and structures. They also feature at all levels of road construction up to the surface, which includes aggregates resistant to polishing, ensuring skid resistance. Aggregates are essential as track ballast for Europe’s rail network. Table 10 shows the consumption of aggregates for typical uses.

Table 10: Main end uses of aggregates

Use	Average consumption of aggregates (tonnes)
Sports stadium	300 000
Motorway — 1 km	30 000
School	3 000
New home	400
Railway for high-speed train (TGV) — 1 m	9

Source: Umweltbundesamt (2008), UEPG (2006).

3.2.2 Related standards and legislation

3.2.2.1 Construction Products Directive

The main purpose of the Construction Products Directive (Council Directive 89/106/EEC ([94])) is to facilitate the free circulation of goods in the EU market by removing non-tariff barriers to trade through means of technical harmonisation. It defines a legal framework applicable to the production and trade of construction products in the EU market.

The directive defines six essential requirements for construction products.

1. Mechanical resistance and strength
2. Safety in case of fire
3. Hygiene, health and the environment
4. Safety in use
5. Protection against noise
6. Energy economy and heat retention.

These are the basis for the preparation of harmonised standards at European level in order to achieve the greatest possible advantage for a single internal market. The European Committee for Standardisation (CEN) is the entity responsible for developing and revising standards and guidelines according to mandates given by the Commission.

In May 2008, the European Commission presented a proposal ([95]) for a regulation to replace the current Construction Products Directive. The aim is to better define the objectives of Community legislation and make its implementation easier by providing some simplified mechanisms especially addressed to alleviate the administrative burden for enterprises and, in particular, for SMEs. The proposal includes basic work requirements for sustainable uses of natural resources as part of basic work requirements across the life cycle of construction works.

([94]) Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (OJ L 40, 11.2.1989, p. 12).

([95]) COM(2008) 311 final, proposal for a regulation of the European parliament and of the council laying down harmonised conditions for the marketing of the construction products.

‘7. Sustainable use of natural resources

The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and ensures the following:

(a) recyclability of the construction works, their materials and parts after demolition;
(b) durability of the construction works;
(c) use of environmentally compatible raw and secondary materials in the construction works.’

In the current Construction Products Directive, only the service life cycle of construction products are covered.

European standards for aggregates

In 1998, the Commission gave CEN Mandate 125 for developing European standards for aggregates. They were developed by the committee’s technical committee 154, defining the engineering requirements for aggregates according to the type of application.

The European standards define three types of aggregates according to the source material — natural aggregate from mineral sources, recycled aggregates from material previously used in construction and manufactured aggregates mineral material resulting from an industrial process. Whatever the source of the material, all the different types of the aggregates should comply with the requirements defined in the European Standards, see Table 11.

The European standards for aggregates also define particular requirements for secondary aggregates. The EN 13242 standard requires the determination of acid-soluble sulphate content for air-cooled blast furnace slag. For steel slags, constituents which affect the volume stability of slags must be determined. The EN 13139 standard defines additional requirements for manufactured aggregates. For air-cooled blast furnace slags and pulverised fly ash, loss of ignition must be determined.

An amendment to the EN 13242 standard (Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction) to incorporate clauses for recycled aggregates was released in April 2008. The revised standard will introduce new requirements and procedures. Among other technical requirements, the amendment introduces a new classification of the constituents of coarse recycled aggregates, to be determined in accordance with the new prEN 933-11 standard (Tests for geometrical properties of aggregates — Part 11: Classification test for the constituents of coarse recycled aggregates), see Table 12 and Table 13.

Table 11: List of published European standards on aggregates.

Standard reference	Title
EN 13043:2002	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
EN 13043:2002/AC:2004	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
EN 12620:2002	Aggregates for concrete
EN 12620:2002/AC:2004	Aggregates for concrete
EN 13139:2002	Aggregates for mortar
EN 13139:2002/AC:2004	Aggregates for mortar
EN 13450:2002	Aggregates for railway ballast
EN 13450:2002/AC:2004	Aggregates for railway ballast
EN 13242:2002	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
EN 13242:2002/AC:2004	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
EN 13383-1:2002	Armourstone — Part 1: Specification
EN 13383-1:2002/AC:2004	Armourstone — Part 1: Specification
EN 13383-2:2002	Armourstone — Part 2: Test methods
EN 13055-1:2002	Lightweight aggregates — Part 1: Lightweight aggregates for concrete, mortar and grout
EN 13055-1:2002/AC:2004	Lightweight aggregates — Part 1: Lightweight aggregates for concrete, mortar and grout
EN 13055-2:2004	Lightweight aggregates — Part 2: Lightweight aggregates for bituminous mixtures and surface treatments and for unbound and bound applications

Source: Umweltbundesamt (2008).

Table 12: Classification of the constituents of coarse recycled aggregates Source: Umweltbundesamt (2008)

Standard reference	Title
R_C	Concrete, concrete products, mortar, concrete masonry units
R_U	Unbound aggregate, natural stone, hydraulically bound aggregate
R_B	Clay masonry units (i.e. bricks and tiles), calcium silicate masonry units, aerated non-floating concrete
R_A	Bituminous materials
R_G	Glass
FL	Floating material in volume
X	Other: cohesive (i.e. clay and soil); miscellaneous: metals (ferrous and non-ferrous), non-floating wood, plastic and rubber; gypsum plaster

Source: Umweltbundesamt (2008), prEN 933–11.

Table 13: Categories of constituents of coarse recycled aggregates

Constituents	Content	Categories
	Percentage by mass	
R_C	≥ 90	$R_{C\ 90}$
	≥ 80	$R_{C\ 80}$
	≥ 70	$R_{C\ 70}$
	≥ 50	$R_{C\ 50}$
	< 50	$R_{C\ Declared}$
	No requirement	$R_{C\ NR}$
$R_C + R_U + R_G$	≥ 90	$R_{CUG\ 90}$
	≥ 0	$R_{CUG\ 70}$
	≥ 50	$R_{CUG\ 50}$
	< 50	$R_{CUG\ Declared}$
	No requirement	$R_{CUG\ NR}$
	≤ 10	$R_{B\ 10-}$
	≤ 30	$R_{B\ 30-}$
	≤ 50	$R_{B\ 50-}$
	> 50	$R_{B\ Declared}$
	No requirement	$R_{B\ NR}$
	≥ 95	$R_{A\ 95}$
	≥ 80	$R_{A\ 80}$
	≥ 50	$R_{A\ 50}$
	≥ 40	R_{A40}
	> 30	R_{A30}
	≤ 30	$R_{A\ 30-}$
	≤ 20	$R_{A\ 20-}$
	≤ 10	$R_{A\ 10-}$
	≤ 5	$R_{A\ 5-}$
	≤ 1	$R_{A\ 1-}$
	No requirement	$R_{A\ NR}$
R_G	≤ 2	$R_{G\ 2-}$
	≤ 5	$R_{G\ 5-}$
	≤ 25	$R_{G\ 25-}$
	No requirement	$R_{G\ NR}$
X	≤ 1	X_1
	Content	**Categories**
	cm^3/kg	
FL	≤ 5	FL_{5-}
	≤ 10	FL_{10-}

Source: Umweltbundesamt (2008), prEN 933–11.

Environmental requirements

Despite being part of the Construction Products Directive, the third essential requirement 'Hygiene, health and the environment', was not covered in detail when developing the European standards for some construction products. The construction work must be designed and built in such a way that it will not threaten the soil, groundwater or indoor air by releasing dangerous substances, which may present a danger to man and the environment during normal use of construction products when installed in works. The actual standards focus more on the engineering properties of the construction products.

European standards for aggregates require the determination of water-soluble constituents when required. The European standardised test EN 1744-3 (Tests for chemical properties of aggregates — Part 3) must be used for the preparation of eluates from aggregates. However, questions about reflecting the actual leaching behaviour of aggregates have been raised (Van der Sloot H., Mulder., E., 2002).

The Annex ZA to the standards introduces a generic clause regarding the release of dangerous substances pointing out that in addition to the requirements of the standards, existing European legislation and national requirements relating to dangerous substances have to be fulfilled. Each country will then define national leaching limit values for the materials to be used in construction works.

The commission is maintaining a database designed to help technical specifications writers to identify all regulated dangerous substances, which exist in Member States applicable to 'dangerous substances', present in products or families of products covered by the harmonised technical specification. It is expected that this database will be fully operational in 2009.

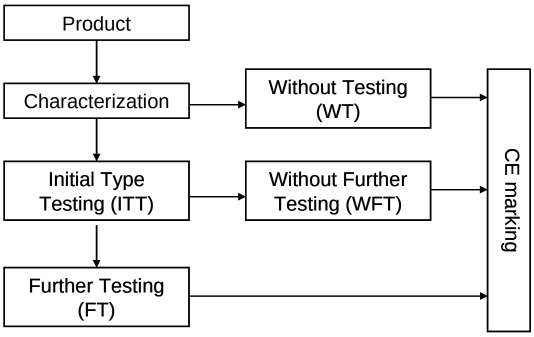
In order to meet the third essential requirement, the European Commission issued an additional mandate. 'The horizontal complement to the mandates to CEN concerning the execution of standardisation work for development of horizontal standardised assessment methods for harmonised approaches relating to dangerous substances under the CPD' (M/366). The additional mandate assigns the development of harmonised test standards to CEN, adapting existing standards whenever possible.

The construction products should be tested for specified intended conditions of use. The producer cannot be held responsible if a product is used in accordance with the conditions declared by the producer. The focus of the CPD and in particular the third essential requirement is on the release of dangerous substances from the construction product, and not on the total content. Substances behave differently in some cases when bound in a matrix, with no risk of releasing dangerous substances.

As a response to the mandate a new TC (technical committee) was created, TC 351 'Construction products: assessment of release of dangerous substances'. This technical committee is responsible for planning and completing the work programme defined in the mandate. It will provide the means/instruments for the quantification of dangerous substances, which may be released from construction products to the environment into the soil, ground and surface water, and indoor air.

The standards tests are part of the strategy leading to the mitigation and, possibly, the avoidance of the exposure to dangerous substances released from construction products. It will also provide input on the strategic use of the standards tests in a systematic way, taking on board a hierarchy of testing. Finally, it will allow an appropriate level of protection of the environment in a cost-effective way.

Figure 8: Concepts of WT and WFT (Dijkstra J., Van der Sloot H., Thielen G., 2005)



The mandate introduces the concept of products and materials ‘without testing’ (WT), ‘without further testing’ (WFT) and ‘further testing’ (FT). With these concepts it should be should be possible to demonstrate, for a large number of products, that they do not contain any regulated dangerous substance or have the possibility of releasing dangerous substances into the soil, ground or surface water and indoor air in quantities above the limits regulated in any Member States of the EU. Based on general knowledge of the constituents and/or the estimated release behaviour (product dossier), some products might not even need initial testing and could be classified as ‘without testing’ together with factory production control measures.

3.2.2.2 Landfill Directive

The objective of the European Union Landfill Directive ([96]) is to reduce landfilling of waste and as far as possible reduce its negative effects on the environment, by introducing stringent technical requirements for waste and landfills. The total cost of establishing maintaining and closing a landfill site is considered when establishing the landfill cost. The directive defines three classes of landfill, for hazardous, non-hazardous and inert waste. Article 2 (e) defines inert waste as,

> *'… waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater.'*

However, the directive does not define limit values and procedures for wastes to be accepted at the different categories of landfills. A subcommittee was formed, and had the task of developing acceptance criteria for waste at landfills. There was a broad agreement that the setting of acceptance criteria and limit values should be based on assessment on the actual risk to the environment. Based on this it was agreed that some institutions from some Member States should carry out calculations for inert waste landfills, using models and scenarios to link the result of a leaching test to a targeted point of compliance.

In December 2002 the Council Decision ([97]), establishing criteria and procedures for the acceptance of wastes at landfills pursuant to Article 16 of the Landfill Directive was published. It took effect on 16 July 2004. Landfills are divided into three classes: landfills for inert waste, landfills for non-hazardous waste and landfills for hazardous waste. Procedures consist of basic characterisation, compliance testing and on-site verification.

The **basic characterisation** is the first step and constitutes a full characterisation of the waste by gathering all the necessary information for safe disposal of the waste in the long term, including type, origin, composition leachability and — where necessary and available — other properties.

As a general rule waste must be tested to obtain the necessary information. In addition to the leaching behaviour the composition of the waste must be known or determined by testing. For waste to be accepted in inert landfill site, it must meet the limit values defined in Table 16 and Table 17. In some cases, testing for basic characterisation can be dispensed with. For wastes mentioned in Table 14, the material can be accepted at inert landfill sites without testing.

([96]) Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).
([97]) Council Decision 2003/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (OJ L 11, 16.1.2003, p. 27),

Table 14: List of wastes acceptable at landfills for inert waste without testing

EWC code	Description	Restrictions
10 11 03	Waste glass-based fibrous materials	Only without organic binders
15 01 07	Glass packaging	
17 01 01	Concrete	Selected C & D waste only (*)
17 01 02	Bricks	Selected C & D waste only (*)
17 01 03	Tiles and ceramics	Selected C & D waste only (*)
17 01 07	Mixtures of concrete, bricks, tiles and ceramics	Selected C & D waste only (*)
17 02 02	Glass	
17 05 04	Soil and stones	Excluding topsoil, peat; excluding soil and stones from contaminated sites
19 12 05	Glass	
20 01 02	Glass	Separately collected glass only
20 02 02	Soil and stones	Only from garden and parks waste; excluding top soil, peat

(*) Selected construction and demolition waste (C & D waste): with low contents of other types of materials (like metals, plastic, soil, organics, wood, rubber, etc.). The origin of the waste must be known.
— No C & D waste from constructions, polluted with inorganic or organic dangerous substances, e.g. because of production processes in the construction, soil pollution, storage and usage of pesticides or other dangerous substances, etc., unless it is made clear that the demolished construction was not significantly polluted.
— No C & D waste from constructions, treated, covered or painted with materials, containing dangerous substances in significant amounts.

Leaching limit values are calculated at liquid solid ratios (L/S) of 2 l/kg and 10 l/kg for total release. To express in mg/l the first eluate (C_0) of a percolation test at L/S 0.1 kg/l should be used. Member States shall decide which of the testing methods and corresponding limit values shall be used (see Table 15).

Table 15: Leaching tests to be used for determining the leaching limit values for waste acceptable at landfill for inert waste

prEN 14405	**Up-flow percolation test (Up-flow percolation test for inorganic constituents)**
EN 12457/1-4	Compliance test for granular waste materials and sludges
	Part 1: L/S = 2 l/kg, particle size < 4 mm
	Part 2: L/S = 10 l/kg, particle size < 4 mm
	Part 3: L/S = 2 and 8 l/kg, particle size < 4 mm (2 steps)
	Part 4: L/S = 10 l/kg, particle size < 10 mm

Table 16: Limit values for waste acceptable at landfill sites for inert waste ([97])

	L/S = 2 l/kg	**L/S = 10 l/kg**	**C_0**
	mg/kg dry substance	**mg/kg dry substance**	**mg/l**
As	0.1	0.5	0.06
Ba	7	20	4
Cd	0.03	0.04	0.02
Cr total	0.2	0.5	0.1
Cu	0.9	2	0.6
Hg	0.003	0.01	0.002
Mo	0.3	0.5	0.2
Ni	0.2	0.4	0.12
Pb	0.2	0.5	0.15
Sb	0.02	0.06	0.1
Se	0.06	0.1	0.04
Zn	2	4	1.2
Chloride	550	800	460
Fluoride	4	10	2,5
Sulphate	560 (*)	1 000 (*)	1 500
Phenol index	0.5	1	0.3
DOC (**)	240	500	160
TDS (***)	2 500	4 000	—

(*) If the waste does not meet these values for sulphate, it may still be considered as complying with the acceptance criteria if the leaching does not exceed either of the following values: 1 500 mg/l as C_0 at L/S = 0.1 l/kg and 6 000 mg/kg at L/S = 10 l/kg. It will be necessary to use a percolation test to determine the limit value at L/S = 0.1 l/kg under initial equilibrium conditions, whereas the value at L/S = 10 l/kg may be determined either by a batch leaching test or by a percolation test under conditions approaching local equilibrium.

(**) If the waste does not meet these values for DOC at its own pH value, it may alternatively be tested at L/S = 10 l/kg and a pH from 7.5 to 8.0. The waste may be considered as complying with the acceptance criteria for DOC if the result of this determination does not exceed 500 mg/kg (a draft method based on prEN 14429 is available).

(***) The values for total dissolved solids (TDS) can be used alternatively to the values for sulphate and chloride.

Table 17: Limit values for total content of organic parameters ([97])

	mg/kg dry substance
TOC (total organic carbon)	30 000 (*)
BTEX (benzene, toluene, ethylbenzene and xylenes)	6
PCBs (polychlorinated biphenyls, seven congeners)	1
Mineral oil (C_{10} to C_{40})	500
PAHs (polycyclic aromatic hydrocarbons)	Member States to set limit value

(*) In the case of soils, a higher limit value may be admitted by the competent authority, provided the DOC value of 500 mg/kg is achieved at L/S = 10 l/kg, either at the soil's own pH or at a pH value from 7.5 to 8.0.

The principles and methodology used for defining the leaching limit values for acceptance criteria of inert waste at inert waste landfills were based on a stepwise procedure based on landfill site characteristics and groundwater modelling, establishing a direct relationship between the release of inorganic contaminants from the waste material and the risk they pose to the environment, in particular to the quality of the groundwater.

Once the waste passes the basic characterisation step, it is subsequently subjected periodically to **compliance testing** to determine if it complies with the results from the basic characterisation.

On-site verification is carried out for each load of waste delivered to a landfill. The waste to be accepted must be the same as the waste subject to basic characterisation and compliance testing.

3.2.2.3 Interpretative communication on waste and by-products

This Communication ([98]) aims to explain the definition of waste as interpreted by the Court of Justice of the European Communities, in order to ensure that the directive is properly implemented. In EU waste law, notions such as by-products or secondary raw materials have no legal meaning — materials are simply waste or not. The scope of the communication is the distinction between waste and non-waste in a production process context. The aim is to improve the legal certainty of waste legislation to guide competent authorities in making case-by-case judgments and to give economic operators information on how this decision should be taken.

The Commission considers that guidelines are better suited to delivering legal clarity than a definition of by-products in the Waste Framework Directive.

In recent jurisprudence, the Court has compiled a three-part test that a production residue must pass in order to be considered a by-product. The Court stated that where the further use of the material was not a mere possibility but a certainty, without any further processing prior to reuse and as part of a continuing process of production, the material would not be a waste. The test is a cumulative test — all three parts must be performed. In addition to this test, the Court noted that the use for which the by-product is destined must also be lawful.

([98]) COM(2007) 59 final.

The communication also gives examples of some cases in which materials may be classified as wastes or not, pointing out that these examples are neither definitive nor comprehensive. One case relates to slags and dusts from iron and steel production with the following explanation.

Blast furnace slag is produced in parallel with hot iron in a blast furnace. The production process for the iron is adapted to ensure that the slag has the requisite technical qualities. A technical choice is made at the start of the production process that determines the type of slag that is produced. Moreover, use of the slag is certain in a number of clearly defined end uses, and demand is high. Blast furnace slag can be used directly at the end of the production process, without further processing that is not an integral part of this production process (such as crushing to get the appropriate particle size). This material can therefore be considered to fall outside the definition of waste.

3.2.2.4 National regulations/guidelines

Several Member States have already established guidelines and regulations for recycling construction and demolition waste, slags from ferrous metal production and ashes from coal combustion processes with regard to environmental protection.

They have used different objectives and principles for defining limit values. In the Netherlands, the old ‘building materials decree’ defines limit values for building materials based on emissions into the soil and surface water. The definition immission values are based on a maximum level for the release of inorganic substance from building materials for a period of 100 years.

In other cases, such as Sweden, the draft guideline/handbook is based on the principles of minimisation of health risks and the protection of soil and ground and surface water, to remove from the eco-cycle any substance of high concern. The category ‘general uses’, defines the maximum level allowed for using the waste without reporting, and are based on the natural background levels. The maximum limits can be regarded as limits for ‘free use’ without any additional administrative burden. For using waste exceeding the maximum level, a case-by-case approach is followed.

To set suitable leaching limits, different approaches are considered to minimise the transfer of contaminants into soil, water and air in the course of the treatment and use of recovered materials. Some Member States have regulations and strict bans on the input material in place whereas other Member States regulate the intended use more strictly. The limits defined in the national regulations and guidelines identify potential environmental risks.

To avoid serious or irreversible harm, environmental risks should be assessed by taking the precautionary principle into consideration. There are important factors which have a great influence on the potential environmental risks of a recycled material, including:

- contaminants of the material (e.g. dangerous substances, leaching and total contents);
- form of application (e. g. bound or unbound, mixed or as bulk material);
- intended use (e. g. traffic areas, industrial areas or agricultural areas);
- background contamination of and long-term conditions at the fitting location.

Table 18, Table 19 and Table 20 give an overview of limit values defined by Member States (Umweltbundesamt, 2008).

The formal leaching limits for Denmark and Italy are defined as µg/l (Table 18). In order to compare with other leaching they were recalculated to mg/kg by multiplication with the applied L/S ratio.

For Germany the comparison is more difficult. The new draft ordinance uses a recently published leaching test, DIN 19528 (Leaching of solid materials — percolation method for the joint examination of the leaching behaviour of inorganic and organic substances).

Table 18 summarises limits on total content in European countries. In Finland, the definition of total content is used for the identification of the material. For acceptance of the material leaching criteria is required. In Belgium, if the total concentration is higher than the background values of the soil then the leaching behaviour of the material must be tested via a column test (Umweltbundesamt, 2008).

Table 18: Limits on total content defined in European countries.

	Austria (1)			**Belgium** (2)	**Denmark** (3)		**Finland** (4)		**Sweden** (5)		**Disposal criteria** (6)
Total content (mg/kg DS)	A+	A	B	Shaped building materials	CAT1	CAT2			General use	Specific use	
Covered waste/ material	C & D	C & D	C & D	C & D, ashes, slags	ashes	ashes	C & D	ashes	C & D, ashes, slags	C & D, ashes, slags	
General unit	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS
Metals											
Arsenic	20	30	30	250	0–20	> 20	50	50	10	10	
Barium								3 000			
Cadmium	0.5	1.1	1.1	10	0–0.5	> 0.5	10	15	0.2	1.5	
Chromium total	40	90	90	1 250	0–500	> 500	400	400	40	80	
Chromium (VI)					0–20	> 20					
Copper	30	90	90	375	0–500	> 500	400	400	40	80	
Mercury	0.2	0.7	0.7	5	0–1	> 1			0.1	1.8	
Molybdenum								50			
Lead	30	100	100	1 250	0–40	> 40	300	300	20	200	
Nickel	30	55	55	250	0–30	> 30			35	70	
Zinc	100	450	450	1 250	0–500	> 500	700	2 000	120	250	
Vanadium	100	450	450	1 250	0–500	> 500	700	400			
Others											
PAH	4 (1)	12 (1)	20 (1)				20	20			(7)
PCB				0.5			1.0	1.0			1
TOC							30 000				30 000
BTEX											6
Mineral oil				1 000							500

Source: Umweltbundesamt (2008).

(1) Including specific limits for recycled building materials and general limits for construction and demolition waste applicable for recovery processes according to different quality classifications (A+, A and B).

(2) Limits and conditions for use of selected construction and demolition waste, slags and ashes in or as a building material.

(3) Limit values for the three quality categories (CAT1, CAT2 and CAT3) on residual products (including bottom and fly ashes from coal fired power stations).

(4) C & D: limit values for concrete chippings made of dismantled concrete structures or concrete waste; ashes: limit values for ashes from coal combustion.

(5) Draft version of a guideline/handbook to be used by competent authorities for issuing permits for recovering waste as construction material.

(6) Limits according to the decision on the acceptance of waste at landfills (Council Decision 2003/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (OJ L 11, 16.1.2003, p. 27).

(7) Member States to set limit value for disposal.

Table 19: Leaching limits (mg/kg DS) defined in European countries

	Austria (1)			**Belgium** (2)	**Finland** (3)				**Spain** (4)		**Sweden**		**Italy** (5) (7)	**Netherlands 'soil quality regulation'**		**Disposal criteria** (6)	**Denmark** (7)	**Disposal criteria** (6)
Leachability (**) **(mg/kg DS)**	A+	A	B		Covered structure	Paved structure	Covered structure	Paved structure	CA	BC	General use	Specific use		Un-moulded materials	IBC		CAT1	
Covered waste/ material	C & D	C & D	C & D	C & D, ashes, slags	C & D	C & D	Ashes	Ashes	Slags	Slags	C & D, ashes, slags	C & D, ashes, slags	C & D, ashes, slags	Con-struction materials	Ashes		Ashes	
General unit	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS
Test method	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	NEN 7343 L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10/kg	EN 12457	EN 12457	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10l/kg	L/S = 2 l/kg	L/S = 2 l/kg
Metals																		
Antimony	0.06	0.06	0.1		0.06	0.06	0.06	0.18	0.06					0.16	0.7	0.06		0.02
Arsenic	0.5	0.5	0.5	0.8	0.5	0.5	0.5	1.5	0.5		0.13	0.44	0.5	0.9	2	0.5		0.1
Barium	20	20	20		20	20	20	60	20	17			10	22	100	20	0.6	7
Cadmium	0.04	0.04	0.04	0.03	0.02	0.02	0.04	0.04	0.04	0.009 – 0.6	0.01	0.01	0.05	0.04	0.06	0.04	0.004	0.03
Beryllium													0.1					
Chromium total	0.3 (1)	0.5 (1)	0.5 (1)	0.5	0.5	0.5	0.5	3.0	0.5	2.6	0.42	0.26	0.5	0.63	7	0.5	0.2	0.2
Chromium (IV)																		
Cobalt													2.5	0.54	2.4			
Copper	0.5 (1)	1 (1)	2 (1)	0.5	2.0	2.0	2.0	6.0	2		0.31	0.64	0.5	0.90	10	2	0.09	0.9
Lead	0.5	0.5	0.5	1.3	0.5	0.5	0.5	1.5	0.5	0.8	0.31	0.33	0.5	2.3	8.3	0.5	0.02	0.2
Molybdenum	0.5	0.5	0.5		0.5	0.5	0.5	6.0	0.5	1.3				1	15	0.5		0.3
Mercury				0.02	0.01	0.01	0.01	0.01	0.01		0.004	0.01	0.01	0.02	0.08	0.01		0.003
Nickel	0.4	0.4	0.6	0.75	0.4	0.4	0.4	1.2	0.4	0.8	0.6	0.62	0.1	0.44	2.1	0.4	0.02	0.2

	Austria (1)			**Belgium** (2)	**Finland** (3)				**Spain** (4)		**Sweden**		**Italy** (5) (7)	**Netherlands 'soil quality regulation'**		**Disposal criteria** (6)	**Denmark** (7)	**Disposal criteria** (6)
Leachability (**) **(mg/kg DS)**	A+	A	B		Covered structure	Paved structure	Covered structure	Paved structure	CA	BC	General use	Specific use		Un-moulded materials	IBC		CAT1	
Covered waste/ material	C & D	C & D	C & D	C & D, ashes, slags	C & D	C & D	Ashes	Ashes	Slags	Slags	C & D, ashes, slags	C & D, ashes, slags	C & D, ashes, slags	Con-struction materials	Ashes		Ashes	
General unit	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS
Test method	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	NEN 7343 L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10/kg	EN 12457	EN 12457	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10l/kg	L/S = 2 l/kg	L/S = 2 l/kg
Selenium	0.1	0.1	0.1		0.1	0.1	0.1	0.5	0.1	0.007 –0.2			0.1	0.15	3	0.1		0.006
Tin														0.4	2.3			
Vanadium					2.0	2.0	2.0	3.0		1.3			2.5	1.8 (8)	20			
Zinc	4	4	18	2.8	4.0	4.0	4.0	12	4	1.2	2.2	2.6	30	4.5	14	4	0.2	2
Others																		
DOC					500	500	500	500	500							500		240
TDS																4 00 0		2 500
KW index	1 (1)	3 (1)	5 (1)															
Phenol index	1	1	1						1							1		0.5
Ammonium — N	1 (1)	4 (1)	8 (1)															
Chloride (Cl^-)	800	800	1 000		800	800	800	2 400	800		147	11.000	1.000	616 (9)	8 800	800	300	550

	Austria (1)			Belgium (2)	Finland (3)				Spain (4)		Sweden		Italy (5) (7)	Netherlands 'soil quality regulation'		Disposal criteria (6)	Denmark (7)	Disposal criteria (6)
Leachability (**) **(mg/kg DS)**	A+	A	B		Covered structure	Paved structure	Covered structure	Paved structure	CA	BC	General use	Specific use		Un-moulded materials	IBC		CAT1	
Covered waste/ material	C & D	C & D	C & D	C & D, ashes, slags	C & D	C & D	Ashes	Ashes	Slags	Slags	C & D, ashes, slags	C & D, ashes, slags	C & D, ashes, slags	Con-struction materials	Ashes		Ashes	
General unit	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS	mg/ kg DS
Test method	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	NEN 7343 L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10/kg	EN 12457	EN 12457	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10 l/kg	L/S = 10l/kg	L/S = 2 l/kg	L/S = 2 l/kg
Electric conductivity (mS/m)																		
Fluoride (F^-)	10	10	15		10	10	10	50	10	18			15	55 (9)	1 500	10		4
Bromide														20 (9)	34			
pH value [-]	7.5 – 12.5 (1)	7.5 – 12.5 (1)	7.5 – 12.5 (1)															
Nitrite-N	0.5 (1)	1 (1)	2 (1)															
Sulphate-SO_4	1 500 (1)	2 500 (1)	5 000 (1)		1 000	3 000	1 000	10 000	1 000	377	227	8 500	2 500	1 730 (9) (10)	20 000	1 000	500	560

Source: Umweltbundesamt (2008).

(**) The applicable test methods have to be taken into consideration if comparing leaching limits of different Member States.

(1) Including specific limits for recycled building materials according to different quality classifications (A+, A and B) and general limits for construction and demolition waste applicable for recovery processes.

(2) Limits and conditions for use of selected construction and demolition waste, slags and ashes as non-shaped building material.

(3) C & D: limit values for concrete chippings made of dismantled concrete structures or concrete waste; ashes: limit values for ashes from coal combustion.

([4]) Leaching limit values for the use of slags in Cantabria (CA) and Basque Country (BC). In addition, they also set some detailed requirements for the use of slags.

([5]) Leaching limits obtained for different recovery activities.

([6]) Limits according to the decision on the acceptance of waste at landfills (Council Decision 2003/33/EC) related to landfills for inert waste.

([7]) Formal limit values are expressed in µg/l but are recalculated to mg/kg by multiplication with the applied L/S ratio.

([8]) Notwithstanding the emission requirements given, a requirement of 4.6 mg/kg DM for vanadium applies in the case of the use of unmoulded steel slag.

([9]) Notwithstanding the emission requirements given, the following applies to the use of building materials in places where direct contact is (possible) with seawater or brackish surface water with a natural content of more than 5.00 mg/l: (a) no emission for chloride and bromide, and (b) the emission requirements given for sulphate and fluoride multiplied by a factor of four.

([10]) Until one year after the regulation is in force, an emission requirement of 2.430 mg/kg dm applies.

Table 20: Leaching limits (µg/L DS) defined in European countries

	Germany (1)						Denmark (3)			Italy (2)	Spain
Leachability (**) (mg/kg DS)	C & D	BF	GC	ST	BA	FA	CAT1	CAT2	CAT3		Catalonia
Covered waste/ material	C & D	Slags	Slags	Slags	Ashes	Ashes	Ashes	Ashes	Ashes	C & D, ashes, slags	Slags
General unit	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L
Test method	DIN 19528 (Column test)						EN 12457 -3 (L/S 2 1st step)	EN 12457-3 (L/S 2 1st step)	EN 12457-3 (L/S 2 1st step)	EN 12457 -2 L/S 10	DIN 3841 4-S4
Metals											
Antimony											
Arsenic					25	100	0–8	0–8	8–50	50	0.1
Barium							0–300	0–300	300–4 000	1 (mg/l)	
Beryllium										10	
Cadmium						35	0–2	0–2	2–40	5	0.1
Chromium total	50–100					1 700	0–10	0–10	10–500	50	0.5
Chromium VI											0.1
Cobalt										250	
Copper	40–100						0–45	0–45	45–2 000	0.05 (mg/l)	2
Lead							0–10	0–10	10–100	50	0.5
Molybdenum				35–230	800	3 000					
Manganese							0–150	0–150	150–1 000		
Mercury							0–0.1	0–0.1	0.1–1	1	0.02
Nickel							0–10	0–10	10–70	10	0.5
Selenium										10	
Vanadium	30–100		30	25–800	65	1 000				250	
Zinc							0–100	0– 00	100–1 500	3 (mg/l)	2
Others											
pH value [-]	7–12.5	9–12	9–12	10–13	10–12	8–13				5.5–12.0	
Asbestos										30 (mg/l)	

COD										30 (mg/l)	
DOC											
PAH	3–15										
Phenol index											
TDS	4 000										
Electric conductivity (µS/cm)	2 000–10 000	5 000–7 000	1 000	10 000	2 000	13 000					6 000
Cyanides										50	
Nitrite-N (mg/l)										50	
Chloride (Cl^-) (mg/l)							0–150 00 0	0–150 000	150 000–3 000 000	100	
Fluoride (F^-) (mg/l)				0.75–4						1.5	
Sodium							0–100 000	0–100 000	100 000–1 500 000		
Sulphate-SO_4 (mg/l)	200–1 400	900–2 500	200		500	5 000	0–250 000	0–250 000	250 000–4 000 00 0	250	

Source: Umweltbundesamt (2008).

(**) The applicable test methods have to be taken into consideration if comparing leaching limits of different Member States.
(1) Draft ordinance. Specific limits values for recycled construction materials (C & D), blast furnace slag (BF), granulated cinder (GC), steel slag (ST), bottom ashes (BA) and fly ashes (FA).

(2) Leaching limits obtained for different recovery activities.

(3) Limit values for the three quality categories (CAT1, CAT2 and CAT3) on residual products (including bottom and fly ashes from coal fired power stations).

3.2.3 Market assessment

In order to understand the market effects of end-of-waste criteria it is important to understand the market for primary, secondary and recycled aggregates. The aggregates market is influenced by a number of factors:

- taxation on primary aggregates
- landfill taxation
- availability and cost of primary aggregates
- public perception or consumer acceptance.

An analysis of production volumes (see 3.2.1.1 Production volumes) shows that the use of recycled and secondary aggregates differs from country to country. Waste management policies (landfill taxes) and restrictions on the use of natural resources (taxation on natural aggregates) are the main reasons for the differences. Countries with taxes on landfill and primary aggregates extraction have the highest recycling rates. Additionally, in some countries the quantification of recycled aggregates produced and used on the demolition site are not quantified as well as road residues reused in situ.

Additionally, the existence of national provisions and guidelines, which guarantee the quality of secondary and recycled aggregates, increases the user perception of and the consumer confidence in the use of recycled and secondary aggregates.

Low prices for disposal do not favour the recycling of the input material used in the production of recycled and secondary aggregates. The decision to go for recycling is strongly dependent on the price of disposal. The low price of primary aggregates, including low transport costs, makes the substitution of primary materials for recycled and secondary aggregates difficult. This, together with a lack of rules to guarantee the quality of secondary aggregates, explains the low recycling rates.

Furthermore the aggregates market is influenced by the demand of building materials, which depends on the situation of the construction sector highly linked to the economic situation.

3.2.3.1 Taxation on natural aggregates

Several Member States have implemented taxation on primary aggregates. There are different motives behind this (Umweltbundesamt, 2008. Swedish Environmental Protection Agency, 2004).

- With a tax on resource extraction, the rate of extraction will decline and the resource will not deplete as quickly, if the tax is high enough.
- As in many other production processes, natural resource extraction tends to give rise to pollution and waste. For instance, mining and minerals processing may cause air and underground water pollution, and also produce solid waste. The case for policy intervention in the form of pollution taxes and/or taxes on waste is very strong here. With such a tax, the natural resource owner has an incentive to consider these undesirables.
- Since all materials extracted eventually become emissions to nature, the current rate of extraction equals the future amount of emissions or waste. Taxing virgin material inputs can thus be a means of preventing the transformation of materials into waste and emissions, for example through taxes that are levied on the consumption of different natural resources (and not only on the extraction). For obvious reasons, the pros and cons of this type of input taxation are very similar to those outlined above for output taxes. Taxes on resource inputs levied at the point of distribution are likely to be cheaper from an administrative viewpoint than are pollution charges.

An overall motive for implementing taxes on virgin natural resources represents a combination of three others; taxes on natural resources may be used as a way of encouraging the substitution of secondary and recycled materials for virgin materials. This approach cannot always be justified on the grounds that it saves virgin resources. However, in general, virgin materials are often associated with more negative externalities than recycled materials. One commonly cited reason is that the processing of secondary materials tends to be less energy intensive. In addition, recycling is one way of avoiding the disposal of solid waste. Taxes on virgin materials will change the relative price of virgin and recycled materials and, in this way, influence waste disposal behaviour. Theoretically, charges on waste disposal would be a good policy in this case, but several studies have also argued that direct charges on waste disposal can be ineffective because of the risk of illegal disposal.

For example, Sweden introduced taxes on natural gravel in 1983. The main motives were conservation and material substitution given that if the level of the production stays the same as 1996 the natural gravel will run out in 40 municipalities within 20 years. With the aim to decrease the annual extraction of natural gravel (to 12 million tonnes/year) and to increase the use of recycled material (up to 15 % of total use) the tax was raised to SEK 10/tonne in 2003. The tax is levied on extraction consumed in Sweden and on extraction for export but not on imports. Theoretically, imports thus become cheaper, but this is unlikely to happen in practice because of high transportation costs.

Denmark, meanwhile, has set a tax of DKK 5/m³ for selected extracted raw materials including, sand, gravel, stones, clay and limestone. The Danish tax is levied on raw materials that are commercially extracted and consumed in Denmark or commercially imported, while no tax is levied on exports. The main intention, which dates back to 1990, is to reduce the use of these resources and encourage substitution with recycled materials.

The UK tax on aggregates came into effect in 2002. It is targeted at the extraction of sand, gravel and crushed rock and it is set at GBP 1.60/tonne. The tax is levied on the extraction of minerals for the production of construction aggregates and imports to the United Kingdom (with the exception of recycled aggregates) but excludes exports. Its main objective is to address the environmental costs associated with quarrying operations (noise, dust, visual intrusion, loss of amenity and damage to biodiversity). The tax is also intended to reduce demand for aggregates and encourage the use of alternative materials where possible.

The motives for taxing aggregates for environmental reasons appear to be mixed, and do not all find strong support in the economics literature. The virgin material conservation motive (i.e. reduce gravel use) may be valid if a relevant market failure can be identified, but in the presence of a well-defined owner of the resource, scarcity of the resource is not a market failure in itself. Moreover, a tax on aggregates extraction also reduces the incentive to find new deposits thereby limiting the economic availability of the resource. Taxing aggregates to promote the use of recycled materials is justified if the environmental net benefits increase as a result.

Further restrictions on planning permission for new extraction sites will make recycling essential — the scarcity of virgin aggregate that will inevitably be created by dwindling reserves will push up aggregate prices, making reuse of existing materials vital (Umweltbundesamt, 2008).

3.2.3.2 Landfill taxation

The purpose of landfill taxation is to make the landfill of waste more expensive than alternatives, forcing the separation or post-separation of waste streams into sub-streams suitable for recovery to become financially more attractive. Table 21

Table 21 shows examples for taxes in European countries.

Table 21: Landfill taxes for selected Member States
Source: Umweltbundesamt (2008)

Member State	Tax description	Related regulation	Tax/tonne of waste
Austria	Since 2006 for excavated materials and inert construction waste	Federal Legal Gazette I No 299/1989 — Act on the Remediation of Contaminated Sites as amended	EUR 8.00
	Since 2006 for inert residues	Federal Legal Gazette I No 299/1989 — Act on the Remediation of Contaminated Sites as amended	EUR 18.00
Belgium (Flanders region)	Specific waste from mining and mineral industries, and to recycling and soil sanitation residues	—	EUR 0.32–7.73
	Inert waste and inert asbestos	—	EUR 10.83
Czech Republic	Basic fee rate for disposal of non-hazardous waste on landfills for 2007 an 2008	Act 185/2001 Coll., on waste and amendment of some other acts, in the wording of later regulations	EUR 15.85 (EUR 1 = CZK 5.2340 on 18 February 2008)
Denmark	Landfill	No 570 of 3 August, 1998 Consolidated Act from the Ministry of Environment and Energy on Taxes on Waste and Raw Materials as amended by Act No 1034 of 23 December 1998 and Act No 380 of 2 June 1999	EUR 50.31
	Landfill of residual waste (slag and fly ash)	No 570 of August 3 1998 Consolidated Act from the Ministry of Environment and Energy on Taxes on Waste and Raw Materials as amended	EUR 28.40

Member State	Tax description	Related regulation	Tax/tonne of waste
		by Act No 1034 of December 23 1998 and Act No 380 of June 2 1999	
Finland	Waste taxes are paid on wastes left at public landfill sites, but are not applied to private or industrial landfills where these do not routinely receive wastes produced elsewhere. Fly ash is excluded from tax.	—	EUR 30.00
France	For hazardous and hazardous waste. Standard rate of EUR 9.50, sites with EMAS or ISO 14000 certification pay a reduced rate of EUR 7.50/tonne, non-authorised landfills pay a rate of EUR 18.29/tonne for municipal waste. Inert wastes disposed of in landfills for inert waste are not taxed. The rate for landfills operating without a licence is EUR 123.63/tonne	—	EUR 7.50–18.29
Germany	Germany does not have any taxation on the disposal of waste on landfill.	—	—
Italy	Industrial waste from mining, extractive, building and metalworking sector activities	Law 549/95	EUR 1.03–10.33
Netherlands	Waste more than 1 100 kg/ m^3 (non-combustible waste)	Environmental Taxes Act entered into force on 1 January 1995	EUR 13.98
Spain	Construction and demolition waste in the Madrid region.	Taxes for landfills are not generally implemented.	EUR 3.00
	Average value in the region Catalonia.	Taxes for landfills are not generally implemented.	EUR 10.00
United Kingdom	Since 1 April 2008 GBP 2.50/tonne for all	Statutory Instrument 2002 No 1559 —	EUR 3.36

Member State	Tax description	Related regulation	Tax/tonne of waste
	inactive waste (ceramic or concrete materials, furnace slags and ash). During 2008/09 tax year GBP 32/tonne for 'active' waste.	The Landfill Regulation 2002	EUR 43.06 (EUR 1 = GBP 0.7432 on 30 January 2008)

Source: Umweltbundesamt (2008).

Landfilling costs differ substantially. The prices can vary from EUR 3 to EUR 50/tonne of waste.

Figure 9: Evolution of landfill tax in the Netherlands

Type of waste	1995-1997	1998	1999	2000	2001	2002	2003	2004	2005
Combustible waste	13.25	29.13	29.75	64.28	65.44	78.81	81.65	83.61	84.78
Non-combustible waste	13.25	13.25	13.53	12.38	12.61	13.00	13.47	13.79	13.98

Source: Umweltbundesamt (2008), Bartelings, H. et al. (2005).

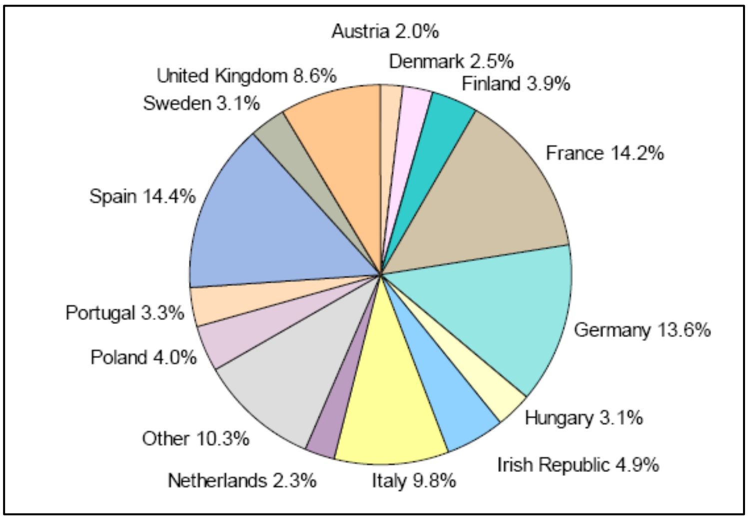
In the Netherlands, construction and demolition waste became subject to a landfill ban in April 2000. The exports of this waste stream rose mainly to Germany (940 000 tonnes in 2002). Of this, about 80 % is recovered and 20 % disposed of. Landfilling is cheaper in Germany than in the Netherlands. Also, the managers of German waste disposal sites have every interest in filling their sites as quickly as possible on account of an impending landfill ban. This provides an incentive not to sort imported waste, as is required, but to dispose of it immediately in landfills (Umweltbundesamt, 2008).

3.2.3.3 Availability and cost of primary aggregates

Secondary and recycled aggregates have to compete against primary aggregates (sand and gravel, and crushed rock). The availability and quality of both — the natural aggregates on the one hand and the materials, which compete with them on the other — are important criteria for the establishment of a market for secondary and recycled aggregates.

One indicator of the availability of natural aggregates is the produced amount of natural aggregates published in the *European Mineral Statistics*.

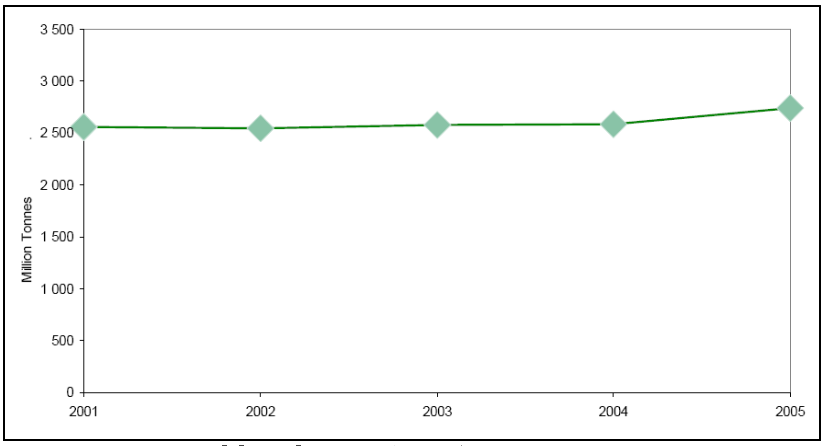
Figure 10: Production of natural aggregates in 2005



Source: Umweltbundesamt (2008),
Natural Environmental Research Council (2007).

Spain was the largest producer of primary aggregates among 31 European countries in 2005, with 395 million tonnes (14 %). In general, the production of natural aggregates increased to 2 742 million tonnes from 2001 to 2005.

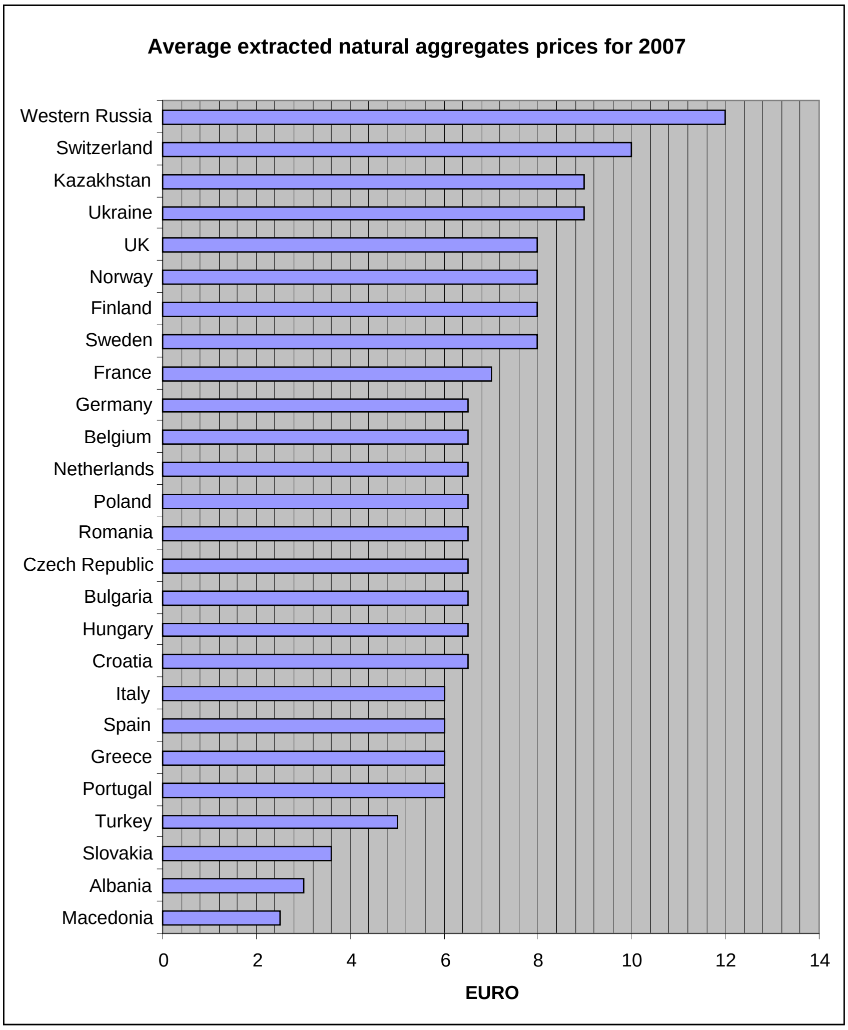
Figure 11: Production of natural aggregates 2001–05



Source: Umweltbundesamt (2008),
Natural Environmental Research Council (2007).

Prices of natural aggregates can vary dramatically from country to country depending on the availability of hard rock, limestone and sand and gravel resources, as well as quality.

Figure 12: Average natural aggregates prices 2007



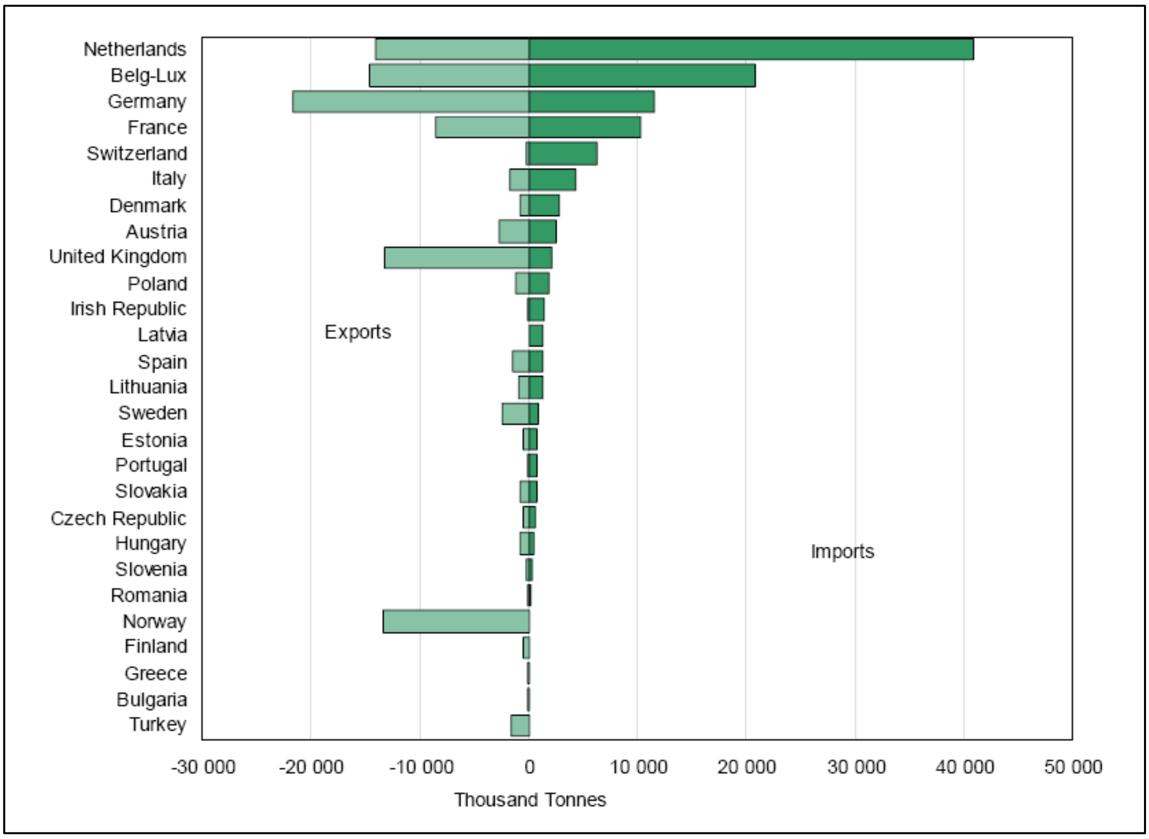
Source: Umweltbundesamt (2008), Aggregates Business Europe (2007).

In 2007 the highest price rises in natural aggregates were seen in eastern Europe, particularly in Bulgaria, Hungary, Romania and Russia. But prices there, with the exception of Russia, have yet to reach the prices commanded in more developed European markets. To compare aggregates prices around Europe, the exercise must be based on the extraction price and not the cost at the construction site, which will include transportation costs that could distort the overall picture. The average price in European countries is not just influenced by market forces but also by the type of resources in a particular region, so that the cost structure for extracting hard rock is different than for sand and gravel extraction.

In normal cases, primary aggregates have to be mined outside of highly populated regions and transported over long distances to the production areas or the areas where they are used.

Recycled and secondary aggregates are mainly generated within production or construction processes taking place near highly populated regions. This fact gives recycled and secondary aggregates some cost advantages in terms of lower transport distances. In some Member States obligations for recycling activities are related to the transport distance.

Figure 13: Natural aggregates in 31 European countries in 2005



Source: Umweltbundesamt (2008), Natural Environmental Research Council (2007).

Figure 13 shows the trade in natural aggregates. Norway and the United Kingdom were the largest net exporters. Germany was the largest exporter, in gross terms, but was also, with the Netherlands and Belgium-Luxembourg, a major importer. Total imports and exports of the 31 European countries are closely balanced from year to year and the considerable total trade (215 million tonnes) is almost entirely within this area.

3.2.3.4 Consumer acceptance

The acceptance of recycled and secondary aggregates by the final consumer is strongly linked with the waste status of the material. Even new products meet the same technical requirements consumers may find hard to trust them, especially when they products are made of waste. Establishing new products on the market requires active awareness raising and promotion even if they are cheaper.

With the end-of-waste criteria minimum quality requirements are defined providing guarantees for safe use of the material. This influences the consumer acceptance in a positive way. The CE mark associated with the fulfilment of technical requirements defined in the European standards, supports consumer acceptance and confidence in the recycled and secondary aggregates without, however, providing a totally secure guarantee of the environmental safety.

CE marking will be a good legislative driver but taxes or incentives to reduce dependence on virgin aggregates and make recycling a financially attractive alternative are also necessary in order to promote recycling.

3.2.4 Construction and demolition waste

3.2.4.1 Generation of construction and demolition waste

Construction and demolition waste (C & D waste) represents a very wide range of materials (see Table 25). To substitute natural aggregates, the mineral fraction of the construction and demolition waste is seen as the potential material for producing recycled aggregates. Depending on the generation of the waste, the following differentiation for C & D waste could be established (Umweltbundesamt, 2008):

construction waste: waste arising from the construction of buildings and/or civil infrastructure;

demolition waste: waste arising from the total or partial demolition of buildings and/or civil infrastructure;

road construction and maintenance waste: road construction material and associated materials arising from road maintenance activities;

soil, rocks and vegetation: waste arising from land levelling, civil works and/or general foundations.

The composition of the demolition waste varies according to the country where is generated. The construction techniques and materials differ from country to country and, consequently, so do the type of residues produced.

Construction waste mainly consists of damaged materials, excess materials left over at the end of the job, intermediate residues and packaging waste used for the construction materials.

Road maintenance generates a significant amount of road arisings. It mainly consists of excavating existing materials; reclaimed asphalt pavement (asphalt, aggregates), sub-base materials, soil and replacing them by new ones. Recycling of reclaimed asphalt pavement into new asphalt can result in both cost savings and reduced environmental impacts. The reclaimed material that cannot be recycled directly into the new asphalt is sent to C & D waste recycling centres.

To enable further recovery of waste in general and of construction and demolition waste in particular, it seems to be essential to separate and sort out defined fractions during the construction and demolition processes.

3.2.4.1.1 Selective demolition

Selective demolition/deconstruction processes and on-site separation are common techniques to produce 'high-quality' waste fractions which have the potential to be reused as construction material. In several Member States on-site separation of construction and demolition waste into specified fractions is obligatory.

Due to the additional works required for sorting and to selective demolition, the process is necessarily more expensive and lengthy. Costs associated with selective demolition could be 17–25 % higher than compared to normal demolition according to (Dantata N., 2005). On the other hand 'clean' material leads to cost saving; the gate fee at the recycling centre is reduced. Also the sale of reusable material and the fact that less waste is sent for disposal by maximising the recyclability of the demolition waste can compensate for the costs of selective demolition. However, these procedures entail higher costs. More time, special machinery and more space are needed.

An essential step both for deconstruction planning and for the quality assurance of the materials is the pre-deconstruction survey, building audit. Although it is not absolutely certain what will be found when structures are dismantled, carrying out such an audit reduces the uncertainty.

An audit consists of making a detailed description of the building and identifying materials. All available information, such as the construction, plans and history of the building need to be collected and analysed. Because deconstruction normally affects older buildings, reliable information is rarely available.

The next step is to prepare a bill of quantities identifying the materials/components with potential applications, tonnages and percentages of recycling/reusing opportunities. The production of the bill of quantities allows the identification of the full potential of the demolition materials, by establishing the quantities of materials which can be reused or recycled (EnviroCentre Ltd, 2003).

Deconstruction assessment tools for dismantling and recycling planning based on computer software are used to plan the demolitions. The configuration of the dismantling activities comprises the determination of the corresponding construction elements and the selection of the resources necessary. The dismantling order is determined and the optimal working schedules are defined (Schultmann F.).

The removal of hazardous material should be done while these materials are still integrated in the building or structure, avoiding the danger of contaminating the 'clean' waste.

Typically the deconstruction process is carried out as the reverse of the construction process. It involves removal of remains and built-in furniture, and then stripping, comprising internal clearing, removal of doors, windows, roof components, heater, heating, and electric installations, leaving only the foundations and main structures (Strufe N., 2005).

The demolition techniques to be used depend on a number of factors: structural form of the building, scale of construction and location, permitted levels of nuisances, scope, safety and time. The demolition process relies on six basic methods. The most commonly used methods are pulling, impact percussion and implosion. Heating, abrasion and bending are new methods which are not so frequently used (Hurley J. Hobbs G.).

3.2.4.2 Quantity

Mineral construction and demolition waste and mixed construction and demolition waste is one of the most significant waste streams. According to F.I.R (Fédération Internationale du Recyclage) more than 200 million tonnes of these wastes are produced in Europe (FIR, 2003).

The external contract on aggregates data gathering, compiled Table 22, which provides an overview on the C & D waste arisings and recycling rates. Statistics on C & D waste are difficult to obtain, and therefore footnotes have to be studied closely. About 390 million tonnes of C & D waste are produced each year in Europe.

Table 22: Arisings of construction and demolition waste in Europe

Member State/region	Year	Arisings (million tonnes)	% Reused or recycled	% Incinerated or landfilled
United Kingdom (England) ([1])	2005	89.6	80	20
Germany ([2])	2002	73.0	91	9
France ([3])	2004	47.9	25	n.s.
Italy	2004	46.5	n.s.	n.s.
Spain	2005	35.0	n.s.	n.s.
Netherlands ([4])	2005	25.8	95	3
Sweden ([5])	2006	11.0	n.s.	n.s.
United Kingdom (Scotland) ([1])	2003	10.8	96	4

Member State/region	Year	Arisings (million tonnes)	% Reused or recycled	% Incinerated or landfilled
Belgium (Flanders) ([6])	2006	9.0	92	n.s.
Czech Republic ([7])	2006	8.4	30	n.s.
Luxembourg	2005	7.8	46	54
Austria ([8])	2004	6.6	76	16
Denmark ([9])	2003	3.8	93	7
Portugal ([10])	1999	3.0	< 5	> 95
Estonia	2006	2.4	73	n.s.
Ireland ([11])	2005	2.3	43	57
Poland ([12])	2000	2.2	75	14
Belgium (Wallonia) ([13])	1995	2.1	74	17
Greece ([10])	1999	2.0	< 5	> 95
Finland ([14])	2004	1.6	54	46
Belgium (Brussels) ([15])	2000	1.2	59	22
Slovenia ([16])	2005	1.1	53	47
Lithuania ([17])	2006	0.6	n.s.	n.s.
Malta	2004	0.2	n.a.	n.a.
Bulgaria	n.a.	n.a.	n.a.	n.a.
Cyprus	n.a.	n.a.	n.a.	n.a.
Hungary	n.a.	n.a.	n.a.	n.a.
Latvia	n.a.	n.a.	n.a.	n.a.
Romania	n.a.	n.a.	n.a.	n.a.
Slovak Republic	n.a.	n.a.	n.a.	n.a.

(n.s. = not specified; n.a. = not available)

Source: Umweltbundesamt (2008).

([1]) Arisings include C & D waste and excavation waste (only inert C & D waste; there is no reasonable data for the non-inert fraction); landfilled as waste: 20 % England (2005), 4 % Scotland (2003).

([2]) The total arisings include 52.1 million tonnes mineral construction waste, 4.3 million tonnes construction site waste and 16.6 million tonnes road construction waste.

([3]) Arisings related to waste from construction, renovation and demolition of buildings.

([4]) The disposition of 2 % is not specified.

([5]) Coarse estimation of the generated amount of construction and demolition waste.

([6]) 8.25 million tonnes reused or recycled as aggregates and 0.75 million tonnes residual waste with unknown disposition.

([7]) Arisings related to C & D waste within the sectors ‘construction and demolition’ and ‘mining and quarrying’.

([8]) ‘Excavated materials’ and ‘construction/demolition wood’ excluded; recycling rate related to the amounts generated by the Members of the ‘Austrian Construction Materials Recycling Association’; 16 % disposed on landfills; the disposition of 8 % can be related to reuse, recycling or incineration.

([9]) Arisings related to waste generated in the ‘building and construction sector’.

([10]) According to Symonds Group (1999), ‘Construction and demolition waste management practices, and their economic impacts’.

([11]) Mixed C & D waste (concrete and rubble, as well as wood, glass, metal and plastics) excluding excavation waste like soil and stones.

([12]) The arisings include the waste types iron and steel, soil from excavations and deepening works, waste concrete and concrete debris coming from demolition and repair works, mixed debris and materials coming from demolition works, waste construction materials based on gypsum, soil and stones; 11 % of the arisings were brought to storage.

([13]) Arisings excluding excavated soils; the disposition of 9 % is unknown.

([14]) Excavated soils are excluded from the arisings.

([15]) The disposition of 19 % is not specified.

([16]) Calculation for reuse and recycling rate done for about 800 000 tonnes of the arisings.

([17]) Arisings including concrete, bricks, gypsum waste, hydrocarbonised road waste (surfacing material) and mixed construction wastes.

Several Member States already have reached a very high rate of reuse and recycling, such the Netherlands with a level of 95 %, Denmark with 93 %, Belgium (Flanders) with 92 % and Germany (91 %). In Belgium (Wallonia), Estonia, Austria and Poland approximately three quarters of the total volume is reused or recycled. Lower recycling levels are documented in the Czech Republic (30 %) and in France (25 %). In some Member States like the United Kingdom large amounts of excavated soil are included in the listed data, so it is not feasible to compare the data with the other Member States.

However, comparison between countries should be done carefully. Countries have different interpretations on C & D waste definition which may be misleading.

The disposal rates vary greatly in Member States. Whereas the disposal rate in Member States like the Netherlands and Denmark are close to 3 and 7 %. In Belgium, Germany, Austria and Poland less than 20 % of the construction and demolition waste is disposed on landfills. Ireland, Luxembourg and Finland have higher disposal rates at about 50 %.

3.2.4.3 Quality

Demolition waste composition varies according to the type of building or structure and also with the age of the building. The material reflects the construction techniques and materials used at the time they were built. Some of the materials used decades ago such as asbestos, are now banned and classified as hazardous substances (see Table 27). However, they are still present in old buildings, and consequently can be a source of contamination when the buildings are demolished.

The composition of the construction and demolition waste stream varies from one Member State to another, because it is affected by numerous factors, including the raw materials and construction products used architectural techniques and local construction and demolition practices.

The main wastes present in this stream are soil, concrete, bricks, tiles, ceramics, wood, glass, plastic, paper and metal. The composition also depends on the separation already carried out on the related waste stream. Wood (often differentiated into untreated and treated wood), paper, plaster, glass, plastic, metals and other non-mineral fractions are best avoided if the intention is to produce recycled aggregates from mineral construction and demolition waste. If separated, these fractions have to be recycled in an adequate way not discussed in this study. Table 23 shows a possible composition of mixed construction and demolition waste.

Table 23: Composition of construction and demolition waste

Component	Proportion (%)
Inert material	30
Non-recyclables	25
Wood	15
Inflammables	10
Metals	7
Sand	7
Glass	3
Paper	1

Source: FIR (2003).

Several Member States have published results of analyses concerning the composition of 'construction and demolition waste' in the past few years. Table 24 gives an overview of the typical composition within selected Member States. The data demonstrate a wide range of possible compositions which may distort statistics. Therefore comparison between countries should be done carefully. Approximately one third of C & D waste consists of concrete. The percentage of masonry varies from 6 to 35 %.

Table 24: Composition of construction and demolition waste in European countries

<table>
<tr><th>Component (in %)</th><th>Netherlands</th><th>Belgium (Flanders)</th><th>Denmark</th><th>Estonia</th><th>Finland</th><th>Czech Republic</th><th>Ireland</th></tr>
<tr><th>Year of publication</th><th>2001</th><th>2007</th><th>2003</th><th>2006</th><th>2006</th><th>2006</th><th>1996</th></tr>
<tr><td>Concrete</td><td>40</td><td>33</td><td>25</td><td rowspan="2">8</td><td rowspan="2">33</td><td>33</td><td rowspan="2">39</td></tr>
<tr><td>Masonry</td><td>25</td><td>6</td><td>6</td><td>35</td></tr>
<tr><td>Asphalt</td><td>26</td><td>4</td><td>19</td><td>4</td><td>—</td><td>—</td><td>2</td></tr>
<tr><td>Gravel</td><td>2</td><td>18</td><td>22</td><td>53</td><td>—</td><td>—</td><td>51</td></tr>
<tr><td>Timber</td><td>1,5</td><td>3</td><td>—</td><td>—</td><td>41</td><td>—</td><td>—</td></tr>
<tr><td>Metal</td><td>1</td><td>—</td><td>—</td><td>19</td><td>14</td><td>—</td><td>2</td></tr>
<tr><td>Miscellaneous</td><td>6,5</td><td>36</td><td>28</td><td>16</td><td>12</td><td>32</td><td>6</td></tr>
</table>

Source: Umweltbundesamt (2008).

Table 25: Adapted from the European Waste Catalogue ([99])

17	CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)
17 01	**concrete, bricks, tiles and ceramics**
17 01 01	concrete
17 01 02	bricks
17 01 03	tiles and ceramics
17 01 07	mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06
17 02	**wood, glass and plastic**
17 02 01	wood
17 02 02	glass
17 02 03	plastic
17 03	**bituminous mixtures, coal tar and tarred products**
17 03 02	bituminous mixtures other than those mentioned in 17 03 01
17 04	**metals (including their alloys)**
17 04 01	copper, bronze, brass
17 04 02	aluminium
17 04 03	lead
17 04 04	zinc
17 04 05	iron and steel
17 04 06	tin
17 04 07	mixed metals
17 04 11	cables other than those mentioned in 17 04 10
17 05	**soil (including excavated soil from contaminated sites), stones and dredging spoil**
17 05 04	soil and stones other than those mentioned in 17 05 03
17 05 06	dredging spoil other than those mentioned in 17 05 05
17 05 08	track ballast other than those mentioned in 17 05 07
17 06	**insulation materials and asbestos-containing construction materials**
17 06 04	insulation materials other than those mentioned in 17 06 01 and 17 06 03
17 08	**gypsum-based construction material**
17 08 02	gypsum-based construction materials other than those mentioned in 17 08 01
17 09	**other construction and demolition wastes**
17 09 04	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03

The treatment price of the construction and demolition waste depends strongly on the quality of the waste generated. The recycler defines the 'quality acceptance criteria' for the incoming waste accepted at the recycling centre based on the composition of the waste.
If the composition of the input material is defined then the gate fee and the treatment costs are both lower. On the contrary if the composition of input material is uncertain, the gate fee is higher due to the treatment necessary to remove unwanted materials (see Table 26).

([99]) Commission Decision 2000/532/EC (OJ L 226, 6.9.2000, p. 3).

Table 26: Gate fee, treatment costs and sales of recycled aggregates (EUR/tonne), in Germany and Austria
Source: Umweltbundesamt (2008)

Austria — takeover price, VAT and landfill costs excluded (if applicable)	Excavated soil depending on the quality	EUR 1,40–5,40
	Construction waste, sorted	EUR 10
	Construction waste, unsorted	EUR 19
	Construction waste, highly contaminated	up to EUR 160
	Used asphalt	EUR 3.50–7.00
	Broken concrete	EUR 7.30–14.50
Germany — takeover price	Concrete and asphalt	EUR 4
	High share of bricks, soil	EUR 8
Austria — treatment costs	Construction and demolition waste	EUR 6–7
Germany — treatment costs	Mineral construction materials (for plants with a capacity of 100 000 tonnes/year)	EUR 8–10
Austria — sale proceeds, VAT excluded	Mineral construction materials fulfilling the requirements defined in the guideline for construction materials	EUR 5–8
Germany — sale proceeds	Mineral antifreeze layer	EUR 3
	Crushed rock	EUR 5
	Crushed concrete	EUR 6

Source: Umweltbundesamt (2008).

3.2.4.4 Uses

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

Inert materials from construction and demolition waste can be reused as (Umweltbundesamt, 2008):

- fill on-site for constitution of landscape hillocks and anti-noise banks;
- sub-grade or sub-base and base courses of roadways with the addition of binders;
- wearing courses which can be regenerated in place, hot or cold;
- pavement which can be treated in place by mixture with binders;
- pavement which can be treated on the spot by crushing or screening before reemployment;

- fill with or without treatment.

Studies show that recycled aggregates are used in several segments as filling, foundation, asphalt and concrete (use in ready-mix concrete is embryonic in spite of the many studies referring to it).

The use of aggregates derived from construction and demolition waste in new concrete is much less common, and technically much more demanding. These materials therefore have the potential to divert equivalent volumes of primary aggregates, thus preserving non-renewable resources, with minimal need for landfill space. Reducing pressure on increasingly scarce landfill space is widely seen as one of the key benefits of recycling of construction and demolition waste.

3.2.4.5 Applied processes and techniques

The C & D waste recycling process is carried out at either a specialised recycling centre or it can be at the demolition site.

On-site recycling options depend on the nature of the project. If a substantial amount of waste is involved, the setting up of mobile equipment on-site could be viable. To minimise transport of aggregates, the processed material could be used on-site as secondary aggregates for the new construction.

On-site recycling can generate noise and dust in the surroundings. Space is needed for the machinery and for storing materials.

A separate recycling centre has the advantage of being more flexible in terms of holding stocks, positive marketing of recycled materials and quality control of the recycled materials. This type of plant enables the implementation of techniques to reduce or mitigate adverse environmental impacts from processing. However, two important issues influencing the quality and the price of the recycled materials in the case of non-selective demolition procedures essential to control input material are the cost of transporting the materials to the site and less control over the demolition process. Large off-site recycling plants operate in a similar way to conventional aggregates quarries, building up different stocks according to the specifications of the materials enabling a rapid response to market demand.

Nowadays, the market offers a wide variety of technical solutions in the form of equipment, which can be applied to recycling of construction and demolition waste, from simple mobile crushers for the inert fraction right through to fully integrated fixed recycling centres capable of dealing with the full range of construction and demolition waste streams.

It should be stressed that however sophisticated the technology and techniques available, selective demolition and the avoidance of treatment at the generation site are always likely to be far preferable to treating wastes at recycling centre.

Screening
Screening separates materials into different size fractions. Material retained on the screen is called oversize, and material passing through the screen is called undersize. Screening equipment can be used to remove contamination and large materials unsuitable for further

processing, or to produce specific aggregate types. Screens can be mounted in decks or placed in series, so that the undersize passing the first screen is further screened to remove smaller particles. This approach produces single-size aggregates and graded aggregates.

Screens can be made of mesh, bars, or from holes punched in plates. Screens can become blocked and require cleaning and maintenance. There are many different types of screens like such as screen decks, mats, plates, as well as trommel screens and vibration screens.

Crushing

Crushing is the breaking or grinding by mechanical means of rock, stone or recycled materials, for direct use or further processing. The main objective of crushing in aggregate production is to reduce the material to a specified size range. Grinding normally refers to the production of finer materials, using machines such as ball and rod mills. Crusher selection affects particle size and shape, as well as the way the plant will be configured.

Several types of crushing machines are used in aggregate processing, including compression type crushers, such as jaw and cone crushers and impact-type crushers, such as bar blow crushers or vertical shaft impactors.

Impact crushers use a high-speed rotor inside a container into which the material to be crushed is fed. There are typically four or six ‘hammer plates’ mounted on the rotor which breaks the material against ‘face plates’ set at operator-determined positions on the inner surface of the container. The ‘cutting’ action is very like that on a conventional cylinder lawnmower (for cutting grass). The throughput is greatly affected by the clearance between the rotating ‘hammer plates’ and the fixed ‘face plates’, and the rate of wear on the plates varies greatly according to the hardness of the material being processed.

Jaw crushers are typically shaped like a wedge, in which one of the faces moves relative to the others, producing a ‘chewing’ action which grinds the material into progressively smaller pieces as it passes towards the narrow end. Material is fed in at the wide end (the top), and falls out at the narrow end. The narrow end can be set to a range of openings to determine the nature of the resulting material.

The choice of an impact crusher over a jaw crusher reflects the fact that it produces a more consistent and predictable aggregate, with sharper edges on the individual granules. Impact crushers produce an aggregate with a smaller range of sizes, and although they are substantially cheaper to buy on a size-for-size basis, their running costs are much higher, particularly with very hard materials like some reinforced concretes. In general impact crushers tend to be designed for higher throughputs than jaw crushers.

Magnets

Magnets are used to remove ferrous materials from the feedstock. This is undertaken to, for example, avoid damage to the plant, recover valuable materials and improve the quality of the product. There are three broad types of magnets that remove ferrous material from the feedstock: suspended permanent magnets, belt magnets and drum magnets (including conveyor end roller magnets). In addition, eddy current systems can be used to remove non-ferrous metals such as aluminium.

Manual sorting
Manual sorting may be required when unwanted material cannot be reliably or efficiently removed by other methods, such as magnetic extraction or screening. The most common way for this to be undertaken is by using a picking station. Picking stations are essentially conveyor belts configured to allow operatives to remove unwanted items. This configuration includes the consideration of correct ergonomics, efficiency and safety.

Conveyors
Conveyors are generally electrically driven machines which extend from a receiving point to a discharge point, and convey, transport, or transfer material between these points. The most familiar form of conveyor is the belt conveyor. The other main form used in aggregates recycling is a vibratory conveyor, which is generally used as a feeder to assist the controlled loading of material into a plant.

Environmental equipment
Environmental equipment is used to control dust, noise and water from recycling operations (see 3.2.4.7 Environmental risks).

- For dust: hoods, screens, extraction fans, water suppression sprays, as well as sweeper, browsers and wheel washers, can be used to minimise dust effects.
- For noise: the equipment can be in the form of baffles, screens and belts encapsulating the noisy kit. Components within the machines that reduce the noise they make, such as elastomeric screening surfaces or linings to chutes and hoppers may also be used.
- For water: filters, settlement tanks, pumps and storage tanks are used to minimise solids emissions. These storage tanks can be used to process water retrieved from aggregate processing or to store water for use in aggregate processing, reducing the need for mains water on-site.

3.2.4.6 Quality assurance schemes

Some Member States have implemented quality assurance schemes associated with recycled aggregates produced from construction and demolition waste.

The Austrian construction materials recycling association developed guidelines for recycled aggregates to be used in construction works. The guidelines are not legally binding. They describe requirements, fields of application and general conditions for processing recycled construction materials. Fully compliance with the requirements is associated with a quality mark, issued by the Austrian recycled construction materials quality assurance association (Österreichischer Baustoff-Recycling Verband, 2004).

The guidelines define requirements and the nature and scope of the tests on the recovered materials. Quality provisions on environmental compatibility are also defined. Environmental parameters were agreed between the association and governmental authorities.

In particular the guidelines define general requirements associated with the generation of the construction and demolition waste, delivery, sorting, processing and storage. Structural engineering provisions and grades are also defined. The recycler must implement internal control procedures and testing to ensure that compliance with the requirements is monitored on a continuous basis. External inspection must be carried out by authorised laboratories, twice a year. The guidelines define the testing provisions for initial and external inspection as well as internal monitoring procedures and testing. Failure or deviations from the requirements may lead to additional requirements as part of the internal processing, increasing external monitoring or leading to temporary/permanent withdrawal of the quality mark.

In Belgium (Flanders) recycled aggregates can only leave the waste status if they are listed (use in or as a building material, 20 categories; use as soil components, six categories) and if they meet the VLAREA requirements on chemical composition. The requirements prescribe maximum total concentrations for heavy metals (guidance value) and organic compounds (imperative value). In addition leaching requirements have to be fulfilled. These values are imperative and based on marginal increase of soil concentration. Once a year the materials are sampled and analysed by a certified laboratory. If they meet the requirements and additional conditions they can lose the waste status.

The certification that is needed to become a secondary raw material must be executed by the Belgian quality control of products (COPRO) or the certification needs to be similar. Some of the certified aggregates additionally need a user certification.

The COPRO certification is a quality control of granulates/aggregates. It requires that the amount of non-stony materials is at most 1 % and the amount of organic materials is at most 0.5 %. These parameters are visual tested and are part of the COPRO certification.

The COPRO certification system requires the use of a calibrated weighbridge; periodical analysis of technical (construction) and environmental aspects; the use of clear-cut procedures (with clear responsibilities for acceptance, treatment and removal of the granulates); maintenance of a register for the incoming waste streams, outgoing recycled material and the waste not recycled.

The producers of recycled aggregates must have internal control implemented. They have to carry out an analysis for every 20 000 tonnes of aggregates.

The external control takes place minimum of four times and maximum of seven or eight times a year. The results are statically analysed and are compared with the results from internal testing. In case of errors or deviations, the producer may be penalised or suspended (De Schoenmakere M., 2008).

In Finland a quality assurance scheme has been developed on the initiative of the Finnish Federation of Environmental Enterprises and published as SFS standard 5884 — Production control of reclaimed concrete for earth construction. The standard specifies the basic requirements for a production control system, technical and environmental classification of crushed concrete products, technical and environmental properties to be monitored as well as sampling and monitoring methods. The properties to be monitored include leaching of Cd, Cr, Cu, Pb and SO_4^{2-}, material purity, grain-size distribution, compression strength and frost susceptibility. If material is classified in environmental Class 1, which may be used in unpaved constructions, the content of PAH and PCB shall also be investigated.

In the United Kingdom the WRAP aggregates programme (waste & resources action programme) was established in 2002 and aims to reduce the demand for primary aggregates by promoting the use of recycled and secondary aggregates, by providing quality management structure to deal with the definition of waste. Three quality protocols (England and Wales, Scotland and Northern Ireland) were developed to provide uniform control process for producers of recycled aggregates to demonstrate fully recovery of the material.

3.2.4.7 Environmental risks

Due to the wide range of materials used in construction, the possibility of hazardous contaminants has to be considered in the recycling processes with special emphasis given to leaching of dangerous substances.

Table 27Table 27 shows possible potentially hazardous elements in construction and demolition waste which could have an impact on the environment. In general, these hazardous substances should be banned as far as possible from materials which are intended to be used as aggregates.

The quantity of hazardous substances may seem relatively small compared with the total volume of the waste stream, but special precautions must be taken for their management since their presence may contaminate the entire waste stream, thus causing problems during the recovery or disposal of construction and demolition waste.

The use stage of the building/structure can also contribute to specific contamination. Concrete and bricks in chimneys can be contaminated by PAHs from the combustion of coal. Structures or buildings which were used for storage or industrial activities using fuels or oils, can have areas contaminated through historical leaks and spills.

Thermal insulation is a key issue in building energy efficiency. Insulation foams play an important role due to their space-saving qualities and the ease of prefabricating and applying them. They are used in the construction industry in roofs, walls, gap fillers and floors. Blowing agents such as CFCs and HCFCs have been used as frothing agents and/or propellants (e.g. spray foams). These are associated with ozone depletion. Blowing agents are emitted during the production, installation, use and end-of-life phase of the insulation foams (Ashford P., 2005).

The release of the blowing agent from the insulation foams during the end-of-life phase depends on the shredding of the foam. The release is fast for fine particles and slow for large particles (Kjeldsen P. Scheutz C., 2003).

Table 27: Potentially hazardous materials in construction and demolition waste.

Product/material	Potentially hazardous component(s)	Potentially hazardous properties
Concrete additives	Hydrocarbon solvents	Flammable
Damp-proof materials	Solvents, bitumen	Flammable, toxic
Adhesives	Solvents, isocyanides	Flammable, toxic, irritant
Mastics/sealants	Solvents, bitumen	Flammable, toxic
Road surfacing	Tar-based emulsions	Toxic
Asbestos	Respirable fibre	Toxic, carcinogenic
Mineral fibres	Respirable fibre	Skin and lung irritants
Treated timber	Copper, arsenic, chrome, tar, pesticides, fungicides	Toxic, ecotoxic, flammable
Fire-resistant wasting	Halogenated compounds	Ecotoxic
Paints and coatings	Lead, chromium, vanadium, solvents	Toxic, flammable
Power-transfer equipment	PCBs	Ecotoxic
Lighting	Sodium, mercury, PCBs	Toxic, ecotoxic
Air-conditioning systems	CFCs	Ozone depleting
Firefighting systems	CFCs	Ozone depleting
Contaminated building fabric (including contamination due to previous use)	Radionuclide's	Toxic
	Heavy metals including cadmium and mercury	Toxic
	Biohazards (anthrax)	Toxic
Animal products	Biohazards (anthrax)	Toxic
Gas cylinders	Propane, butane, acetylene	Flammable
Resins/fillers, precursors	Isocyanides, anhydride	Toxic, irritant
Oils and fuels	Hydrocarbons	Ecotoxic, flammable
Plasterboard	Source of hydrogen sulphides	Flammable, toxic
Road planning	Tar, asphalt, solvents	Flammable, toxic
Sub-base (ash/clinker)	Heavy metals including cadmium and mercury	Toxic
Insulation foams blown with ODS	Ozone-depleting substances	Ozone depleting

Source: Based on Symonds Group (1999).

Additionally, substances considered not to be hazardous can create an impact to the environment. Gypsum is currently used in construction, and may be present in the waste stream. The material is non-inert and in contact with water may leach sulphates creating an impact to the environment.

In northern countries, de-icing salts are used to reduce the formation of ice on pavement structures. Their accumulation in the input material used in the production of recycled aggregates contributes to a potential release of chlorides in the use phase of the recycled material creating an impact to the environment (Samaris, 2006).

Furthermore, recycled aggregates containing concrete may lead to high pH (> 11), while the rate of carbonation, which depends on particle size/surface exposure, may lead to a reduction of the pH. Recycled aggregates containing concrete may release chromium VI. (Samaris, 2006).

One of the relevant issues associated with road residues is the tar content. Tar is considered a hazardous substance containing high levels of polycyclic aromatic hydrocarbons (PAHs), some of which are carcinogenic and have an impact on human health. Even though tar is no longer used in hot asphalt for road construction, the risk exists when old roads are reclaimed.

Additionally, in some countries, roads constructed in the past 30 years contain a wide range of materials such as municipal solid waste incinerator bottom ash. These materials create problems for the recyclability of the road residues.

Typically, the responsibility of the identification of this material is the responsibility of the relevant authority and the planning company. In some countries, it appears that if tar is found it is left *in situ* and resurfaced due to the additional handling and disposal costs of the material.

The processing of the construction and demolition waste has an environmental impact associated. These are the most important environmental impacts involved in the production of recycled aggregates (LUC and Wintec Environment, 1999).

- Dust is generated during the crushing and screening. Materials in storage may be a source of dust due to wind. The transport of the materials, and loading and unloading also creates dust.
- Noise is generated during the crushing and screening. Additionally, vehicle movements, loading, and unloading material contribute to noise disturbance.
- Emissions to water may occur during storage and processing of the construction and demolition waste. In particular, rain and dust suppression sprays cause solids to be released into drainage. If the processing includes washing, emission of solids and contaminants occur.
- Air emissions besides dust, are mainly associated with exhaust emissions from plant equipment and vehicles used in the processing.

3.2.5 Ashes from coal combustion

Solid fuels produce much more ash than liquid or gaseous fuels. Coal is one of the most frequently used fuels for electricity production. Sometimes other materials are co-combusted together with the coal. The coal is finely ground and is combusted in controlled conditions. The heat released is used for the production of electricity, and the mineral content of the coal is collected.

One of the driving forces for operating a coal power plant besides the production of electricity is ash production. Depending on the quality and composition there could be a market for the ash avoiding the disposal.

3.2.5.1 Generation and quality of ashes from coal combustion

The choice of system employed at a facility is based on many factors, such as the demand for energy (heat and power), the flexibility to deal with changing load conditions, the availability of the fuels, and the environmental situation at local, regional and national level.

The amounts of solid residues generated by fossil fuel combustion depend on the content of non-combustible substances in the fuel, i.e. ashes and sulphur. The main coal combustion residues are fly and bottom ash, boiler slag and fluidised bed combustion ash.

Fluidised bed combustion ashes are rich in lime and sulphur due to the desulphurisation process, so their application as aggregate, inert material is limited. In addition, the removal of SO_2 through flue gas desulphurisation or spray dry absorption generates solid sulphur residues such as gypsum.

Pulverised solid fuel firing

In more than 90 % of installed capacity of solid fuel combustion systems the fuel is pulverised before combustion. Two general lines are possible.

- Dry bottom ash furnace. The burning temperature of dry bottom furnaces is from 1 100 to 1 400 ^{o}C. During the coal combustion mineral particles are formed leaving the boiler at the bottom (bottom ash) or with the flue gas (fly ash).
- Slag tap furnace. The burning temperatures are higher from 1 500 to 1 700 ^{o}C and the fly ash is normally fed back to the boiler where it melts again and forms boiler slag.

Fluidised bed combustion furnace

For this type of furnace, solid fuel generally has to be reduced in size and homogenised. Fine particulates would be blown out of the fluidised bed, and large particulates would stop fluidisation. Ground coal and milled limestone for desulphurisation are fed to a fluidised bed combustion boiler. The fluidised bed consists of sand-like materials which are fluidised by addition of air from the bottom of the boiler. The coal and limestone are mixed and heated to 850–900 °C. The coal is burned and the limestone is decomposed and reacts with the sulphur from the coal.

Fly ash

This is a fine powdery spherical material (0.2 to 200 micron in diameter on average) transported with the exhaust gas from the furnace. It is separated by means of an electrostatic precipitator or by mechanical separation. Depending on the chemical composition, fly ash can be classified as:

- Siliceous fly ash, with pozzolanic properties. The pozzolanic activity of a material is defined as the capacity to react with calcium at an ordinary temperature in the presence of water so generating solid materials comparable to those from the reaction of cement (see Table 28). It consists essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3). Due to this, fly ashes are used in blended cements. The ashes react with the calcium hydroxide liberated by the reaction of Portland cement.
- Calcareous fly ash with high lime content, which presents hydraulic properties in addition to the pozzolanic properties. The hydraulic activity is capacity to harden in presence of water or moisture, retaining strength and stability. It consists essentially of reactive calcium oxide (CaO), reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3). Due to its hydraulic properties, fly ash can also be used as a hydraulic binder.

Fly ash can also be used to replace a certain portion on limestone and as a source of aluminate and silicate components to replace clay in clinker production.

Table 28: Chemical composition ranges of siliceous and calcareous fly ash in Europe. Source: ECOBA

	V siliceous fly ash (silica-aluminium)	W calcareous fly ash (sulphur-calcium)
SiO_2	38–55	20–88
Al_2O_3	20–40	0.6–19
FeO_3	4–17	1–22
CaO	1–10	2–52
CaO_{Total}	< 0.1–1.0	0.1–25
MgO	0.8–4.8	0.5–11
K_2O	1.5–5.5	< 0.1–3
Na_2O	0.1–3.5	< 0.1–2
SO_3	0.1–2.5	1–15

Bottom ash

During combustion, coarser particles from the mineral content of the fuel remain in the bottom of the boiler. This material is too heavy to leave the boiler with the exhaust gas, remaining in the bottom of the boiler. It is removed directly or by jets of water. The bottom ash particles are irregularly shaped with a rough surface. According to the type of application, bottom ash may need to be further processed, dewatered, ground or graded before being stored. Table 29 serves as an example of heavy metal content, in bottom ash and fly ash.

Table 29: (Heavy) metal content of coal bottom and fly ash

Heavy metal mg/kg	Coal	Bottom ash	Fly ash
Arsenic	10.8	12.0	43.9
Cadmium	0.07	0	0.295
Chromium	39.1	204.7	154.5
Copper	16.0	63.2	67.6
Lead	6.7	11.6	27.7
Mercury	0.28	0	0.1
Nickel	40.5	204.0	158.7
Selenium	0.99	0.6	1.4
Vanadium	41.3	94.7	169.0
Zinc	26.1	38.1	116.1

Source: Umweltbundesamt (2008), European Commission (2006).

Boiler slag

Boiler slag is a glassy material produced when the fuel is burned in slag-type furnaces at 1 500–1 700 ºC. The slag is removed from the furnace in a molten state and is cooled with water solidifying and resulting in glassy granules.

3.2.5.2 Quantity

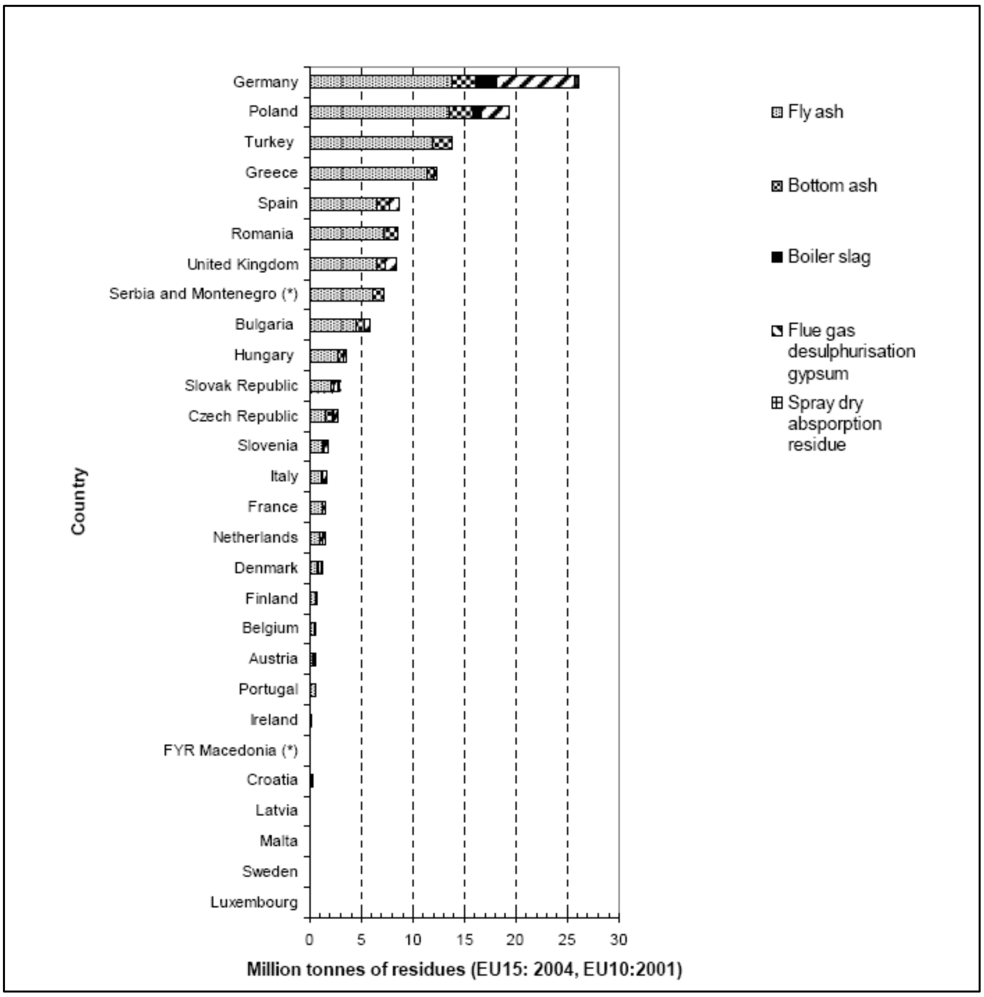
Within the EU-27, six Member States (Germany, Greece, Spain, Poland, Romania and the United Kingdom) account for more than 75 % of the total generation of residues. Differences between countries are to a large extent due to different amounts of coal consumption, but also to differences in the efforts made in installing flue gas cleaning technologies.

Table 30: Coal combustion residues in Europe 2004
Source: ECOBA, Umweltbundesamt (2008)

(million tonnes/year)	Fly ash	Bottom ash	Boiler slag	Flue gas desulphurisation gypsum	Spray dry absorption residue	Total	Percentage of the total	Year
Germany	13.88	2.28	1.95	7.66	0.28	26.05	29.10	2004
Poland	13.517	2.348	0.809	2.629	0.057	19.359	21.60	2001
Greece	11.392	0.659	0	0.292	0	12.343	13.80	2004
Spain	6.513	1.276	0	0.895	0	8.684	9.70	2004
Romania	7.159	1.378	0	0	0	8.537	9.50	2002
United Kingdom	6.513	0.81	0	1.05	0	8.373	9.30	2004
Bulgaria	4.47	0.826	0	0.616	0	5.911	6.60	2003
Hungary	2.724	0.51	0	0.378	0	3.612	4.00	2000
Slovak Republic	2.088	0.33	0	0.309	0.193	2.92	3.30	1998
Czech Republic	1.5	0.666	0.23	0.328	0.007	2.731	3.00	2005
Slovenia	1.343	0.033	0	0.382	0	1.757	2.00	2002
Italy	1.13	0.126	0	0.362	0	1.618	1.80	2004
France	1.341	0.142	0	0.068	0	1.551	1.73	2004
Netherlands	1.017	0.183	0	0.307	0	1.507	1.68	2004
Denmark	0.726	0.104	0	0.264	0.058	1.152	1.30	2004
Finland	0.535	0.093	0	0.07	0.028	0.726	0.80	2004
Portugal	0.544	0.049	0	0	0	0.593	0.70	2004
Belgium	0.396	0.061	0	0.056	0	0.513	0.57	2004
Austria	0.351	0.037	0	0.054	0.055	0.497	0.55	2004
Ireland	0.18	0.02	0	0	0	0.2	0.20	2004
Latvia	0.015	0.002	0	0	0	0.017	0.00	2003
Luxembourg	0	0	0	0	0	0	0.00	2004
Sweden	0	0	0	0	0	0	0.00	2004
Malta	0	0	0	0	0	0	0.00	2003
Estonia	—	—	—	—	—	—	—	—
Lithuania	—	—	—	—	—	—	—	—
Cyprus	—	—	—	—	—	—	—	—
Total	77.334	11.933	2.989	15.72	0.678	108.651	1.2123	

Source: Umweltbundesamt (2008) based on ECOBA.

Figure 14: Generation of coal combustion residues in Europe 2004



Source: Umweltbundesamt (2008).

Table 31: Generation of coal combustion residues in Europe, data gathered on reported data from Member States

	Year	Fly ash (million tonnes/year)	Bottom ash (million tonnes/year)
Germany	2004	13 150	2 280
Poland	2000		
Greece	2004	11 400	0.670
Czech Republic	2006	2 130	3 025
Slovenia	2006	0.690	0.230
Netherlands	2000	0.961	0.153
Denmark	2004	1 470	
Finland	2006	0.670	0.380
Belgium	2000	0.542	0.083
Austria	2004	0.520	0.067
Ireland	2004	0.186	0.36 (1998)
Sweden	2005	0.045	0.019

Source: Umweltbundesamt (2008).

There are differences between the yearly arisings mentioned in Table 30 and the arisings reported by Member States gathered by (Umweltbundesamt, 2008) Table 31. Particularly for Belgium, Czech Republic, Denmark, Austria, Slovenia and Finland there are big differences for no apparent reason. In general, it could be argued that the data reported by the national authorities or agencies are aggregated on a higher level summarising also waste types not typically related to coal combustion (e.g. ashes from waste incineration).

Residues from coal combustion in the EU-15 were stable in the 1990s and have since increased to amount to about 59 million tonnes annually and approximately 65 million tonnes in the 10 new EU Member States (about 30 million tonnes) and other European Countries (about 35 million tonnes). These amounts represent about 3.6 % and 4 % respectively of the total generation of waste and residues from all economic activities in the EU-15 and EU-10.

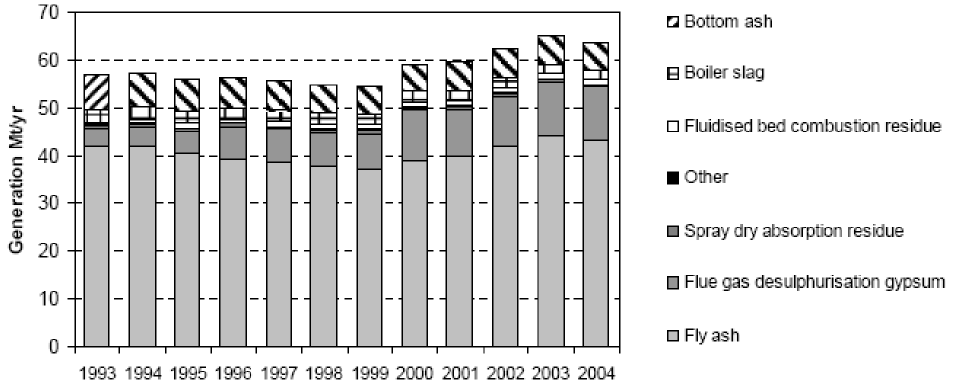
The trend towards a rising amount of sulphur residues reflects the steady increase in the number of flue gas desulphurisation units used to control SO_2 emissions, see Figure 15

Figure 15.

There was a declining trend in ash generation during the 1990s but another increase from 1999 onwards. The decline in the 1990s can partly be explained by a reduction in the use of coal as fuel in this period, combined with a switch towards the use of coal of higher quality, with lower ash content. The subsequent increase indicates a return to the use of coal as fuel.

The future generation of coal combustion residues is difficult to predict, because it is affected by several factors. On the one hand, the progressive installation of air pollution control equipment in power plants, avoiding gas and particle release to the atmosphere, can result in increasing amounts of residues being generated in the coming years. On the other hand, a possible reduction in the use of coal for power generation and a switch to low-ash and low-sulphur-containing coal can result in an overall decrease of residue generation.

Figure 15: Trend in the generation of coal combustion residues in the EU-15



Source: ECOBA (2006)

Note: Low-volume residues that comprise other solid and liquid streams such as coal mill rejects, coal pile runoff, boiler and cooling tower blowdown, or water and wastewater treatment sludge are not included. They account for less than 1% of the total volume of residues.

Source: Umweltbundesamt (2008).

3.2.5.3 Uses

In the EU-15, almost all gypsum from flue gas desulphurisation and all boiler slags are used mainly as construction materials. Ash is used as construction material but also as filling material in opencast mines, quarries and pits, see Table 32

Table 32.

Table 32: Utilisation of coal combustion residues in the EU-15

		Utilisation based on the substance's properties in e.g. cement, concrete, gypsum	Use as filling material in civil works and underground mining	Use as restoration and filling material in open cast mines, quarries and pits	Temporary storage	Disposal (landfill, dumping)	Other uses
Fly Ash	**2001**	33,40%	12,50%	42,60%	7,70%	4,40%	1,10%
	2003	33,85%	12,56%	42,34%	7,83%	2,69%	0,73%
	2004	35,76%	13,20%	41,61%	7,14%	1,50%	0,78%
Bottom Ash	**2001**	25,80%	15,20%	47,80%	2,70%	8,10%	0,40%
	2003	27,57%	16,00%	44,16%	2,10%	10,08%	0,10%
	2004	22,84%	14,36%	48,24%	3,35%	9,73%	1,48%
Boiler Slag	**2001**	6,70%	62,10%	0,00%	0,00%	0,00%	31,30%
	2003	7,63%	53,27%	0,00%	0,00%	0,00%	39,10%
	2004	9,08%	57,54%	0,00%	0,00%	0,00%	33,38%
FBC-Ash	**2001**	1,90%	49,40%	13,50%	9,70%	23,20%	2,40%
	2003	0,00%	48,67%	16,35%	3,67%	28,83%	2,48%
	2004	2,15%	47,95%	29,88%	14,16%	3,91%	1,95%
SDA-residue	**2001**	4,70%	43,60%	35,90%	0,00%	6,40%	9,30%
	2003	4,49%	6,53%	36,73%	0,00%	43,88%	8,37%
	2004	7,84%	23,04%	39,19%	0,00%	19,95%	9,98%
FGD-Gypsum	**2001**	72,50%	0,00%	12,70%	14,20%	0,60%	0,10%
	2003	66,93%	0,00%	17,43%	15,41%	0,23%	0,01%
	2004	66,93%	0,00%	17,43%	15,41%	0,23%	0,01%

Source: ECOBA (2003,2006)

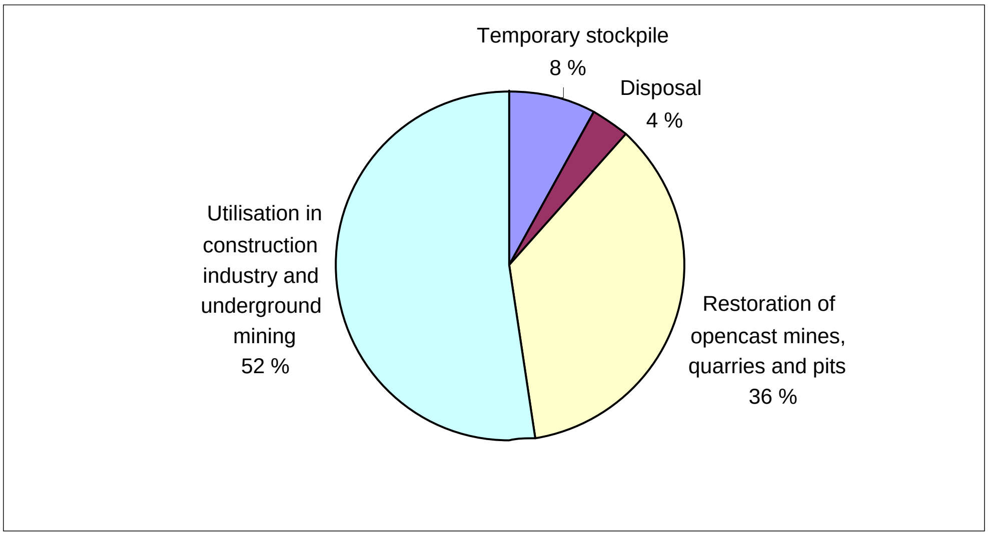
Notes: FBC: Fluidised bed combustion; SDA: Spray dry absorption; FGD: Flue gas desulphurisation

Source: Umweltbundesamt 2008.

The European Coal Combustion Products Association (ECOBA) statistics on the production and utilisation of residues from coal combustion reflect the typical combustion products fly ash (FA), bottom ash (BA), boiler slag (BS) and fluidised bed combustion (FBC) ashes as well as the products from dry or wet flue gas desulphurisation, especially spray dry absorption (SDA) residue and flue gas desulphurisation (FGD) gypsum.

Most of the coal combustion residues are used in the construction industry, in civil engineering and as construction materials in underground mining (52.4 %) or for restoration of opencast mines, quarries and pits (35.9 %). In 2003, about 8.0 % were temporarily stockpiled for future utilisation and 3.7 % were disposed of (Umweltbundesamt, 2008).

Figure 16: Utilisation of coal combustion residues in the EU-15 (total production 65 million tonnes)



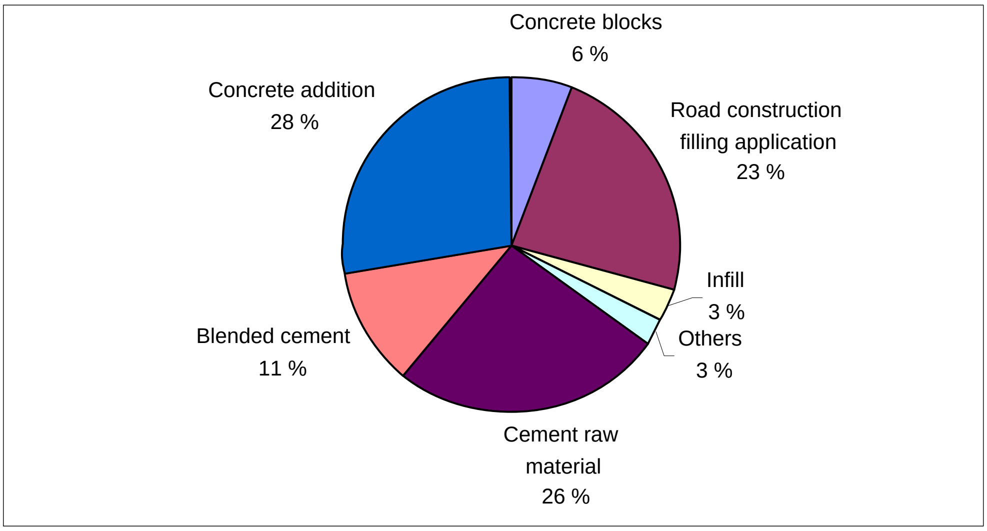
Source: Umweltbundesamt (2008).

Utilisation of fly ash

Fly ash is the most important coal combustion residue and accounts for nearly 70 % of the total amount. Approximately 33 % of the total fly ash produced in Europe is used as cement raw material, as a constituent in blended cements and as an addition for the production of concrete. This means that it is a main constituent of the cement or else it replaces part of the cement necessary for the production of concrete.

In 2003, about 21 million tonnes of fly ash were utilised in the construction industry and in underground mining. Most of the fly ash produced in 2003 was used as a concrete addition, in road construction and as a raw material for cement clinker production, see Figure 17. Fly ash was also utilised in blended cements, in concrete blocks and for infill, i.e. for filling voids, mine shafts and subsurface mine workings.

Figure 17: Utilisation of fly ash in 2003



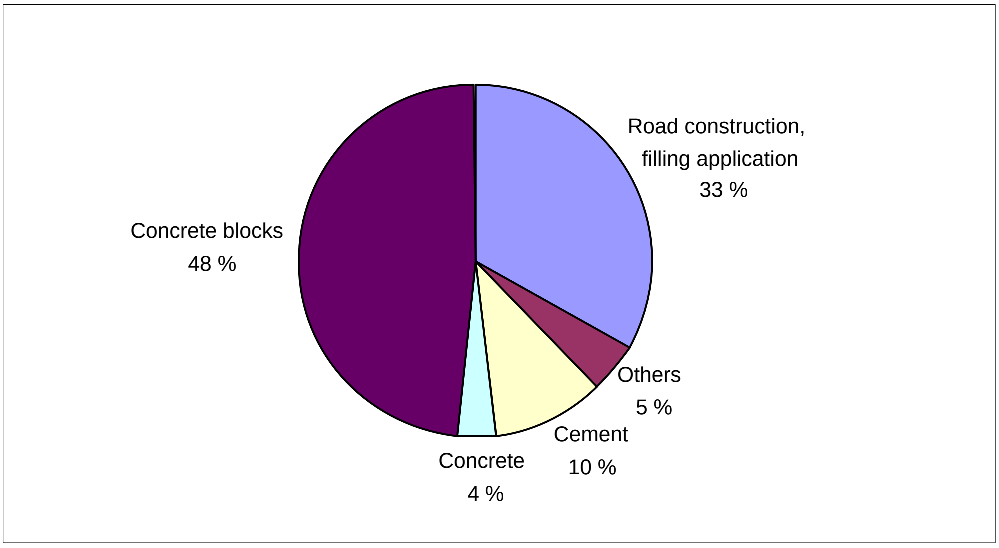
Source: Umweltbundesamt (2008).

Fly ash contains the largest part of condensed (heavy) metal. Critical parameters for use in cement ignition loss, sulphates, Cl (physical, chemical, mechanical parameters of cement are regulated in the European Standard EN 197-1).

Utilisation of bottom ash

Bottom ash is produced as a granular material and removed from the bottom of dry boilers. It is much coarser than fly ash. In 2003 about 6 million tonnes of bottom ash were produced in Europe. About 2.7 million tonnes were used in the construction industry. Of this, 48 % was used as fine aggregate in concrete blocks, 33 % in road construction and about 14 % in cement and concrete.

Figure 18: Utilisation of bottom ash

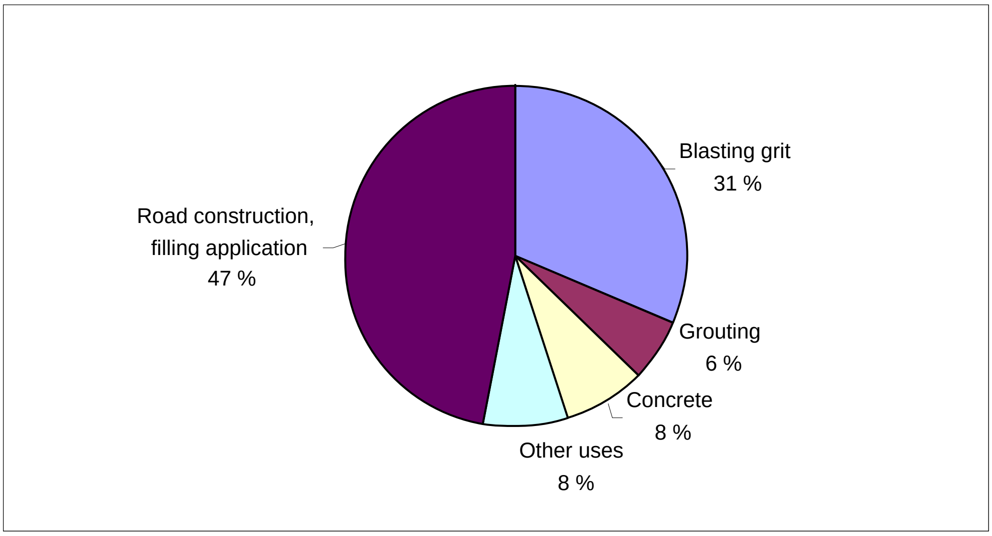


Source: Umweltbundesamt (2008).

Utilisation of boiler slag

Boiler slag is a glassy material of which about 55 % was used in road construction in 2003, for example as a drainage layer. Another 31 % was used as blasting grit and smaller amounts as aggregates in concrete and grout. In 2003, about 2.1 million tonnes of boiler slag were produced in Europe (EU-15).

Figure 19: Utilisation of boiler slag



Source*:* Umweltbundesamt (2008).

Requirements and standards for the use of fly ash and bottom ash

As a raw material for cement clinker production
There are no standards or directives for the use of coal ash as a raw material for cement clinker production. Nevertheless, the raw material situation of a cement plant, i.e. the composition of the limestone and marl resources and the plant technology cause specific requirements for fly ash quality. Furthermore, fly ash needs to be licensed as a raw material component for the cement plant.

As a constituent of blended cement
The requirements for siliceous and calcareous fly ash for use as a constituent of blended cements are defined in European Standard EN 197-1. Besides requirements for the basic composition in view of reactivity, limit values are defined for specific parameters (loss on ignition, sulphur, chlorine) to avoid unsoundness or damaging reactions in concrete constructions. Over the last years about 2 million tonnes of fly ash per year have been used for this application. As the cement industry is obliged to reduce CO_2 emissions from cement production this amount is expected to increase.

As an addition to concrete
Fly ash has been successfully used in concrete around the world for more than 50 years. In Europe approximately 30 % of the fly ash produced is used as a concrete addition and is replacing a part of the cement necessary for the production of concrete. Technical

requirements for the use of fly ash for concrete are given in European Standard EN 450 'Fly ash for concrete'. The standard was first published in 1994 and the revised standards EN 450-1 'Fly ash for concrete — Part 1: Definition, specifications and conformity criteria' and EN 450-2 'Fly ash for concrete — Part 2: Conformity evaluation' will be published this year by the national standardisation bodies in Europe. The standards refer to siliceous fly ash only. Calcareous fly ash — mostly obtained from the combustion of lignite — cannot be utilised as concrete addition according to EN 450.

In road construction

For the use of coal ashes in road construction bound and unbound applications have to be considered. Unbound applications cover use in, for example, base layers as filling material, dam construction or soil beneficiation. Bound applications cover the use in hydraulic road binders and concrete for road construction. For these applications national and/or country-specific regulations of road construction authorities have to be fulfilled. Furthermore, the European standards for soil beneficiation with fly ash (prEN 14227-13), fly ash bound mixtures (prEN 14227 — Part 3) and for fly ash for hydraulically bound mixtures (prEN14227 — Part 4) have to be considered.

The two last European standards refer to siliceous or calcareous fly ash which is produced from the combustion of pulverised coal or lignite in power plants. For use in hydraulic road binders the requirements of European Standard prEN 13282, currently under revision, have to be considered. The requirements for fly ash are based on the definitions given in the cement standard EN 197-1.

It has to be noted that these European standards, as of now, are not harmonised. They can be used in addition to or instead of national regulations. In Germany, national regulations to be considered for road construction include the regulations of the road and transport research society FGSV (Forschungsgesellschaft für Straßen und Verkehrswesen), while in the Netherlands they are based on the Building Materials Decree (BoustoffBesluiten).

As aggregates

On 1 June 2004 new harmonised European standards for (heavy) aggregates for concrete (EN 12620) and for lightweight aggregates for concrete, mortar and grout (EN 13055-1) were introduced. These standards contain requirements regarding the characteristics of aggregates and the conformity criteria. The standards have a common structure in view of the definition of categories, as in European countries different climates cause different requirements. National authorities have to introduce the relevant categories in their country by for example, national application documents. In Germany, the application documents DIN V 2000-103 for aggregates for concrete and DIN V 2000-104 for lightweight aggregates (defined in clause 1 — Area of application) give types of industrially manufactured aggregates that may be used in concrete in accordance with the technical standards, i.e. bottom ash.

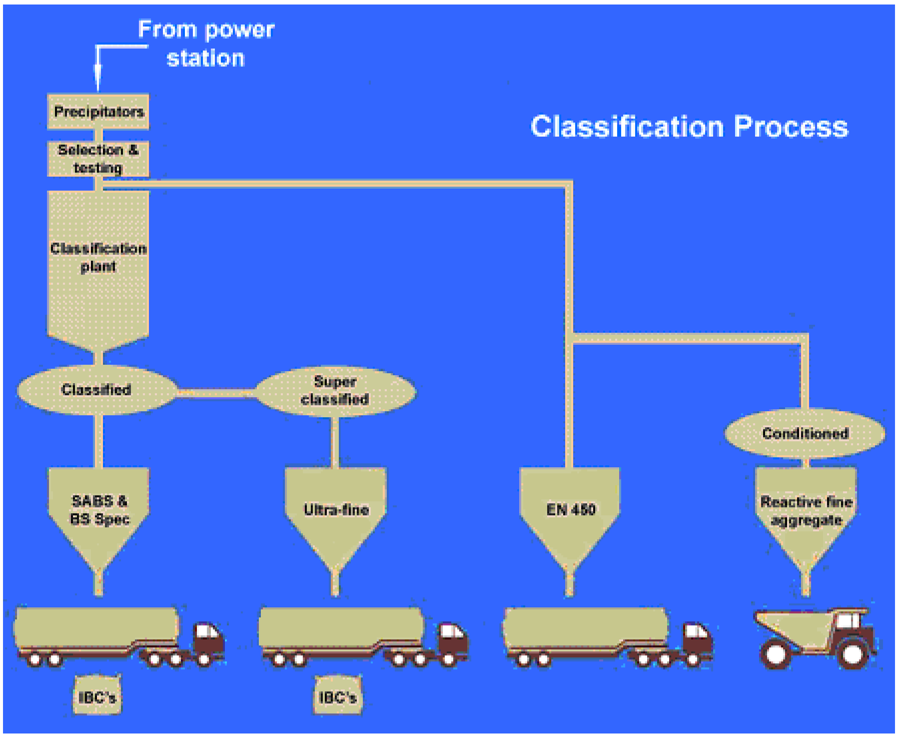
3.2.5.4 Applied processes and techniques

Coal ash taken as run-of-station is limited in the markets into which it can be sold. Developing specifications for construction products and other higher value applications demands some form of residue improvement. There is the concept that materials initially regarded as wastes may be improved through a process of quality control and upgrading to become increasingly accepted as a valuable resource, and ash can be treated in this way via beneficiation processes. A number of methodologies and systems for improving ash quality have been developed which include (Umweltbundesamt, 2008) including:

Classification and blending

Ash may be separated into components having useful properties through classification, usually by sieving into different size fractions. This process often helps reduce residual carbon content. A number of plants have been set up within Europe for beneficiation and blending. An example is shown below.

Figure 20: Example of classification process



Source: Umweltbundesamt (2008), Barnes, I. Lindon, S., (2004).

Ash milling

The size range distribution of fly ash is sometimes not ideal for specific applications and cannot be improved by classification and blending alone. For example, in high strength and high durability concretes, finer fly ash (< 10 µm) would be the preferred feedstock. Grinding or micronisation is sometimes used to reduce all particles to below the maximum size specified, allowing product properties to be enhanced.

Ash flotation

Ash flotation is practised in its simplest form by the separation of cenospheres from the surface of fly ash ponds. More complex flotation systems based on minerals processing technology use frothing and other agents to separate materials as a suspension. The process has been demonstrated as a viable method for separating carbon from fly ash. The downside is that the materials may require drying.

Magnetic separation technologies
Many fly ashes contain significant concentrations of ferromagnetic material and this may be refined by magnetic separation. Removing the magnetic fraction from fly ash, using an electromagnet, can produce ash which may impart higher flowability to mortars. The process often forms part of a combined system

Carbon removal
The presence of high levels of carbon restricts applicability. Consequently, considerable efforts have been made to develop techniques for its reduction. These techniques include carbon burnout, electrostatic separation, froth flotation, pneumatic transport separation and triboelectric separation. The electrostatic separator can readily process a wide range of fly ashes, reducing unburned carbon content from 30 % to a consistent 2 %, thus meeting all standards for use in concrete.

Chemical processing
Where a fly ash has a low pozzolanic activity, its reactivity can be enhanced by treatment with Na_2SO_4 or $CaCl_2$. Ashes having relatively high concentrations of leachable salts can be rendered usable by 'weathering over' in long-term storage ponds. Ash residues with high levels of free lime, particularly those from the newer clean coal technologies, can be rendered usable for cement and concrete applications by a hydration processing step.

Combined beneficiation technologies
A number of beneficiation and blending facilities have been set up for the production of quality-assured ash products. Some may specialise in, for instance, the supply of premium PFA and PFA cementitious products primarily to the construction sector, although specialist materials may also be produced.

For ashes to be used as aggregate, the processing is limited to crushing and sieving. For fly ash the material can be used directly without processing. For boiler slag and bottom ash, crushing could be used depending on the type of application.

3.2.5.5 Environmental risks

(Heavy) metals bound in coals are liberated during combustion and are released into the atmosphere on particles or as vapours. The adequate method for obtaining data on the behaviour of (heavy) metals during combustion and flue gas cleaning is to establish a mass balance across the total combustion installation considered (heavy) metal mass balance investigations have been carried out for various types of large-scale hard coal and lignite-fired power plants, also presented in BREF LCP 2006.

Because volatile metal elements are emitted in the gaseous form or enriched in the fine-grained particulate material carried downstream of the combustion chamber, the emission of these elements to the atmosphere depends more on the efficiency of the gas-cleaning system than upon the method of fuel conversion.

Most metal elements condense on the surface of particulates at lower temperatures and thus are enriched by a factor of 10–20 compared to coal. Volatile elements preferentially condense onto the surface of smaller particles in flue gas streams because of the larger surface area.

Mercury is a highly toxic metal with low vapour pressure thus escaping capture by flue gas control devices (Umweltbundesamt, 2008).

Each of the options for the utilisation of fly ash and bottom ash from coal combustion described in the previous sections has different specific criteria for the quality of ash it needs. In general, the quality criteria are connected to the physical and structural properties of the ash and the content and mobilisation potential of (heavy) metals.

Depending on their nature, some (heavy) metals detected in fly ash and bottom ash show a variety of adverse effects on human beings. From a toxicological point of view some (heavy) metals are classified as toxic (e.g. Pb, Cd, Cr (VI) and Hg), carcinogenic (e.g. Cd, Cr (VI)) or possibly carcinogenic (Hg and Ni). Some of them accumulate in the human being (such as Pb and Cd) and cause chronic diseases; others show strong irritant effects (such as Cr (VI)). Some are mutagenic and/or teratogenic (Umweltbundesamt, 2008).

Metals which are major concern with respect to fossil fuel utilisation are As, B, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Se, V, Tl, Sb, Mn, Sn and Zn. A reduction of (heavy) metal concentrations in the residues from coal incineration can be achieved by the use of ‘clean’ coal with a high heating value, with the ash content being an important parameter for the concentration of hazardous substances. Generally, coal purification is not a common practice in Europe (Umweltbundesamt, 2008).

It has been shown that metals which condense on the surface of particulates (in particular B, Mo, Se, As) are easier to mobilise than metals which are incorporated into the particulates matrix. Weathering increases the mobilisation of metals. The actual behaviour of pollutants in the ashes depends on the source of the ash and the total amount present. Besides, leaching behaviour is strongly influenced by the pH value of the solution with higher leaching rates at lower pH values (Umweltbundesamt, 2008).

The following Table 33 gives the leaching behaviour of the fly ash.

Table 33: Leaching results from fly ash analysis

µg/l	min	max	median	n	n'
As	1	270	15	362	20
Ba	1	1 490	380	141	1
Cd	0.02	5	1	372	152
Co	1	66	10	133	126
Cu	1	50	4	369	155
Hg	0.02	7	0.2	372	160
Mo	10	1 204	340	37	0
Ni	1	500	10	189	158
Pb	< 1	50	5	367	148
Sb	1	190	4	332	20
Se	0.2	880	40	163	16
Ti	0.5	100	4	191	145
V	0.1	1 110	10	336	201
Zn	0.5	60	7.0	363	152
B	25	6 360	2 310	129	2
Cr Total	1	1 250	280	374	10
F^{2-}	0.1	6 900	1 620	148	4
Cl^- mg/l	0.6	97.6	10	329	109
SO_4^{2-} mg/l	14	1 490	498	326	0
CN^-	5	50	10	131	129
CN_{if}	all values below detection limit detection limit = 10			101	101

Leaching test, DEV-S4 LS 10/1

min — minimum value
max — maximum value
median — median value
n — number of tests results
n' — number of test results below detection limit

Source: VGB Power Tech.

Special attention has to be paid to the quality of fly ash and bottom ash when waste is co-incinerated in power plants (Umweltbundesamt, 2008).

- Depending on the amount and composition of co-incinerated waste, the co-incineration of wastes in coal-fired power stations tends to lead to higher levels of contamination (compared to coal-only incineration) of fly ash and bottom ash. In addition to this, burn out behaviour may be badly influenced leading to higher concentrations of organic pollutants in solid residues.
- Higher contents of Cl, P and (heavy) metals are expected in ashes from co-incineration, compared to ashes from coal-only incineration.
- From an economic (operators’) point of view the use of bottom and fly ash in the construction industries is of commercial interest. Therefore, it should be common practice to monitor the waste composition (physical and chemical composition and the hazardous potential) strictly and to limit the share of waste input to a few per cent.

Apart from the environmental risks associated with the use material, the processing also may lead to an impact to the environment. Dust is considered the main problem, in particular for fly ash due to particle size. Where dust is generated, engineering control measures should be considered (water sprayers) to maintain the airborne dust concentration as low as is reasonably practical.

3.2.6 Slags from iron and steel production

Iron and steel slags are inevitably generated in the production of iron and steel. They have a long tradition as construction materials in road construction and hydraulic engineering. Their technical and engineering properties make them a desirable product in certain applications. The use of iron and steel slags as a construction material avoids the use of natural resources, and their disposal at landfill sites.

3.2.6.1 Generation and quality of slags from iron and steel production

Blast furnace slag
The blast furnace process remains by far the most important process for the production of pig iron/hot metal. A blast furnace is a counter-flow reactor in which iron-bearing materials (iron ore lump, sinter and/or pellets), additives (slag formers such as limestone and slag correction agents like bauxites etc.) and the main part reducing agents (coke) are continuously fed from the top of the shaft furnace. In counter-flow hot blast (sometimes enriched in oxygen) is injected at the bottom of the furnace. Additionally reducing agents are injected through the tuyers to minimise the use of coke. Mainly coal is injected, sometimes heavy oils are used and, recently, also spent plastics and other carbon residues are used as reducing agents for injection. The hot air blast reacts with the carbon of the coke mainly producing carbon monoxide, which, in turn, reduces iron oxides to iron metal. The hot reduction gas (a mixture of nitrogen, CO/CO_2 and H_2/H_2O) in counter-flow to the solid materials leaves the furnace at the blast furnace top (Umweltbundesamt, 2008; EUROSLAG, 2008).

Due to the exothermic reactions in the raceway of the blast furnace, iron ore is melted into liquid hot metal. The part of the furnace burden which cannot be reduced forms the liquid blast furnace slag by combining the remaining oxides, silicates and aluminates from the coal ash, the gangue of the ores and mainly lime and periclase from the added slag formers. At an average temperature of about 1 500 °C hot metal and blast furnace slag are tapped from the furnace. Due to its lower density slag floats on the hot metal. Hot metal and slag are separated in the skimmer in the main runner (EUROSLAG, 2008).

Depending on the final use, the liquid blast furnace slag is either granulated by rapid cooling (granulated blast furnace slag — GBS) forming a glassy material or poured into slag pits for slow air cooling (air-cooled blast furnace slag — BFS) resulting into a crystalline material. The glassy nature is responsible for its cementitious properties. The four major chemical components, calculated as oxides, are CaO, SiO_2, Al_2O_3 and MgO. Important for the quality of the granulated blast furnace slag (GGBS) is the content of TiO_2 and MnO which might have an influence on the latent hydraulic properties of the GBS (see Table 34).

Natural resources are subject of varying chemical compositions. Thus, the chemical composition of the slag is liable to the raw materials being used. There is no difference in the chemical composition of GGBS and BFS from the same source.

The main mineral phase in air cooled BFS is melilite, a calcium-aluminium-magnesium-silicate solid solution. This type of BFS is mainly used as aggregates in road construction. A small amount is ground into fine powder and used as fertiliser or liming agent in agriculture.

The chemical composition of blast furnace slag, which does not differ between the granulated, crystalline and pelletised slag is given in Table 34.

Table 34: Chemical composition of blast furnace slag

Parameter (*)	Typical content (w/w %)
CaO	40
SiO_2	37
Al_2O_3	11
MgO	9
S_{total}	1
TiO_2	0.8
K_2O	0.6
MnO	0.5
Na_2O	0.4
FeO	0.4
F	< 0.1
Ba	0.08

(*) Parameters with typical concentrations > 0.1 w/w % are usually declared in the form of oxides although they have varying specifications and are components of different mineral phases.

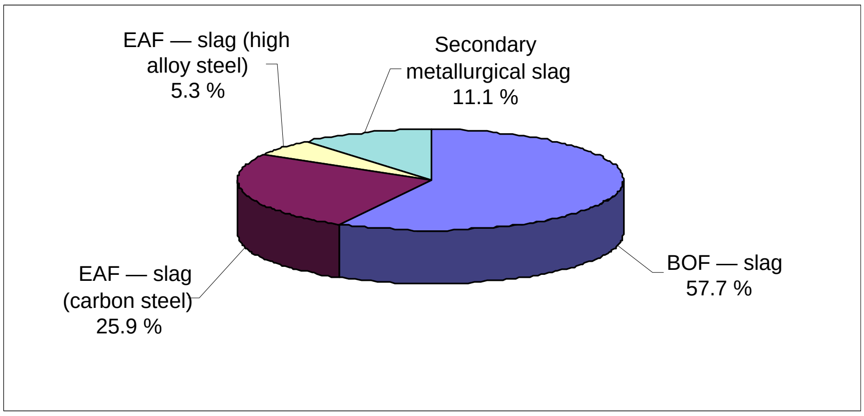
Source: EUROSLAG, 2008.

Steel Slags

Steel slag composition depends on the production process route as well as the steel being produced (i.e. carbon, stainless or high alloy). There are two main production routes for the production of carbon steel, the carbon-based blast furnace — BOF route — and the electric arc furnace — EAF route. Due to the different production routes, the raw materials of the burden are also different and so are the slags.

Steel is produced in two steps today; the first step is the production of liquid crude steel; in the second step the final analysis and properties of the steel are adjusted. For this second step a totally different slag to the first step is produced. The metallurgical task of this kind of slag is to guarantee a clean steel without side reactions between steel and slag.

Figure 21: Generation of steel slags in Europe in 2006 (total 16.9 million tonnes)



Source: EUROSLAG, 2008.

According to EUROSLAG the total amount of steel slags generated in 2006 was about 16.9 million tonnes: 57.7 % of this tonnage was produced as basic oxygen furnace slags; 25.9 % as electric arc furnace slags from carbon steel production; 5.9 % as electric arc furnace slags from high alloy steel production; 11.1 % as secondary metallurgical slags (see Figure 21).

Oxygen-based steel making process

There are different oxygen-based steel-making processes. The most frequently used process is the LD-process. This process has been developed by voestalpine steel in Linz and Donawitz. Oxygen is blown by top lance on the steel to refine the hot metal. Further developments result in a combination of top blowing and injection of inert gases like argon or nitrogen via tuyers in the bottom of the vessel.

A variation of the LD-process had been the LDAC (Linz-Donawitz/Arbed-CRM) process, which was necessary to refine phosphorous-rich hot metal. As phosphorous-rich hot metal is no longer produced in Europe, the process has been obsolete since the mid 1970s.

A third variation is the bottom blown converter (LWS) as the follow-up version of the Thomas steel-refining process. In this process oxygen and sometimes also natural gas and/or coal is injected via tuyers in the bottom. Although the mixing of the steel is much better and thus the refining has advantages, the process is only very rarely in use in Europe (EUROSLAG, 2008).

Basic oxygen furnace slag

The main source for the production of steel in the basic oxygen furnace is hot metal from the blast furnace. To produce steel from hot metal, the carbon content has to be eliminated. For this reason pure oxygen with high pressure is blown on top of the iron bath. Carbon is burnt to carbon monoxide (CO). As a result of the intensive contact of oxygen and the iron bath an intensive mixing occurs due to CO bubbling. According to the exothermic oxidation reaction the temperature of the molten bath increases. For cooling purposes, to protect the refractory lining, scrap is added to maintain the temperature. The also *in situ* oxidised iron immediately oxidises base metals such as silicon, manganese, phosphorus, and sulphur. To catch the formed oxides into the slag, lime is added to the process. The formed slag is a calcium-silicate melt rich in iron, containing considerable amounts of undesirable impurities from the steel.

After tapping the slag from the converter into a slag pot, the slag pot is transported by slag carrier to the slag pit and poured into the pit. There the slag solidifies to a dense grey stone-like material.

The chemical composition of BOF-slag is strongly dependent on the steel process and the additives. Basically the slag is distinguished according to its lime, phosphate, silicate and iron content (Umweltbundesamt, 2008).

BOF slags contain free CaO and MgO which hydrates in contact with moisture and creates volume stability problems in the material. The free lime hydrates rapidly and can cause large volume changes over a relatively short period of time (weeks), while magnesia hydrates much more slowly and contributes to long-term expansion that may take years to develop.

According to EUROSLAG, magnesia and lime content below 5 % do not cause damage in road construction since the expansion is compensated by filling pores in the structure (EUROSLAG, 2008).

The chemical composition of the slag depends on the processes employed and is given in the following table.

Table 35: Typical composition of BOF slags

Parameter (*)	**Typical concentration (w/w %)**
CaO	48
FeO	24
SiO_2	16
MnO	3
MgO	2.5
Al_2O_3	2
P_2O_5	1.5
TiO_2	0.8
V_2O_5	0.3
Cr_2O_3	0.3
Na_2O	0.2
F	< 0.1

(*) Parameters with typical concentrations > 0.1 w/w % are usually declared in the form of oxides although they have varying specifications and are components of different mineral phases.

Source: EUROSLAG, 2008.

Electric arc furnace slag
The direct smelting of iron-containing materials such as scrap is usually performed in electric arc furnaces (EAF), which play an important and increasing role in modern steelwork design.

The major feedstock for EAFs is ferrous scrap which may compromise scrap from inside the steelworks (e.g. offcuts), cut-offs from steel product manufactures (e.g. vehicle builders) and capital or post-consumer scrap end-of-life products). In addition, direct reduced iron is used as feedstock.

The slag in this process is formed by lime or dolomitic lime additions to the melt. The use of dolomitic lime is common practice to protect the refractory lining of the furnace. Just like in the BOF process the base metals which have a higher oxygen affinity are oxidised into the slag. Due to longer reaction time in the furnace compared to the BOF process the lime is almost fully dissolved into the slag. As a result the EAF slag contains almost no free lime. However, there are sometimes considerable amounts of free MgO due to reaction of the liquid slag with the refractory lining or as a result of MgO additions (EUROSLAG, 2008).

The different input materials (like scrap, additives and alloy elements) determine the chemical composition of the EAF slag. Due the alloy content from the scrap heavy metal and trace elements content of EAF slags is higher than in BOF or blast furnace slags,
Table 36.

Table 36: Chemical composition electric arc furnace slags

Parameter (*)	Typical concentration (w/w %)
FeO	32
CaO	28
SiO_2	19
Al_2O_3	7
MgO	7
MnO	5
Cr_2O_3	1.8
TiO_2	0.5
P_2O_5	0.4
Na_2O	0.2
K_2O	0.14
S_{total}	0.1
Ba	0.08
V	< 0.1

(*) Parameters with typical concentrations > 0.1 w/w % are usually declared in the form of oxides although they have varying specifications and are components of different mineral phases.

Secondary slags

In secondary steelmaking the final analysis and the properties of the steel are adjusted. For that purpose, the slag from primary steelmaking is skimmed off and a new slag forming material is added to protect the steel from re-oxidation. The added slag formers are lime and/or calcium aluminate. The treatment is carried out either in the steel ladle at the ladle treatment station or in a special EAF for reheating the steel. During most of the processes of secondary metallurgy, slags are used to capture the non-metallic compounds generated during treatment (European Commission, 2008).

Due to the preparation of the final product the slag composition varies on wide ranges. Most of the products have a CaO/SiO_2 basicity of about 2. This is why these slags are in the range of the dicalcium silicate conversion. This compound tends to disintegrate during cooling of the slag, disturbing the slag matrix into fine powder.

One example of secondary steel slags is slags from high alloy and stainless steel-making. Steel is melted in the EAF; after deslagging the steel is further treated either by the argon-oxygen-decarburisation (AOD) or the vacuum-oxygen-decarburisation (VOD) process. The resulting slags are comparable. These slags tend to disintegrate due to the dicalcium silicate transformation at lower temperatures.

Stainless steel slags are not commonly used today in Europe, mainly because of their mechanical properties — low strength and disintegration due to dicalcium silicate as well as their environmental behaviour mainly chrome leaching (Kühn M., 2006).

3.2.6.2 Quantity

Table 37 shows the generation of slags in Europe, according to the data gathered by (Umweltbundesamt, 2008) reported by Member States.

Table 37: Generation of slags in Europe.

Member State/region (million tonnes)	Total	Blast furnace slag	Steel slag	Year
Germany	14.490	7.62	6.87	2006
France	6.346	4.116	2.230	2004
United Kingdom	5.200	2.0	3.2	2005
Poland	3.334	n.s.	n.s.	2000
Finland	3.000	n.s.	n.s.	2005
Austria	2.456	1.6	0.8	2004
Netherlands	1.700	1.2	0.5	2000
Belgium (Flanders)	1.850	1.20	0.65	2006
Czech Republic	1.510	n.s.	n.s.	2006
Sweden	0.996	0.580	0.416	2001
Luxembourg	0.435	n.s.	n.s.	2005
Belgium (Wallonia)	0.194	0.085	0.109	1995
Slovenia (**)	0.135	n.s.	n.s.	2006
Latvia (**)	0.047	n.s.	n.s.	2006
Ireland (*)	0.035	n.s.	n.s.	1998
Belgium (Brussels)	—	—	—	—
Estonia	—	—	—	—
Malta	—	—	—	—
Bulgaria	n.a.	n.a.	n.a.	n.a.
Cyprus	n.a.	n.a.	n.a.	n.a.
Denmark	n.a.	n.a.	n.a.	n.a.
Greece	n.a.	n.a.	n.a.	n.a.
Hungary	n.a.	n.a.	n.a.	n.a.
Italy	n.a.	n.a.	n.a.	n.a.
Lithuania	n.a.	n.a.	n.a.	n.a.
Portugal	n.a.	n.a.	n.a.	n.a.
Rumania	n.a.	n.a.	n.a.	n.a.
Slovakia	n.a.	n.a.	n.a.	n.a.
Spain	n.a.	n.a.	n.a.	n.a.

(— = no iron and steel industry; n.s. = not specified; n.a. = not available)
(*) Waste from the processing of slag (EWC = 10 02 01).
(**) Unprocessed slag (EWC = 10 02 02).

Source: Umweltbundesamt (2008).

Blast furnace slag
Blast furnace slag is generated from the non-reducible part of the blast furnace burden, e.g. gangue of ores, coal ash additions necessary to form a liquid slag with a certain viscosity to guarantee a smooth running of the furnace.

Approximately 210–310 kg of blast furnace slag/tonne of pig iron is generated (European Commission, 2000).

BOF slag
The amount of BOF slag is depending partly on the silicium content of the hot metal. To compensate the SiO_2 in the slag and to enhance the kinetic operation of the slag a considerable amount of lime is added.

Approximately 85–110 kg of BOF slag/tonne of liquid steel is accumulated (European Commission, 2000).

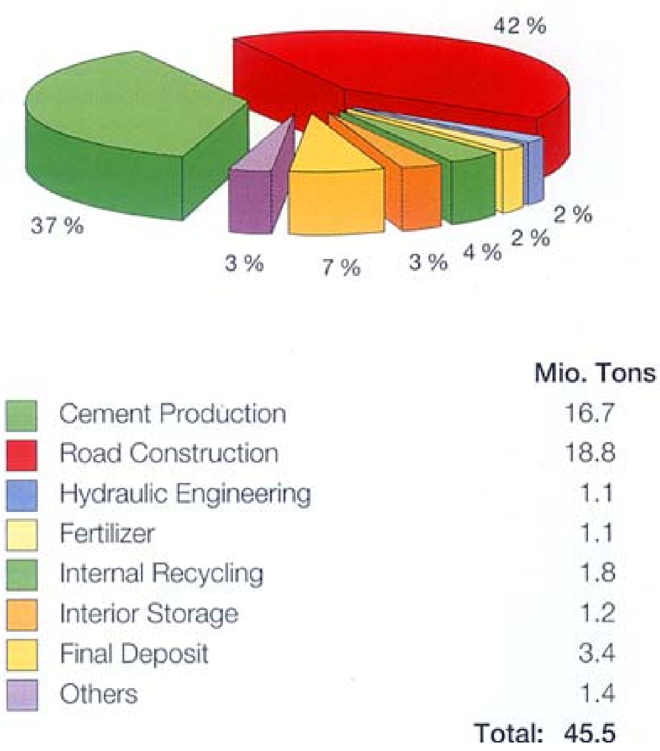
EAF slag
The amount of slag produced during EAF steel-making depends mainly on the scrap quality and the quality of steel produced. Low alloy or carbon steel production generates less slag quantities. For this production an amount of 100–120 kg slag/tonne of steel is generated. High alloy steel-making generates a higher slag amounts due to the necessary reduction of the slag (to recover the chromium from slag) at the end of the process. For this kind of production the amount of steel slag is from 120 to 150 kg slag/tonne of steel.

3.2.6.3 Uses

Figure 22

Figure 22shows applied uses of slags in 12 European countries: Belgium, Denmark, Germany, Spain, France, Luxembourg, the Netherlands, Austria, Slovenia, Slovakia, Finland and the United Kingdom. They account for approximately 90 % of the European total steel output (Reynard J. EUROSLAG, 2007). The main uses are cement production and road construction.

Figure 22: Utilisation of slags in Europe 2005



Source: Reynard J., EUROSLAG (2007).

Blast furnace slag

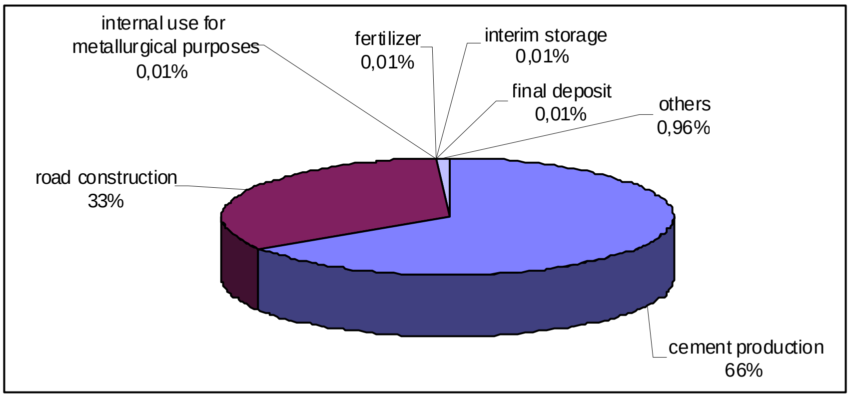
The use of blast furnace slag in cement industry is about 66 %. Other uses such as aggregate in road construction account for approximately 33 % according to EUROSLAG (2006), see Figure 23 below.

There is a long tradition of using of air-cooled blast furnace slag for road construction. It is used only for asphalt base or sub-base. Due to porosity air cooled blast furnace slags are not used in surface layers.

A special advantage can be reached by using carbonatic and hydraulic reactions which take place in mixtures from air-cooled and granulated blast furnace slags and which can be intensified by BOF slag. These reactions lead to a hardening and an increase of the load bearing capacity of roads (EUROSLAG, 2008).

Blast furnace slag as mineral wool is used as insulation.

Figure 23: Utilisation of blast furnace slags in Europe 2006, 32.2 million tonnes



Source: EUROSLAG (2008).

Table 38: Uses of blast furnace slags

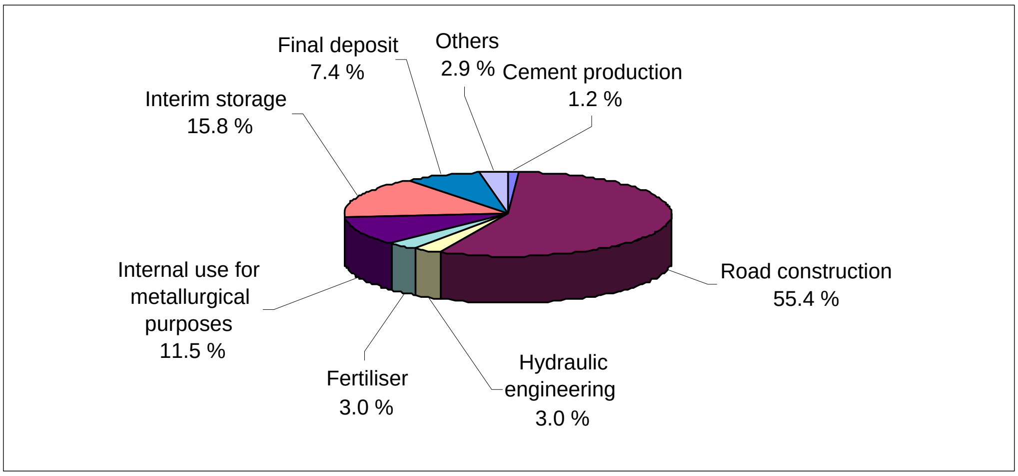
Type of application	Description
Slag cement	There are two possibilities to produce slag cement. The individual components (granulated blast furnace slag and Portland cement clinker) are ground separately and subsequently blended. Or they are ground together, which means mixing and grinding in one single operation. In the European cement standard EN 197-1, nine cements containing slag are listed which have slag contents from 6 % to 95 % of weight.
Concrete	In some parts of Europe slag cement is available as a separately ground material which is be used by the concrete producer as a cementitious component.
Mortar	Slag used as a cementitious component in mortars enhances their workability and can allow further working time for the bricklayer.
Grout	Grouts containing slag have been used to control temperature rise during hydration and in areas of aggressive conditions.
Aggregate	Unground granulated blast furnace slag is also used as a weight aggregate in concrete.
Road-making	Unground granulated blast furnace slag can be used as a base layer material in road construction.

Source: Umweltbundesamt (2008).

Steel Slags

In Europe 2006 the generation of BOF slag, EAF slag and secondary steel slag mount up to a total of 21.1 million tonnes. As shown in Figure 24, 11.5 % was recycled into metallurgical processes and 3 % was marketed as fertiliser. About 58.4 % of the steel slag generated was processed and marketed as construction materials in civil engineering; in particular 3 % was used in hydraulic engineering and 55.4 % in earthworks, ways and roads. About 15.8 % was stored for further marketing and 7.4 % was landfilled, most of it secondary steel slag.

Figure 24: Utilisation of steel slags in Europe 2006 (21.1 million tonnes)



Source: EUROSLAG (2008).

Basic oxygen furnace

A considerable amount of crystalline LD slag is used in the building sector and in road construction, mostly because of its abrasive resistance. Before using BOF slags as building aggregates a thorough classification has to be made; if the content of free CaO is over 7 %, the slag cannot be used as building aggregate due to volume stability problems (Umweltbundesamt, 2008).

BOF slag is used in hydraulic engineering because of its high bulky density. BOF slag can be reused by returning it to the iron-making process. It can also be used for fertiliser manufacture.

Electric furnace slags

EAF slags are mainly used in road construction. Unlike BOF slags, EAF slags do not have volume stability problems. They have a good adhesion to bitumen, contributing to the durability of the road.

Typical polished stone values (PSVs) and internal coefficient are high, making good characteristics for asphalt surface layers. The material presents a high density compared to normal aggregates and also a good skid resistance which is beneficial for safety and durability of the road (see Table 39).

Table 39: Technical properties of steel slags and natural aggregates
Source: Motz H., Geiseler, J. (2001)

	BOF Slags	*EAF Slags*	*Granite*	**Flint gravel**
Bulk density (g/cm^3)	3.3	3.5	2.5	2.6
Shape — thin and elongated pieces (%)	< 10	< 10	< 10	< 10
Impact value (%/wt)	22	18	12	21
Crushing value (%/wt)	15	13	17	21
10 % fines (KN)	320	350	260	250
Polishing (PSV)	58	61	48	45
Water absorption (%/wt)	1.0	0.7	< 0.5	< 0.5
Resistance to freeze-thaw (%/wt)	< 0.5	< 0.5	< 0.5	< 1
Binder adhesion (%)	> 90	> 90	> 90	> 85

Source: Motz H. (2001).

3.2.6.4 Applied processes and techniques

Blast furnace slag

Currently there are three commonly used processes in operation to treat blast furnace slag (Umweltbundesamt, 2008).

1. Slag granulation process
2. Slag pit process
3. Slag pelletising process.

Slag granulation process
When cooling the fluid blast furnace slag, a vitreous fine-grained granulated cinder is formed. Granulation plants have a granulation and dewatering system. The granulation system determines the quality of the produced slag. There are different processes for the production of granulated slag.

The slag is rapidly cooled through a high-pressure water spray in a granulation head. After granulation, the slag/water slurry is transported to a drainage system. In several cases, the slag/water slurry is transported to a separation tank prior to water drainage. After dewatering the residual moisture of the slag sand is generally around 100 %.

Slag pit process
The slag pit process involves pouring thin layers of molten slag directly into slag pits adjacent to the furnaces. Alternatively, after collection of the slag in ladles, the molten slag is slowly cooled and crystallised in the open air. The pits are alternately filled and excavated, and lump slag is broken up and crushed for use as coarse aggregate. The cooling time can be reduced by spraying the hot slag with a controlled amount of water. When properly applied, the cooling water is totally consumed by evaporation.

The slag pit process produces lump slag that is a desirable raw material for road construction. The cooling time has a strong influence on the quality of the lump slag produced.

Slag pelletising process
The slag pelletising process is only used in one plant in the EU, in France. The molten slag is spread in a layer on a plate, which acts as a deflector. The sheet of slag is sheared by controlled water jets. The slag is then projected centrifugally into the air on a rotating drum to complete the blowing up and cooling. When properly applied, the process water is totally consumed by evaporation and as moisture in the product.

Basic oxygen furnace and electric arc furnace slag
The direct use of BOF slag is only partly possible, because of the free CaO and MgO and, thus, the unstable volume of the slag. In contact with moisture the CaO and MgO hydrates and the volume increases. The free lime hydrates rapidly and can cause large volume changes over a relatively short period of time, while magnesia hydrates much more slowly and contributes to long-term expansion that may take years to develop.

Several techniques are used to overcome this problem (Umweltbundesamt, 2008):

- adding silica sand into the liquid steel slag, combined with oxygen blowing;
- ageing the slag by steam — the slag is covered with tent sheets and steam is injected for 48 hours;
- ageing the slag by steam under pressure — the steel slag is placed in an autoclave where steam is injected under pressure and the slag is kept for about three hours at 0.5 Mpa of pressure;
- ageing the slag by spraying with water in controlled heaps.

After pouring the liquid BOF slag into a slag ladle it is transported to a pit where it is air-cooled under controlled conditions forming crystalline slag. For a quicker cooling, the hot slag is treated with water. The iron content of the slag is then separated in a magnetic process. Cooling water is normally recirculated in a closed circuit. Because of the quick cooling when granulating blowholes are encased in the slag, they could be useful for noise insulation. The material is crushed, sieved and graded, similarly to primary aggregates.

After pouring the liquid EAF slag into a slag ladle it is transported to a pit where it is air-cooled under controlled conditions forming crystalline slag. For a quicker cooling, the hot slag is treated with water. The iron content of the slag is then separated in a magnetic process. The material is crushed, sieved and graded, similarly to primary aggregates.

3.2.6.5 Environmental risks

Steel industry slags contain certain metals at concentrations that are higher than typical concentrations in soil. These include antimony, cadmium, total and hexavalent chromium, manganese, molybdenum, selenium, silver, thallium, tin and vanadium.

Steel industry slags are alkaline, producing water leachate with a pH of approximately 11. The elevated pH is one of the reasons for the reduced mobility (i.e. leachability) of metals in slag, and an important consideration for slag applications in or near surface water and groundwater bodies that have limited dilution volume (see Table 40 and Table 41). However, with carbonation the pH decreases and the leachability changes.

The high pH due to the slags can have the side effect of changing the leaching behaviour of the underlying soil, mobilising constituents that were bound as DOC-bound species (dissolved organic carbon) (Van der Sloot H., 2008).

The release of sulphide is of concern for steel slags and has caused direct environmental problems in the Netherlands (Van der Sloot H., 2008).

The environmental risks associated with the use of secondary aggregates strongly depend on the type of application. If the material is bound, the risk of leaching is smaller than if the material is unbound and in contact with water.

When using BOF slags in hydraulic engineering the rate of water volume in contact with the slag has to be measured so that the pH value lies in the neutral or slightly alkali range. Blast furnace slags must not be used with moisture — so that no sulphur compounds are enriched in the water. The following table gives the leaching behaviour of slags (Samaris, 2006).

Table 40: Leaching data of slags
Source: Gries, S., Chevalier J. (2003)

		GBFS (*)	**BFS**	**BOF**	**EAF**
		0/5 mm	**0/5 mm**	**0/5 mm**	**0/5 mm**
		EN 12457-4	**EN 12457-4**	**EN 12457-4**	**EN 12457-4**
pH		11.2	10.4	11.7	11.5
el. cond.	µS/cm	330	590	1 070	550
COD		< 15	19	< 15	< 15
Ca	mg/l				
As	µg/l	< 1	< 1	< 1	< 1
Ba	µg/l	10	100	40	110
Cd	µg/l	< 0.1	< 0.1	< 0.1	< 0.1
Co	mg/l	< 10	< 10	< 10	< 10
Cr tot.					
Cr ges	µg/l	< 10	< 10	< 10	10
Cu	µg/l	< 10	< 10	< 10	< 10
Hg	µg/l	< 0.2	< 0.2	< 0.2	< 0.2
Mo	µg/l	< 10	< 10	< 10	10
Ni	µg/l	< 10	< 10	< 10	< 10
Pb	µg/l	< 40	< 40	< 40	< 40
Se	µg/l	< 0.5	< 0.5	< 0.5	< 0.5
Zn	µg/l	< 0.01	< 0.01	< 0.01	< 0.01
F	mg/l	0.4	0.5	< 0.4	0.4
Cl	mg/l	5	< 5	< 5	5
CN	mg/l	< 0.01	< 0.01	< 0.01	< 0.01
NH_4 (N)	mg/l	< 0.1	< 0.1	< 0.1	< 0.1
S_2O_3 (S)	mg/l	1	37	1	1
SO_4	mg/l	12	365	< 10	26

(*) GFBS granulated blast furnace slag.

Source: Gries S. Chevalier J. (2003).

Table 41: Leaching data of slags

Leaching tests, leaching method DIN 38 414, S4, analytical method FGSV — paper 28/1								
	Blast furnace slag				**Steel slag**			
	Lump slag 8–11 mm		Granulated slag 0–5 mm		BOF slag 8–11 mm		EAF slag 8–11 mm	
	average	max.	average	max.	average	max.	average	max.
pH	11	11.4	11	11.5	12.1	12.7	11.6	12.3
Cond. (MS/m)	82	126	46	100	269	765	77	198
COD (mg/l)	78	182	< 20	< 20	2,4	7	5	20
	in mg/l:							
Al	1.3	2.9	0.07	1.1	1.7	7.0	9.5	40
As	0.002	0.005	0.001	0.003	< 0.001	< 0.001	0.001	0.003
Cd	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Co	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Cr	0.001	0.002	0.001	0.001	0.001	0.04	0.026	0.08
Cr^{VI+}	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.02	0.016	0.04
Cu	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.001	0.002
Hg	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0006	0.001	< 0.0005	0.0005
Mo	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.02	0.01	0.03
Ni	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.002
Pb	< 0.001	0.001	< 0.001	0.001	0.001	0.002	0.002	0.006
Se	0.006	0.009	0.0009	0.002	0.0005	0.0005	0.0005	0.002
Tl	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
V	0.01	0.02	0.005	0.01	0.02	0.05	0.06	0.38
Zn	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02
Anions								
F	0.5	1.0	< 0.2	< 0.2	2.0	8	0.5	1.5
Cl	5	10	<5	<5	5	20	1	7
SO_4^{2-}	288	598	34	106	22	45	15	18
CN total	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.02	< 0.01	0.01
CN l.fr.	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Source: Umweltbundesamt (2008).

Apart from the environmental risks associated with the use material, the processing also may lead to an impact to the environment.

Blast furnace slag is rich in sulphur. The reaction of water with molten slag, particularly with sulphur compounds, generates both steam and diffuse H_2S and SO_2 emissions. These emissions cause potential odour and corrosion problems. If slag is not exposed to water but air-cooled, long-lasting low emissions, mainly of SO_2 will occur.

All slag cooling processes may generate emissions to water.

Dust is considered the main problem, due to crushing and sieving. Where dust is generated, engineering control measures should be considered e.g. water sprayers to keep the airborne dust concentration as low as is reasonably practical.

3.3 End-of-waste criteria

The objective of waste legislation is the protection of human health and the environment against harmful effects caused by the collection, transport, treatment, storage and tipping of waste. To ensure a high level of protection all operations dealing with waste, from its production to its final disposal, should be controlled. Activities such as inspection, authorisation and registration allow the control and trace of waste generation, recovery and disposal.

Additionally, waste legislation also encourages the recovery of waste and reuse of materials in order to conserve natural resources, without endangering human health and the environment.

Waste is defined as material that the holder discards, intends to discard or is required to discard. This definition, however, does not set clear boundaries for when a waste has been adequately recovered and can be used as a product. This ambiguity creates legal uncertainty that, despite EU court clarifications, may prevent a further use of the recycled and secondary material, and also influences the investment in infrastructures for recycling the waste materials.

The 'Thematic Strategy on the prevention and recycling of waste' ([100]) proposed to clarify when a waste that might cease to be a waste and can be considered as a recovered material and freely traded on the open market. In this respect the revised Waste Framework Directive (WFD) contains provisions that could enable the Commission to propose implementing measures to set end-of-waste criteria for some specific waste streams. These conditions concern the use of substances, the existence of a market, the respect of technical requirements and standards and the protection of human health and the environment.

The definition of European end-of-waste criteria for some specific waste streams could help to mitigate this ambiguity. It should result in a simplification for some specific waste streams to be used as secondary materials. It would bring a greater certainty and predictability for the users of recycled products or materials. These should result in an increase in recycling rates avoiding disposal and the use of natural resources.

This case study aims to develop end-of-waste criteria for recycled and secondary aggregates produced from construction and demolition waste, iron and steel slags and ashes from coal combustion processes. In order to define such criteria a comprehensive assessment was done in sub-chapter 3.2 to characterise the three waste streams. Technical, market and environmental issues related to these waste streams were analysed.

By using the information and the knowledge gathered on these waste streams, this sub-chapter intends to identify essential elements that should be part of end-of-waste criteria, taking into consideration the general end-of-waste methodology. The objective is the definition of operational procedures associated with the recycling and the generation of these waste streams that could be used as end-of-waste requirements.

([100]) COM(2005) 666.

3.3.1 Rationale for end-of-waste criteria

Harmonisation and clarification of the legal status

As foreseen in the WFD some Member States have developed rules for recovering and using recycled and secondary aggregates. In some countries, recycled and secondary aggregates retain their waste status whilst in other countries these aggregates are not wastes. In addition, recovery rules differ between Member State and this hinders the marketing of the recycled and secondary materials between countries.

The legal uncertainty associated with the waste definition also inhibits the investment in waste management facilities. A clear definition of rules for the recovery of waste would create a solid base for the development of more recycling centres, promoting an increase in recycling rates.

User perception

The user decision to apply recycled and secondary aggregates is strongly influenced by whether they are waste or not. Users would often rather use a recycled or secondary product than a waste.

End-of-waste criteria would help to improve confidence in the recycled and secondary products by ensuring that the products fulfil technical and environmental requirements that guarantee safe use.

Unnecessary burdens associated with the waste status

Associated with the waste status are all the administrative procedures needed to ensure proper control of the material. Typically the use of recycled or secondary aggregates is done on a case-by-case basis, which makes a quick response to the market demand difficult. These procedures increase the final cost of the recycled and secondary products which compete with primary aggregates, thus creating a potential barrier to recycling and reusing the material.

Aggregates have a low market price and therefore the removal of unnecessary burdens on the production and use of recycled and secondary aggregates would facilitate the competition with primary aggregates.

Environmental benefits

The establishment of end-of-waste criteria which do not entail an environmental risk would overcome these ambiguities, promoting the reuse and recycling of C & D waste, slags and ashes. Using these waste streams as input material for the production of recycled and secondary aggregates, disposal is avoided. Simultaneously recycled and secondary aggregates replace the use of primary aggregates in most types of applications, avoiding the consumption of natural resources.

This case study focused on a number of representative waste streams with the potential to be used as recycled and secondary aggregates. These waste streams were studied and analysed in order to identify relevant elements for defining end-of-waste criteria considering the end-of-waste principles. Other materials might be suitable for aggregate use without the waste status; however, they were not analysed and studied in this case study.

3.3.2 Conditions for end-of-waste criteria

To determine if a certain waste has ceased being waste, and has completed its recovery and to classify it as a secondary product, some principles have to be fulfilled in order to guarantee that the fundamental objectives of Waste Framework Directive are not jeopardised with the removal of the waste status. According to the Article 6 of the revised Waste Framework Directive, a material may only cease to be a waste if the following principles are met.

(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 criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.'

The operational end-of-waste requirements for a specific waste stream must be developed in accordance to these principles.

The secondary material is commonly used for a specific purpose

End-of-waste criteria create an exception for specific waste streams that may cease to be waste under certain conditions. A material should only cease to be a waste when it is clear that there is a specific use for the secondary material. The end-of-waste criteria should be built on the evaluation of the risks associated with a specific use.

C & D waste, ashes from coal combustion and iron and steel slags, are commonly used as input material in the production of recycled and secondary aggregates. Their use is demonstrated by the recycling rates described in sub-chapter 3.2.

Recycled and secondary aggregates can be used in an unbound or bound form. In a bound type of application, the aggregates are mixed with a binding agent, such as cement, bitumen or a substance that has binding properties in contact with water.

Recycled and secondary aggregates are used in road construction, for example as road base and sub-base and also for the construction of embankments and anti-noise banks. They are used as filler or in the case of steel slags used as armour stone for river bank and coastal protection.

A market or demand exists for such a material

Secondary materials should only cease to be wastes if their use is certain. The existence of a market or a demand assures that the material will be used. The removal of the waste status must not lead to disposal or discard; it must result in the utilisation of the secondary material. If there is a market or demand then the likelihood of using the secondary material is high.

According to the data gathered and the analysis of the aggregates market presented in sub-chapter 3.2 there is a potential market for recycled and secondary aggregates. The share of recycled and secondary aggregates is small compared to the consumption of primary aggregates. Looking at countries with high recycling rates, there is considerable utilisation of primary aggregates, so recycled and secondary aggregates cannot meet the full demand for aggregates.

The price of aggregates is low and their density is high. Therefore the market is strongly influenced by the costs of transporting them. This results in markets with a small range of about 50 km.

The availability of primary aggregates strongly influences the aggregates market. In some countries good-quality primary aggregates are abundant and have a low price resulting in a barrier for the utilisation of recycled and secondary aggregates. In other countries, due to geological conditions, primary aggregates are neither of such good quality nor so abundant and, therefore, the use of recycled and secondary aggregates is higher.

National economic instruments are used to apply national waste management provisions influencing the aggregates market. These differ from country to country. Some countries have established levies for the extraction of primary aggregates in order to favour the use of recycled and secondary aggregates.

Landfill taxes and landfill bans are also used to influence the disposal strongly affecting the recycling of C & D waste, slags from iron and steel production and ashes from coal combustion. A high price for disposal favours the recycling of these materials into recycled and secondary aggregates.

It fulfils the technical requirements for the specific purpose and it meets the existing legislation and standards applicable to products

Once it ceases to be waste the secondary material is subject to the product legislation associated with the specific purpose.

Recycled and secondary materials are construction materials replacing natural aggregates and therefore have to comply with the legislation applicable to primary aggregates.

The Construction Products Directive is the legal reference for aggregates to be placed in the European market. The directive defines essential requirements for all construction products that are reflected as specifications in the European standards. The essential requirements cover not only principles for guaranteeing a safe use of the construction material, but also the release of dangerous substances from the material to the environment and indoor air. The essential requirements are broken down into detailed requirements/specifications in the European standards.

The European standards for aggregates define technical specifications for aggregates according to the type of application. They foresee different sources of materials to be used as aggregates. Depending on the type of the material specific requirements are defined e.g. BOF slags to be used in bituminous mixtures the maximum expansion volume must be determined. Environmental requirements are still lacking in the European standards. A generic clause concerning the release of dangerous substances refers to other European and national legislation that the materials have to comply. Based on this at least one Member State has developed environmental requirements for construction materials from the point of view of soil, surface water and groundwater protection, for the use of primary and secondary materials building materials. Most of the countries that have developed environmental requirements for construction materials cover only the use secondary materials as building materials.

Its use will not lead to overall adverse environmental or human health impacts

The criteria have to guarantee that the removal of the waste status will not create an additional impact to the environment compared with the situation of the material as a waste. Otherwise the material should remain as a waste, and its recovery and reuse should be carried out under the waste legislation with all the pertinent controls foreseen.

In general, recycled and secondary aggregates present little risk to the environment. However, the fact that these materials may be in direct contact with the environment for long periods of time needs to be considered and evaluated in order to guarantee that no overall adverse impact to the environment results from the removal of the waste status.

As identified in the sub-chapter 3.2 the most relevant issue from the environment point of view is the release of substances from the secondary materials to the environment due to contact with water. The exposure of the material to water may result in the dissolution of substances from the material and their transport to the soil and water, creating an impact to the environment.

The definition of end-of-waste criteria must consider this risk and assess the best way to minimise it by looking at the production chain. These measures should be feasible practical and effectively guarantee a minimum risk to the environment.

3.3.3 Set of end-of-waste criteria for aggregates

The end-of-waste criteria are defined in the light of the different elements and steps in waste management, processing and use. One or more of these elements might or not be relevant for defining end-of-waste, depending on the characteristics of the waste stream.

In order to define when a material ceases to be a waste, it is necessary to take a fundamental look at the overall production chain of recycled and secondary aggregates — from the generation of the input material, through the processes and techniques applied, to product requirements, quality control procedures, and potential application or uses. These steps have to be analysed in order to define operational procedures that can guarantee the fulfilment of the end-of-waste conditions.

Based on the information described in the previous sub-chapter it has become evident that is not advisable to define a single set of end-of-waste criteria for aggregates. Specific end-of-waste criteria need to be defined for different waste streams, taking into account the conditions under which the waste is generated.

3.3.3.1 Input material

Wastes are, in most cases, very heterogeneous materials. This heterogeneity results in a potential risk of contaminants and possible release to the environment. If contaminants are not removed at the collection or processing stage they will be incorporated in the secondary product and there is a risk of them being released to the environment in the use phase of the material.

Therefore the first measure to control the environmental risk associated with the use of recycled or secondary aggregates is to control the composition of the waste input. The generation and collection of the waste are fundamental to control the risk of impurities. In the case of C & D waste, the elimination of contaminants and hazardous substances when they are still integrated in the building or structure minimises the risks associated with the input material. Additionally the knowledge of the waste composition allows a better adjustment of the processing techniques and consequently predictability of the quality of the secondary product manufactured.

3.3.3.2 Processing

The recovery processes and techniques used for treating the waste influence the characteristics of recycled and secondary aggregates. The processing removes undesired contaminants and impurities, which can affect the technical performance of the aggregates and could create a risk to the environment in the use stage of the material. Typically the processing includes sorting and visual inspection. The processing can be used to minimise the risk of contaminants. Minimum processing standards should be used to control the contaminants level in the product, controlling the risk associated with the product.

3.3.3.3 Product requirements

The recovered material can only cease to be a waste if it fulfils product legislation relevant to aggregates. The material should be tested to demonstrate compliance with the existing product requirements. Product requirements cover technical and environmental requirements.

Technical requirements
For aggregates, the most relevant legislation is the Construction Products Directive (CPD) which defines essential requirements for construction products to be placed in the European market. These guarantee a safety use of construction products. The European standards (ENs)

are based on these essential requirements. They define the technical specification for aggregates according to the type of application. They foresee different sources of materials to be used as aggregates. In addition to the European standards, applicable national standards or requirements for specific uses must also be met in order to guarantee safe use.

Environmental requirements

The environmental requirements associated with the product legislation must be fulfilled by the secondary and recycled aggregates.

The European standards for aggregates should cover 'hygiene, health and the environment' as defined in the CPD. However, the standards only refer to a general standard clause (Annex ZA) without making specifications for environmental protection. The general clause states that it is also necessary to comply with all European and national regulations on dangerous substances. It is expected that the next revision will cover this aspect. A CEN technical committee is working on this issue with the objective of defining horizontal testing methods for assessing the release of dangerous substances from construction products, however, have not yet been developed.

As a result of the non-existence of environmental requirements for aggregates as a product and due to the fact that for a material to cease to be waste the principle of 'no overall adverse environmental or human health impacts' has to be met, environmental requirements for secondary and recycled aggregates have to redefined.

In some cases a clear identification of the waste stream originating the input material, its composition and management practices until the processing stage (e.g. C & D waste from selective demolition, source segregation) can be considered a sufficient guarantee of the environmental risks linked to the use of the material. Adequate quality control measures should be established to ensure that the recycler applies the required procedures.

In those cases where the above mentioned procedures are not used or cannot guarantee that the secondary material can be considered safe from the environmental point of view, a different approach is needed. As identified above, the release of substances from the material to the environment is the major concern associated with these materials. In this case leaching references should be used as environmental requirements.

End-of-waste leaching references have to consider the long-term behaviour of the materials, linked to the expected exposure conditions of the recycled and secondary aggregate in the use phase of the material. Moreover attenuation factors such as background pollution and soil interactions which influence the bioavailability of the leached substances should be part of the method to be used. The references should define quantitatively a maximum allowable impact to the environment for general use of the material.

Member States could then define more stringent limit values for the utilisation of aggregates as a construction material, depending on local conditions.

The environmental impact of using secondary materials is strongly dependent on existing local conditions. As an example, the environmental impact of certain products in seawaters and still waters depends is different. The Water Framework Directive and the Groundwater Directive themselves recognise these differences leaving specification of local surface water quality and groundwater quality to national authorities and authorities responsible for river basins of groundwater bodies.

Taking into consideration that the release of substances from the material to the environment is associated with the type of application of recycled and secondary aggregates, the definition of leaching limit values could be based on conditions for using the material. The limit values could be less restrictive if it were assumed that the material would be used according to a defined use. More materials could meet the environmental criteria and, therefore, higher recycling rates could be expected. However, the risk of inappropriate use of the recycled and secondary materials exists, and control is needed to ensure a proper use.

To define European end-of-waste leaching limit values several approaches could be envisaged.

Some Member States have developed legislation or regulations establishing environmental conditions for secondary building materials from the point of view of soil and groundwater protection. These could be used for defining the end-of-waste leaching requirements. However, from the analysis in the sub-chapter 3.2 (see Table 19 and Table 20) it is clear that Member States have different leaching requirements. Different methodologies were used which result in different leaching limit values. Therefore to derive common end-of-waste leaching references by using national references is hardly feasible.

Another option could be to use existing national regulations for defining leaching requirements. End-of-waste leaching requirements consist of the fulfilment of existing national leaching requirements. This would imply that end-of-waste would be applicable only to the countries which have defined leaching requirements for secondary materials to be used in construction works. Only a small number of countries have rules in place for using secondary and recycled materials in construction works, so the applicability of the criteria would be restricted to those Member States.

Another possible scenario could be to make leaching limit values uniform and define a new European common leaching limit values for recycled and secondary aggregates to cease to be a waste. This approach would have to be made on a different level, with relevant expertises and leaching information and would be much more time consuming.

Rationale for using the limit values for waste acceptable at landfills for inert waste as basis for European end-of-waste leaching requirements

The Landfill Directive defines leaching acceptance criteria for inert waste to be accepted at inert landfill sites. The leaching limit values have been determined using a methodology that includes a scenario and groundwater modelling. It establishes a direct relationship between the release of dangerous substances from inert waste and the risk that these contaminants pose to groundwater quality.

The acceptance criteria were defined considering the definition of inert waste in Article 2(e) of the Landfill Directive. *'The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater.'* Leaching limit values were established to define wastes that are considered inert, whose environmental impact is insignificant, and wastes that can have a significant impact for which measures have to be undertaken to safeguard the environment and public health.

The inert waste acceptance criteria could be used as European end-of-waste leaching references for defining the environmental requirements for recycled and secondary aggregates to cease to be wastes. Considering that the definition of inert waste was used in the development of the leaching limit values, these could be used as European end-of-waste leaching references.

Comparing the inert waste disposal criteria with the national limit values for general use of recycled and secondary materials (see Table 19 and Table 20), is possible to conclude that several Member States have used a similar approach as the inert waste disposal criteria when establishing their leaching limit values.

Looking at Member States' parameters for evaluating the leaching behaviour of recycled and secondary materials, these are common to the disposal criteria of the Landfill Directive. However, Member States require some additional parameters to be tested. Beryllium is required by Italy. Chromium (IV) is required by Spain (Catalonia). Cobalt is required by the Italy and the Netherlands. Vanadium is required by the Germany, Spain (Basque Country), Italy, the Netherlands and Finland. Manganese is required by Denmark and tin is required by the Netherlands.

By looking at each country and comparing with the landfill criteria, it is possible to verify that Belgium, Spain (Cantabria) Austria and Finland follow similar approaches.

For Austria, the major discrepancy is copper. The Austrian limit value for copper is four times lower that the disposal criteria. Chromium is also slightly lower.

Finland's limit value for cadmium is half than the inert disposal criteria limit value. The remaining leaching requirements are that same as the inert waste disposal criteria.

Belgium (Flanders), Spain (Basque Country, Catalonia), and the Netherlands have different approaches which limits the comparison with the landfill inert criteria. In some cases for copper, zinc, chlorides and cadmium, the values are stricter. However, in most of the cases the limit values are more relaxed than the disposal criteria.

Denmark and Sweden have a more conservative approach. Almost all leaching limit values are below the inert waste disposal criteria. For the category 'general use' Sweden's draft guideline/handbook defines leaching limit values for substances of very high concern based on natural background levels.

For Germany the comparison is difficult because different leaching tests are used to evaluate the leaching behaviour of the materials.

Concerning salts, Denmark, the Netherlands, and Sweden have stricter leaching limit values for chlorides. Denmark, Spain (Basque Country) and Sweden and have more stringent limit values for sulphates.

In conclusion, the inert waste acceptance criteria are used in most of Member States as national leaching limit values for recycled and secondary material. There are some common discrepancies between Member States' leaching requirements and inert waste leaching criteria. The copper content in the inert waste criteria is considerably higher than in most of national regulations. Additionally the fact that the Member States require the evaluation of other parameters besides those parameters defined in the inert waste criteria may lead to release of contaminants not addressed in the end-of-waste leaching criteria.

In some cases and due to local conditions, Member States may develop stricter requirements for specific uses.

3.3.3.4 Product application

The use and the type of application strongly influence the release of substances from the materials to the environment which is the more relevant environmental impact of using recycled or secondary aggregates.

Several factors contribute to the release of substances from the material. The contact of the material with water and the surface exposure influence the release of substances present in the materials and its transport into the soil, groundwater and surface water. By defining conditions for using the material the environmental impact will be minimised and controlled.

A bound-type application prevents the aggregate material from being exposed directly to water. The surface of the aggregate particle is covered with the binder preventing direct contact. The structure is bound together so it is difficult for the water to penetrate. The mechanism of release is more diffusion controlled.

In an unbound type of application, the aggregate particle can be directly in contact with water. The water percolates through the product. Water can easily access the particle surface of the aggregates and therefore the risks of releasing substances from the material to the soil and water increase.

The definition of type of application or conditions for using the recycled and secondary material can guarantee a control of the risk of releasing dangerous substances from the material to the environment.

Dealing with the environmental risk of using recycled and secondary aggregates by defining the type of application for the materials would broaden significantly the range of materials that can be used as aggregates. Products are, in general, placed on the market together with information on the conditions for safe use. Instructions accompanying the product provide information to the user on how to use the product.

This could be the case for recycled and secondary aggregates. Defining conditions for using the material and passing them on to the user guarantees control of the risk of releasing dangerous substances from the material to the environment.

The introduction of control measures on the utilisation of recycled and secondary material to guarantee that it is used according to the prescribed type of application or condition for using the recycled material would not represent any simplification in comparison to the waste status.

The criteria are only justified if they improve the conditions in the recycling of the material. In principle, this requires that no further conditions, apart from product-related regulations, are applicable to the materials after meeting the product requirements. Recycled and secondary aggregates have relatively low market prices and represent a high volume of materials. To impose controls at the use/application stage would result in additional costs, which in the aggregates case, might reduce or prevent its use. End-of-waste criteria should not define specific conditions related to product applications.

Recycled and secondary aggregates apart from the European end-of-waste environmental requirements need to fulfil existing general rules for pollution prevention to groundwater and soil protection.

3.3.3.5 Quality control procedures

For recycled and secondary aggregates to cease to be wastes, it is fundamental that characteristics of the final product are highly reliable. The actual properties of the materials must correspond to the product specifications declared by the producer.

Quality management is a set of methods that help to control the production process and the quality of the product, guaranteeing that it meets the declared specifications in a reliable way. By using quality assurance and control processes, the characteristics of the product are consistent and trustworthy.

These methods should be used for a reliable implementation of the end-of-waste measures. The generation of the input material, the treatment processes and the fulfilment of the product requirements should also be covered by quality management methods to guarantee the end-of-waste requirements are met in a reliable way.

Some countries have developed quality assurance standards on national level. These are frequently associated with certification and should be checked and adapted in order to fulfil the end-of-waste requirements.

As minimum requirements, the quality management system must comply with quality assurance standards, recognised by Member States. The system should include internal and external testing in order to validate the producer's declared properties. The quality assurance system should be externally monitored and inspected by third parties recognised by Member States.

3.3.4 End-of-waste criteria for recycled aggregates derived from C & D waste

C & D waste represents a large variety of materials, e.g. wood, paper, bricks, metals, plastics, used asphalt, see Table 25. The composition of C & D waste varies according to the function of the structure or building that generates it. The inert fraction of the C & D waste is seen as potential material to be used in the production of recycled aggregates in replacement of primary aggregates, see the following Table 42.

Table 42: Construction and demolition wastes (adapted from the European Waste Catalogue)

EWC code	Description
17 01 01	Concrete ([1])
17 01 02	Bricks ([1])
17 01 03	Tiles and ceramics ([1])
17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06 ([1])
17 03 02	Bituminous mixtures other than those mentioned in 17 03 01 ([2])
17 05 08	Track ballast other than those mentioned in 17 05 07 ([2])
17 05 04	Soil and Stones ([1])

([1]) Lists of wastes acceptable at landfills for inert waste without testing, selected C & D waste only.
([2]) With dangerous substances.

Sub-chapter 3.2 provides a detail analysis of the C & D waste and of the major concerns associated with this stream. Due to its variable composition, the presence of contaminants and hazardous substances is a potential problem. The risk of contamination and of potential leaching of dangerous substances to the environment should be addressed in order for the material to cease to be waste.

For C & D waste, the possibility of PAH, PCBs and asbestos in the waste stream is a major concern. C & D waste originating from old buildings and structures reflects the type of construction materials and the techniques used when they were constructed (see Table 27).

The use stage of the building/structure can also contribute to specific contamination. Concrete and bricks in chimneys can be contaminated by PAHs from the combustion of coal. Structures or buildings which were used for storage or industrial activities using fuels or oils can have areas contaminated through historic leaks and spills.

The utilisation of insulation foams blown with ozone-depleting substances (ODS) in the construction industry is reflected in the composition of the C & D waste. The crushing and shredding associated with recovery of demolition waste leads to emissions of blowing agents from the insulation foam. Therefore, insulation foams should be removed as a whole before the demolition. If that is not feasible insulation foams should be removed before the input material enters in the crusher.

Two types of unwanted materials can be found in the C & D waste — hazardous materials as described above and substances that if not removed can jeopardise the recyclability of the material, see Table 42.

Table 43: Unwanted substances present in C & D waste

Hazardous substances	Asbestos, hydrocarbons, PCB, lead paint, treated wood (with hazardous substances), tar, lamps containing mercury, mineral wool, air-conditioning fluids, insulation foams blown with ODS (ozone-depleting substances) substances.
Non-hazardous substances that can jeopardise recycling	Wood, plastics, gypsum, glass, metals, paper, rubber.

The environmental impact associated with recycled aggregates must be seen not only from the perspective of the release of hazardous substances, but also the release of non-hazardous substances from the recycled material when in contact with water which can create an impact to the environment.

The presence of gypsum or plaster in the input material may lead to the release of sulphates that not only creates an impact to the environment but also additional problems in the technical performance of the recycled material. Gypsum board can be removed in selective demolition, yet plaster is more difficult or even impossible to remove.

In northern countries, de-icing salts are used to reduce the formation of ice on pavement structures. Its accumulation in the input material used in the production of recycled aggregates contributes the potential release of chlorides in the use phase of the recycled material creating and impact to the environment (Samaris, 2006).

It is essential to separate the C & D waste stream into defined fractions that can be processed into recycled aggregates (see Table 42) by removing hazardous materials and other substances that can jeopardise the recycling or create an impact to the environment. The generation and segregation at source of the C & D waste at the demolition site, and the processing of the waste at the recycling centre are fundamental to get a defined input material. In some Member States the sorting of the C & D waste is obligatory. The waste needs to be sorted out on-site or at treatment installations.

Another aspect to consider in the evaluation of the input material is the presence of secondary materials used under specified conditions in the building/structure to be demolished, e.g. recycled aggregates that could only be used in bound applications and road residues containing municipal solid waste incineration bottom ash. These materials, once they become waste, should be kept separated from other wastes. Crushing and sieving lead to the surface exposure of the material; depending on the type of application it may lead to release of substances to the environment, impacting the environment.

I. Input material

Depending on the separation of hazardous materials and contaminants from the input material at the demolition site or at the recycling centre, several categories of input material could be envisaged.

C & D waste from selective demolition

The most efficient way for separating unwanted substances from the waste stream is to remove them at source, when they are still integrated in the building or structure, before the demolition. The demolition of a structure or building is done in a planned and organised way that maximises the recyclability of the waste generated and facilitates the removal of contaminants.

Box 1: Selective demolition, relevant features for controlling the composition of the waste

Determination of the previous uses and history of the building or structure
All available information (construction plans, function of the building) is used in order to identify the construction materials used. However, this can be a difficult task because demolition is usually carried out on old structures where little information is available.

Identification and estimation of materials used in construction
By carrying out the building audit, the customer (possibly with the help of a third party) can estimate the amount and type of materials that will be generated, allowing an optimisation of the demolition project in terms of resources. The materials include the following:

- reusable materials such as window frames, fireplaces and carved doors which can be reused;
- unwanted materials estimated on the amount of waste that can be recycled, and waste that needs to be disposed of (see Table 43); these include hazardous materials and substances that can jeopardise the recovery of the wastes as recycled aggregates;
- potentially recyclable inert material.

Building or structure deconstruction
The two previous steps are essential for planning the dismantling of the building/structure, yet frequently as the dismantling starts, unforeseen materials may appear.

- Removal of hazardous material, depollution. As a first stage, removal of all hazardous materials from the entire building is done. Typically a demolition company subcontracts a specialised company e.g. for asbestos removal. Lamps and lighting structures are also removed, as mercury-bearing lamps are frequently used. Mineral wool and air conditioning fluids are removed.
- Removal of substances that can jeopardise the recycling of the inert fraction. Materials such as gypsum from walls and ceiling, wood, pipes, cables, and

surface materials, should also be removed before the demolition. Once these materials are removed, the remaining materials are mainly concrete and bricks.

- Separation of material on the demolition site. Once the dismantling starts it is essential that the wastes materials are kept separated, according to material type.

Before the demolition, an inspection should be done to guarantee that all hazardous and non-hazardous materials were properly removed.

Demolition.
The demolition techniques vary according to the building or structure. Implosion techniques, hydraulic crushing, and use of a wrecking ball are examples of demolition methods. These could also facilitate the waste segregation by material type.

Selective demolition procedures allow a good knowledge of the composition of the source materials used in the production of recycled aggregates, resulting in a minimum risk of contaminants and hazardous substances. The main steps of selective demolition are described in Box 1.

Typically, the responsible for the building/structure to be demolished contracts a demolition company.

For the sake of liability between actors involved in the demolition, the building audit should be required by the responsible for the building/structure. This audit is done by a competent auditor and provided as an essential document in the tender. The demolition contractor elaborates its answer to the tender based on this document. However, it is recommended that the demolition contractor goes to the site and checks if he is in accordance with the audit.

The quality of selective demolition procedures should guarantee that the removal of hazardous substances and contaminants that may jeopardise recycling is effective. These actions should be part of a quality management system that provides quality assurance and control on the quality for all the procedures related to the demolition.

The quality assurance system must be required by the contracting authority (responsible for the building/structure), and shall be defined and implemented by the demolition contractor.

Additionally the C &D recycling centre responsible for treating the residues should require the demolition contractor to have a quality assurance scheme defined and implemented by the demolition contractor according to the 'quality acceptance criteria' of the recycling centre.

For recycled aggregates produced from C & D waste generated following selective demolition procedures, the environmental risk is low. The input material encompasses the inert materials mentioned in Table 42. This is free from contaminants and hazardous substances and the risk of releasing substances from the recycled materials to the environment is low.

However, selective demolition entails a higher cost when compared to traditional demolition procedures. More labour, space at the demolition site and time is needed and special equipment may be necessary. This can be compensated by lower costs on processing the C & D waste and less waste going to landfill.

These factors sometimes lead to non-selective demolitions. The time and space is scarce and in many countries these procedures are not yet implemented to any great extent.

C & D waste from depolluted building or structures

In some situations the decontamination and removal of hazardous materials is done before the demolition, — depollution. Yet unwanted materials that affect the recyclability — such as bricks, concrete, plastic, gypsum and wood — are mixed with the inert fraction.

Comparing with the previous category 'C & D waste from selective demolition', the difference is the presence of non-hazardous materials mixed with the inert fraction. However, hazardous materials were removed. The separation the non-hazardous materials are done at the recycling centre.

The recycler defines the 'quality acceptance criteria' for the incoming waste accepted at the recycling centre based on the composition of the waste. If the input material contains non-hazardous materials mixed with the inert fraction, then the price is adjusted according to the processing needed in order to obtain the inert fraction to be used in the production of recycled aggregates.
Table 26 (sub-chapter 3.2) compares the price the gate fee for unsorted construction waste EUR 19 and for sorted construction waste EUR 10.

It is essential that the depollution of the building or structure is done in a reliable way with the removal of all hazardous materials. The depollution procedures should be part of a quality management system that provides quality assurance and control for all the procedures related to the removal of hazardous materials from the building or structure.

C & D waste without previous depollution

If the hazardous substances are not removed from the building or structure before demolition, the risk of contamination of the input material with hazardous substances exists. Consequently, the recycled product produced from this input material presents a risk of leaching hazardous substances from the material to the environment.

The uncertainty associated with the mixed C & D waste without previous depollution is high. The removal of hazardous substances and non-hazardous substances that might be present is done at the recycling centre, which cannot guarantee a full removal of hazardous substances. Therefore recycled aggregates derived from C & D waste without previous depollution, must not cease to be waste. The material can be used as aggregates under the waste regime.

Road residues

The maintenance and reconstruction of roads generates wastes that have the potential to be reused in roads or used as aggregate in construction works. The residues (reclaimed asphalt pavements, or RAP) are composed of a mixture of bitumen and aggregates which can be added to new asphalt mixtures, replacing new bitumen and new aggregates, or they can be used as aggregates in construction works by removing the bitumen.

One of the main problems associated with the use of this type of residues is the tar content. Tar is considered a hazardous substance containing high levels of polycyclic aromatic hydrocarbons (PAHs), some of which are carcinogenic and have an impact on human health. Even though tar is no longer used in hot asphalt mixes for road construction, in the case of reclaiming old roads the risk exists.

Additionally, in some countries, roads constructed in the past 30 years contain a wide range of materials such as municipal solid waste incinerator bottom ash. These materials create problems for the recyclability of the road residues.

In order to identify possible hazardous substances incorporated into the road structure, an initial assessment on the composition of the road must be done, prior to the recovery process in order not to contaminate 'clean' waste. Based on this assessment different categories of road residues could be envisaged.

- **Road residues containing tar**. These residues must not cease to be waste. Tar is a hazardous substance and therefore road residues with tar should be adequately treated reused under the waste regime.
- **Road residues containing mineral wastes.** Road residues containing bottom ash from municipal solid waste incinerator may present a risk to the environment. The risk exists and needs to be evaluated in order to enable the removal of the waste status.
- **Road residues without tar and mineral waste.** The presence of tar or ash from municipal solid waste incinerator in roads residues must be assessed before the recovery of the road residue. By carrying out this initial assessment the risk of contaminating 'clean' waste is avoided. The input material is composed of bitumen and aggregates, which have the potential to be reused in roads or used as aggregate in other construction works.

II. Processing

The processing determines to a certain extent the physical characteristics of the aggregate, defining the quality of the product. Unwanted materials present in the input material are removed before the crushing step resulting in a clear input of inert waste (see Table 42). The material is then crushed according to the product specifications.

The removal of hazardous and non-hazardous material must be done through sorting and visual inspection. The sorting has to be adjusted according to the composition of the input material (see Box 2).

However, sometimes, it is technically and economically not feasible to remove all the non-hazardous materials. Therefore, it is important to define minimum processing requirements that provide a reference for the processing needed.

The revised European standard for 'aggregates for unbound and hydraulically bound materials for use in civil engineering works and road construction' (EN 13242) classifies the recycled aggregates according to the constituents. The presence of unwanted materials such as metals, non-floating wood, plastic, rubber, gypsum and insulation foams blown with ODS (ozone-depleting substances) substances, must be lower than 1 % by mass. Presently, only this EN standard defines composition requirements for recycled aggregates. These shall be used as minimum processing requirements.

Independently from the removal of hazardous and non-hazardous substances at source or at the recycling site, the processing of the input material must be done in a controlled way including visual inspection and sorting. It must guarantee that unwanted substances present in the recycled product do not exceed 1 % by mass.

Box 2: Recovery process, relevant features for controlling the composition of the input material

Visual inspection

Typically, the recycler has acceptance criteria in place. The gate fee is defined according to these criteria. By carrying out a visual inspection of the load at the gate and at the unloading bay, the operator judges the waste quality type and decides whether to accept the waste or not. This is fundamental to evaluate the processing needed and the presence of contaminants.

Visual inspection should always be present in the recycling of C & D waste, independently of the composition of the input material in order to remove any contaminant or hazardous material that might be present.

Sorting before crushing

The sorting operations enable the removal of contaminants and dangerous substances from the input material, and consequently minimisation of the risk associated with the recycled aggregates. It is essential that these operations are adjusted to the composition of the material. Manual sorting should be used when contaminants and hazardous material cannot be efficiently removed by other methods.

For ***C & D waste from selective demolition*** the processing is facilitated by having a good knowledge of the waste composition. Sorting and visual inspections must be part of the recycling process to guarantee that only materials listed in Table 42 (inert waste) are present in the input material before the crushing step. The processing must be controlled in order to produce recycled aggregates that meet the requirements defined in the standards.

For ***C & D waste from depolluted building or structures***, the processing needs to be adjusted according to the composition of the material. The treatment process needs to be adapted in order to guarantee the removal of contaminants that might jeopardise the recyclability of the material. Sorting and visual inspection are processing techniques that should part of the processing aiming at the removal of non-hazardous materials. Only the inert material (see Table 42) should enter into the crusher.

Road residues

The treatment of road residues depends on their final use. They can be reused in roads *in situ* or at an asphalt treatment plant or they can be used as aggregate in other construction works. Depending on the type of application, the processing of the material must enable the production of recycled materials that meet the standards defined for each application of aggregates.

Control on the processing is essential for guaranteeing that the recovery is done in an effective and reliable way. The recycler should have in place procedures to guarantee that the product meets the claimed product specifications.

Processing should be part of a quality management system that provides quality assurance and control on the quality of all the procedures related to the recovery of the material.

III. Product requirements

To cease to be considered as wastes, recycled aggregates must fulfil the product requirements defined for aggregates as construction material. The quality of the recycled aggregates must be evaluated according to the technical and environmental requirements defined for the use of aggregates as construction material.

Technical requirements

Independently from the separation of hazardous materials and contaminants from the input material at the demolition site or at the recycling centre, all recycled aggregates must fulfil the technical requirements necessary to guarantee a safe use. These provide a guarantee to the user on the technical performance of the material. The technical requirements that the material have to comply with are the European standards (ENs) established within the context of the Construction Products Directive as well as applicable national standards or requirements for specific use not covered by the European standards (ENs)

Environmental requirements

The requirements to prove that the use of the substance will not lead an overall adverse environmental or health impact for recycled aggregates to cease to be wastes are defined according to the way in which the material was generated — by either the separation of hazardous and non-hazardous materials from the input material at the demolition site or at the recycling centre. These differences lead to different approaches for defining the requirements for a material to cease to be waste.

For recycled aggregates derived from C & D waste from selective demolition

For recycled aggregates produced from C & D waste from selective demolition the composition of the material should be fairly known. The removal of hazardous and non-hazardous substances must be demonstrated through a quality management system associated with the demolition. This would enable the recycler to demonstrate the quality of the input material composed of only the inert materials referred in (see Table 42). Together with a controlled processing, according to the existing product standards, the environmental risk associated with the recycled material is low. The materials listed in Table 15

Table 15, are considered inert by the criteria for the acceptance of inert waste landfill without the need for testing ([101]).

For recycled aggregates produced from C & D waste from selective demolition to cease to be a waste, the input material used must be include only the inert material defined Table 42. *The selective demolition must guarantee that no contaminants and hazardous substances are present.*

For recycled aggregates derived from C & D waste from depolluted building or structures

For recycled aggregates produced from C & D waste from depolluted building or structures, the composition of the input material is free from hazardous materials. The removal of hazardous substances must be demonstrated through a quality management system associated with the demolition. However, non-hazardous contaminants are present in the input material. The processing removes these non-hazardous contaminants according to the requirements defined in the standards, typically their presence must be below 1 % by mass. However, these contaminants, may lead to an impact to the environment even if they are not considered hazardous. Gypsum may be present in the recycled product as a contaminant, and may leach sulphates to the environment creating an impact to the environments.

For recycled aggregates produced from C & D waste from depolluted building or structures to cease to be a waste, the recycled material must fulfil the European end-of-waste leaching requirements.

Road residues

For road residues the environmental requirements depend on the composition of the road structure from which the road residues were originated.

For road structures containing mineral wastes there is a risk associated with the mineral waste used. It may leach to the environment substances that could create an impact to the environment.
For road residues produced from road structures containing mineral wastes, they have to fulfil the European end-of-waste leaching requirements in order to cease to be waste.

For road residues without tar and mineral waste, initial assessment on the composition of the road is enough to guarantee that tar or any other mineral waste is present, and therefore no additional risk to the environment will occur.

IV. Product application

In order to guarantee a safe use, recycled aggregates must meet existing national regulations and standards applicable to the use of aggregates as construction materials.

([101]) Council Decision 2003/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (OJ L 11, 16.1.2003, p. 27).

V. Quality control procedures

The recycler should have implemented a quality management system. This is fundamental to guarantee that the product meets the declared specifications. Quality management systems are methods and procedures that guarantee quality control and assurance of the product characteristics.

Some countries have developed quality assurance standards on national level. These are frequently associated with certification and should be checked and adapted in order to fulfil the end-of-waste requirements.

The quality management system must be validated and monitored by competent/independent authorities recognised by Member States. The product should be tested internally and externally in order to validate the producer's declared properties.

The implementation of the quality management system should be monitored and inspected by competent/independent authorities recognised by Member States

3.3.4.1 A set of end-of-waste criteria for recycled aggregates derived from C & D waste

The following table summarises the previous discussion, identifying clearly end-of-waste conditions that have to be met for recycled aggregates to cease to be waste. Further explanations and rationales are also given to justify the end-of-waste conditions.

Construction and demolition waste			
	Criteria	**Explanations**	**Reasons**
Input material	**The input material used in the production of recycled aggregates must be clearly identified (categorised and traceable).** **Only the substances referred in Table 42 should be considered potential materials to cease to be wastes.**	The substances referred in Table 42 can, due to its intrinsic properties, be used as potential input material for the production of recycled aggregates.	
	The C & D waste must be classified according to the following categories: • **C & D waste from selective demolition** • **C & D waste from depolluted building or structures.**	Depending on the separation of hazardous materials and contaminants from the input material at the demolition site or at the recycling centre, several categories of input material could be envisaged.	This categorisation facilitates the definition of end-of-waste conditions according to knowledge of the input material.
	Input material from C & D waste from selective demolition procedures: the removal of hazardous and non-hazardous materials must be done while the substances/materials are still integrated in the building or structure. **The demolition contractor must have implemented a quality assurance system.**	Selective demolition procedures allow a good knowledge of the composition of the source materials used in the production of recycled aggregates, resulting in a minimum risk of contaminants and hazardous substances. The input material must include only the inert material referred to in Table 42.	The most efficient way of for separating hazardous substances and contaminants from the waste stream is to remove them at source, when they are still integrated in the building or structure, before the demolition. These actions should be part of a quality management system that provides quality assurance and control on the quality of all the procedures related to the demolition.

Construction and demolition waste			
	Criteria	**Explanations**	**Reasons**
	Input material from C & D waste from depolluted building or structures; the depollution must be done while the materials are still integrated in the building or structure. **All the procedures associated with depollution must be under a quality assurance scheme.**	The removal of hazardous material before demolition guarantees a minimum risk of hazardous substances in the input material. The depollution should be done under a quality assurance scheme which provides quality assurance and control of all procedures associated with the removal of hazardous substances.	The most efficient way of for separating unwanted substances from the waste stream, is to remove them at source, when they are still integrated in the building or structure, before the demolition. The quality of the depollution should guarantee that the removal of the unwanted substances is done in an efficient way.
	In order to identify possible hazardous substances incorporated into the road structure, an initial assessment on the composition of the road must be done, prior to the recovery process. **Different rules apply to different categories of road residues:** —**road residues containing tar** —**road residues containing mineral wastes** —**road residues not containing tar and mineral wastes.**	This initial assessment prevents the contamination of clean waste. Based on this assessment different categories of road residues could be envisaged.	 This categorisation facilitates the definition of end-of-waste conditions according to knowledge of the input material.
	Road residues containing tar must not cease to be waste.	Tar is one of the major issues associated with this type of residue. It is considered to be a hazardous substance with health and environmental risks associated.	

Construction and demolition waste			
	Criteria	**Explanations**	**Reasons**
Processing	**Independently from the removal of hazardous substances and contaminants at source or at the recycling site, the processing of the input material must be done in a controlled way including visual inspection and sorting.**	Sorting and visual inspection of the input material are techniques that help the removal of hazardous and non-hazardous materials from the input material. These must be used to guarantee that only inert material referred to in Table 42 enters into the crusher. The composition of recycled aggregates should be used as minimum process requirement for the treatment of the input material.	The revised standard EN 13242, classifies the recycled aggregates according to the constituents. The presence of metals, non-floating wood, plastic, rubber, gypsum plaster and insulation foams blown with ODS (ozone-depleting substances) substances must be below than 1 % by mass.
	Processing must be part of a quality management system.	Quality management systems provide quality assurance and quality control on recovery process of the C & D waste.	
Product requirements	**Recycled aggregates must fulfil the ENs technical standards, national regulations and standards applicable to the use of aggregates as construction materials.** **European standards (ENs) are the basis for minimum technical requirements.** **Unwanted materials present in the recycled product do not exceed 1 % by mass.**	Technical standards define common technical requirements that guarantee safe use of the material. The ENs take into consideration the essential requirements defined in the Construction Products Directive that guarantee a safe use.	The user has information about declared specifications. The ENs define the technical requirements for aggregates to be used as contraction materials. These create a solid base for the user to decide to use a recycled product. Other requirements or national standards might also be applicable depending on the type of utilisation of the material.

Construction and demolition waste			
	Criteria	Explanations	Reasons
	For recycled materials produced from C & D waste from selective demolition, the guarantee of a controlled selective demolition procedure is considered sufficient to ensure that there is no risk related to the use of these materials. **These procedures must be accompanied by a quality assurance scheme that provides control and assurance on the quality of tasks associated with the selective demolition.**	Assuming that the selective demolition and separate collection of the C & D waste was properly done, the risk associated with the release of hazardous material from the recycled product is controlled.	The input material is composed of the inert materials listed in Table 42. These inert materials are accepted and inert landfills sites without testing.
	For recycled aggregates produced from C & D waste from depolluted buildings or structures to cease to be a waste, the recycled material must fulfil end-of-waste leaching requirements.	End-of-waste leaching requirements guarantee that independently of the type of application, materials meeting the leaching requirements will not create an adverse impact to the environment. The recycled material can be used freely.	C & D waste from depolluted buildings or structures presents a risk in terms of contaminants present in the recycled material which can create an impact to the environment in the use stage of the material. The recycled material produced from C & D waste from depolluted building or structures may contain a small percentage of contaminants typically below than 1 % by weight, defined in the standards of the aggregates. A full removal of contaminants is not economically or technically feasible. These contaminants are non-hazards but could create an impact to the environment (e.g. sulphates from plaster).

Construction and demolition waste			
	Criteria	**Explanations**	**Reasons**
	Road residues produced from road structures containing mineral wastes have to fulfil end-of-waste leaching requirements in order to cease to be waste.	End-of-waste leaching requirements guarantee that materials meeting the leaching requirements will not create an adverse impact to the environment. The recycled material can be used freely.	Mineral wastes used in the past in road construction could create a risk to the environment. The risk exists and needs to be assessed.
	For road residues without tar and without mineral waste, the initial assessment on the composition of the road is enough to guarantee no risk to the environment will occur.		
Product application	**Recycled aggregates must comply with national regulations and standards applicable to the use of aggregates as construction materials.**	Recycled aggregates should fulfil all the legislation related to aggregates, technical requirements associated with specific uses, and legislation for construction materials applicable to aggregates.	Once the material ceases to be waste, all the product legislation applies to guarantee a safe use.
Quality control procedures	**The recycler must have implemented a quality assurance system in compliance with recognised quality assurance standards.** **The product should be internally and externally tested in order to demonstrate the producer's declared properties.** **The implementation of the quality management system should be monitored and inspected by competent/independent authorities.**	Quality management systems are methods and procedures that guarantee quality control and assurance of the product characteristics. Third-party validation and monitoring guarantee a correct implementation of the quality management system.	The characteristics of the recycled product must be highly reliable. Some Member States have developed quality assurance standards (e.g. COPRO certification). The external testing should be done by authorised laboratories.

3.3.5 End-of-waste criteria for secondary aggregates derived from materials generated in industrial processes

Ashes from coal combustion and slags from iron and steel production are materials currently used as aggregates due to their intrinsic physical properties, replacing the use of natural aggregates.

I. Input material

Iron and steel slags
Iron and steel slags are materials generated in parallel with the production of iron and steel.

According to the Commission's interpretative communication on waste and by-products, blast furnace slags may be classified as a by-product according to certain conditions, see Section 3.2.2.3 Interpretative communication on waste and by-products. They are generated with pig iron production. The production process is controlled and adapted in order to generate a material that meets requirements for later use, in parallel with the iron production. The slag can be processed in different ways according to the final use of the material.

Steel slags are generated in parallel with steel production. There are two main ways to produce steel, depending on whether pig iron or metal scrap is used as raw materials. The basic oxygen furnace (BOF) process uses mainly hot iron and scrap metal, generating BOF slags. Limestone is added to act as a fluxing agent forming the slag. In some cases, the slag is treated in order to overcome volume stability problems. The electric arc furnace (EAF) steel process uses metal scrap as the primary raw material. The metal is melted and limestone is added to form the slag.

The composition of the slag depends on the type of steel product produced. Slags generated from carbon steel production are used as aggregates. The production process is rather stable and consequently the composition of the slag follows a typical range.

The following table defines which input material is a candidate to cease to be waste.

Table 44: Wastes from the iron and steel industry (adapted from the European Waste Catalogue)

EWC code	Description	Restrictions
10 02 01	Waste from processing of slag	Blast furnace slag from pig iron production Steel slags, from carbon steel production: basic oxygen slag, and electric arc furnace slag
10 02 02	Unprocessed slag	

The heavy metal content and its release when in contact with water is the major problem associated with this type of material. Leached heavy metals and other substances such as sulphates can pollute the soil and water creating an impact to the environment.

To some extent the iron and steel industry chooses the raw materials, additives and the process conditions to influence the slag composition. However, these modifications cannot jeopardise the quality of the iron and steel produced.

Ashes from coal combustion
Ashes from coal combustion are the mineral content of coal used as fuel in electricity production. Their composition varies according to the type of coal and other fuels used, type of boiler and combustion conditions.

Boiler slag and bottom ash are the coarser fractions of ash produced during the coal combustion in coal-fired power stations. Fly ash is the fine ash fraction that goes with the flue gas and is extracted by flue gas cleaning equipment.

The following table defines which input material is candidate to cease to be waste.

Table 45: Wastes from thermal processes, wastes from power stations and other combustion plants (adapted from the European Waste Catalogue)

EWC code	Description	Restrictions
10 01 01	Bottom ash, slag, and boiler dust	Fuel used: coal or coal mixed with a certain percentage of other materials.
10 01 02	Coal fly ash	

The heavy metal content of the ashes is the major concern associated with this material. When the material is exposed to water, dangerous substances present in the ashes might be released to the soil and water creating an impact to the environment.

The chemical composition of the ashes is strongly dependent on the fuel used. To some extent the industry chooses the fuel combustion conditions to influence the ash composition. However, these modifications cannot jeopardise the electricity production.

For materials generated in parallel with industrial processes, control of the secondary material quality is achievable primarily by attention to process conditions and raw materials. However, the paramount objective of the industrial process is the production of the primary product. Modifications in the process conditions and raw materials to influence the secondary products' characteristics are only accepted if they do not influence the characteristics of the primary product and do not entail excessive cost.

II. Processing

Iron and steel slags
To enable the use of iron and steel slags as aggregates, the material is typically cooled down, crushed and classified. In some cases and due to the free lime content, the material has to be treated to avoid volume stability problems. This can be done before or after the cooling

depending on the technique used. For steel slags, the material may have to pass a magnetic separation step to remove metal content.

Ashes from coal combustion
Depending on the type of application and type of ash, the material may need to be crushed and sieved. For bottom ash and boiler slag, the material may need dewatering, crushing and sieving. For fly ash, the material is normally used without processing.

The processing of the secondary material ashes and slags does not influence so strongly the composition of the final product. The waste material is processed similarly to primary aggregates, and in some cases is not processed at all.

Therefore, processing will not be covered by specific end-of-waste conditions. The only requirement is that processing must be controlled according to the product requirements defined in the standards.

III. Product requirements

The origin of the input material and the processing of the secondary aggregates do not provide sufficient guarantees that these materials will not lead to adverse environmental impact when they are used under normal conditions. Therefore aggregates from slags and ashes can only cease to be waste if they meet the relevant technical requirements and comply with the European end-of-waste environmental requirements.

The material must fulfil all the technical requirements necessary to guarantee a safe use. These will provide a guarantee to the user on the technical performance of the material. The technical requirements that the material has to comply with are the European standards (ENs) established in the context of the Construction Products Directive as well as applicable national standards or requirements for specific use.

Ashes and slags to be used as secondary aggregates have to meet the end-of-waste environmental requirements. Due to the fact that the composition of secondary aggregates cannot be controlled during either the generation of the material or the processing, the environmental behaviour of the material in the long term needs to be assessed according to expected exposure conditions. Secondary aggregates need to be tested and evaluated according to the end-of-waste leaching requirements associated with general use of the materials.

For secondary aggregates to cease to be waste, they have to meet the end-of-waste European end-of-waste leaching requirements.

IV. Product application

The product application strongly influences the environmental impact associated with the use phase of the secondary aggregate. The surface exposure and the external conditions affect the release of substances from the secondary material to the environment. For secondary aggregates the product application is an important issue because the environmental behaviour of the material can be controlled by defining conditions for using the material.

Defining conditions for using the secondary material as part of the end-of-waste criteria would imply that a system of registration and control must established to guarantee that the material is used according to the defined conditions. This would not change the existing situation under the waste legislation.

The criteria are only justified if they improve the conditions of using the material. In principle, this requires that no further conditions apart from product-related regulations are associated to the materials after meeting the product requirements. When the secondary material leaves the processing centre the material is no longer a waste and can be transported and used as a product. The environmental requirements must provide enough guarantees that the material will not create an impact to the environment independently from the intended use.

In order to guarantee a safe use, secondary aggregates must meet existing national regulations and standards applicable to the use of aggregates as construction materials.

V. Quality control procedures

The producer of secondary aggregates should have implemented a quality management system. This is fundamental to guarantee that the product meets the declared specifications. Quality management systems are methods and procedures that guarantee quality control and assurance of the product characteristics.

The quality system must be validated and monitored by a third party. The characteristics of the product should be evaluated externally in order to validate the producer's declared properties.

3.3.5.1 A set of end-of-waste criteria for secondary aggregates derived from materials generated in industrial processes

The following table summarises the previous discussion, identifying clearly end-of-waste conditions that have to be met for secondary aggregates to cease to be waste. Further explanations and rationales are also given to justify the end-of-waste conditions.

Materials generated in industrial processes			
	The criteria	**Explanations**	**Reasons**
Input material	**The input material used in the production of secondary aggregates must be clearly identified.** **Only the substances referred to in Table 44 and Table 45 should be considered as potential materials to cease to be waste.**	The substances referred to in Table 44 and Table 45 can, due to their intrinsic properties, can be used as input materials for the production of secondary aggregates.	
Processing	**The processing of the input material must be done in a controlled way, according to the product requirements defined in the standards.**	The standards should be used as minimum process requirements for the treatment of the input material.	The processing of the secondary material does not so strongly influence the composition of the final product. Therefore processing will not be covered by specific end-of-waste conditions. The only requirement is that processing must be controlled according to the product requirements defined in the standards.
Product requirements	**Secondary aggregates must fulfil the technical standards applicable to aggregates, in particular European standards (ENs) developed in the context of the Construction Products Directive as well as applicable national standards or requirements for specific use.**	Technical standards define common technical requirements that guarantee safe use of the material. The ENs take into consideration the essential requirements defined in the Construction Products Directive that guarantees a safe use of the construction material. Other requirements or national standards might also be applicable.	The user has information about declared specifications. The ENs define the technical requirements for aggregates to be used as construction materials. These create a solid base for the user to decide to use secondary aggregates.

Materials generated in industrial processes			
	The criteria	**Explanations**	**Reasons**
	For materials generated in parallel to an industrial process to cease to be a waste, they must meet the European end-of-waste leaching requirements.	End-of-waste leaching requirements provide a maximum allowable impact to the environment associated with the general use of the material.	The leaching requirement must take into consideration the long-term behaviour, the exposure conditions of the material and the attenuation factors affecting the bioavailability of the substances to be released from the secondary material. The end-of-waste leaching requirements must guarantee that independently of the type of application, materials meeting the leaching requirements will not create an adverse impact to the environment. The secondary material can be used freely.
Product application	**Secondary aggregates must comply with national regulations and standards applicable to the use of aggregates as construction materials.**	Secondary aggregates should fulfil all the legislation related to aggregates; technical requirements associated with specific uses, and legislation for construction materials applicable to aggregates.	Once the material ceases to be waste, all the product legislation applies to guarantee a safe use.

Materials generated in industrial processes			
	The criteria	**Explanations**	**Reasons**
Quality control procedures	**The producer of secondary aggregates must have implemented a quality assurance system in compliance with recognised quality assurance standards.**	Quality management systems are methods and procedures that guarantee quality control and assurance of the product characteristics.	The characteristics of the secondary product must be highly reliable.
	The product should be internally and externally tested in order to demonstrate the producer's declared properties.	Third-party validation and monitoring guarantee correct implementation of the quality management system.	The external testing should be done by authorised laboratories.
	The implementation of the quality management system should be monitored and inspected by competent/independent authorities.		

3.4 Impact assessment

In order to evaluate the soundness of end-of-waste criteria developed for recycled aggregates from construction and demolition waste and for secondary aggregates from material generated in parallel to industrial processes, it is necessary to assess the possible impacts of removing the waste status from these materials. The impact assessment provides feedback on the fulfilment of end-of-waste principles in addition to implications and consequences associated with the criteria.

The impact assessment covers environmental, market, economic and social impacts that may result once recycled and secondary aggregates cease to be wastes. This comprehensive analysis indicates the benefits and disadvantages of end-of-waste criteria for these waste streams.

As described in sub-chapter 3.2 the utilisation of recycled and secondary aggregates differs from country to country. Some Member States have developed rules for using recycled and secondary aggregates, while others do not have rules and the material is used on a case-by-case basis or it is used without any control. As a result, since there are different existing approaches the impact of end-of-waste would be different from country to country.

3.4.1 Environmental and health impact

The introduction of end-of-waste criteria for recycled aggregates from construction and demolition waste and secondary aggregates from material generated in industrial processes will have an impact to the environment in two different ways.

- It will increase the recycling rates of the three waste streams.
- It will modify the legal status of recycled and secondary aggregates.

The increase in the recycling of construction and demolition waste, slags from iron and steel and ashes from coal combustion in the production of recycled and secondary aggregates has a number of environmental benefits. It allows the:

- the savings of natural resources. Recycled and secondary aggregates replace the use of primary aggregates;
- the reduction on the landfill space necessary for the disposal of these three waste streams.

Other benefits might occur depending on local conditions. The harmful effect associated with transport might be reduced for C & D waste. The material arises at urban centres, which are also the areas that consume most aggregates. The production of primary aggregates is typically done at quarries located outside urban areas, so the material needs to be transported longer distances.

The use and production of recycled and secondary aggregates have a number of risks to the environment that need to be evaluated when assessing the environmental impact of recycled and secondary aggregates to ceasing to be wastes.

- The use stage of recycled and secondary aggregates has a risk associated with the release of substances from the aggregates into the environment creating a possible impact.
- The processing associated with the production of recycled and secondary aggregates has an environmental impact associated. Dust, consumption of energy and emissions to air and water might happen, though the same applies to the production of primary aggregates (see Section 3.2.4.5 Applied processes and techniques).

Within the context of the waste legislation, some Member States have developed provisions to overcome these risks and protect the environment, see Table 18, Table 19 and Table 20. A screening of the situation in each Member State reveals substantial differences in the nature and stringency of the rules adopted.

Some Member States have defined national provisions that can be considered equivalent to the end-of-waste criteria. In this case, material meeting the national requirements can be used without waste controls.

The introduction of end-of-waste will modify the current legal status and the provisions related with the recycling and the use of these materials. Depending on the national provisions, the environmental impact will be different in each Member State, see Table 46.

Table 46: Comparison between end-of-waste leaching limit values and national regulations

Group	**Member States**	**Environmental impact of European end-of-waste leaching requirements**
Member States with stricter leaching limit values	Sweden and Denmark	**Probable increase** Denmark's regulation on the use of coal ash in building and construction works, is more restrictive that the European end-of-waste requirements. Sweden's draft guidelines for the recovery of waste as construction material, defines the leaching values for the recovery of waste as a construction materials. The limit values for general uses, is more restrictive that the end-of-waste requirements. For substances of very high concern the values are based on natural background levels. Other values are based on risk assessment. **The leaching values of the Landfill Directive as end-of-waste leaching requirements are not as strict for all the pollutants as in these two Member States; therefore, the removal of the waste status on this basis could lead to additional release of substances to the environment.**

Group	Member States	Environmental impact of European end-of-waste leaching requirements
Member States with comparable leaching limit values	Austria, Finland and Spain (Cantabria)	**No substantial change** For Austria, the leaching limits values are comparable, with the exception of the Cr and Cu. For the latter, the difference is more significant. For Finland (covered structures), the leaching limits for recycled aggregates are comparable, with the exception of Cd. For Spain (Cantabria) the leaching limit values for slags are the same as the end-of-waste leaching values. **The leaching requirements for Cd and in particular for Cu of the Landfill Directive are not as strict as those required for these two countries. Therefore, the removal of the waste status on this basis might lead to additional release of substances to the environment. However, in general, most of the national leaching limit values are the same as the leaching values of the Landfill Directive, therefore no substantial change would happen on this basis.**
Member States with no comparable leaching limit values	Netherlands, Belgium (Flanders), Spain (Basque country)	**Probable decrease** The national leaching requirements for these countries are not comparable with the end-of-waste leaching references. In some particular cases the leaching limits values are more stringent. For Cu there is a significant difference (the Netherlands and Belgium). For Zn, the Belgian and the Spanish (Basque country) requirements are more stringent and for chlorides the Dutch limit value is more stringent. For sulphates and Ba the Spanish (Basque country) limit values are more stringent. However, in general, the end-of-waste leaching limit values are more stringent that the national leaching requirements. **In the overall analysis, a probable decrease of release of substances to the environment might be expected if the leaching values of the Landfill Directive are used as end-of-waste criteria. However, for Zn and, in particular, for Cu an increase might occur.**
Member States which do not have leaching requirements for using recycled and secondary materials in construction works		**Likely to decrease** **In countries with no rules or no leaching criteria, the end-of-waste criteria might result in a decrease in release of substances to the environment by requiring leaching evaluation.**

Some Member States require the evaluation of additional parameters besides the ones required by the end-of-waste leaching criteria. The fact that end-of-waste leaching criteria do not cover these parameters could lead to an impact to the environment, in those specific countries.

End-of-waste criteria were designed to exclude materials that in absolute terms create an impact to the environment. In general the conditions imposed by the criteria are stricter than the current norms, although in some cases, where national rules are very stringent, a potential increase in the release of the substance to the environment cannot be excluded.

The proposed end-of-waste criteria only affect indirectly the environmental impact of recycling operations, since they do not imply any change of the legal status of the input material. Demolition, collection, transport of the waste and processing are waste treatment operations that will continue to be covered by waste regulatory controls.

The end-of-waste criteria are directly related to the use of the recycled and secondary materials and the environmental impact associated. The criteria exclude all the material with hazardous contaminants, which should eventually continue to be used under the waste regime.

The criteria require that in all cases, except for recycled aggregates produced from C & D waste from selective demolition, the producer has to prove that the material meets the end-of-waste leaching requirements.

End-of-waste leaching requirements define the maximum allowable release of substances to the environment, by considering the long-term behaviour of the material and the expected conditions of exposure of the recycled and secondary aggregates in the use phase of the material.

3.4.2 Economic impact

Costs associated with the fulfilment of end-of-waste criteria

The fulfilment of end-of-waste criteria has a cost for the recycler who needs to adapt the recovery of C & D waste, iron and steel slags and coal combustion ashes according to end-of-waste requirements. In some cases, end-of-waste requirements address the generation of the waste, testing of the material and costs associated with quality assurance control.

End-of-waste establishes that the production of the recycled and secondary aggregate must be covered by a quality assurance system. In some Member States this already happens, going further than end-of-waste requirements and associating it with product certification. In other Member States quality assurance systems are not implemented or need to be upgraded in order to fulfil all the end-of-waste requirements.

End-of-waste criteria for recycled aggregates derived from C & D waste distinguishes various approaches according to the generation of the waste. They favour the segregation at source of contaminants and hazardous materials by carrying out selective demolition. However, these procedures entail higher costs. More time, special machinery and more space is needed. Costs associated with selective demolition could be 17–25 % higher than for normal demolition according to (Dantata N. 2005).

In most of the cases, recycled and secondary aggregates have to meet end-of-waste leaching requirements. Depending on the national provisions leaching evaluation could already be part of existing frameworks. In other cases, recycled and secondary aggregates are used without testing so recyclers would have to perform leaching tests on the recycled material. With the end-of-waste criteria, leaching testing is required most of the times.

Costs associated with removal of the waste status
According to a recycling association the costs associated with the administrative procedures related to the waste status could reach 1 % of the turnover of the recycling sector.

With the end-of-waste, the costs associated with these tasks will be reduced once the recycled material fulfils the end-of-waste criteria. The transport and use of the recycled material is done as a product, with no waste controls.

Overall assessment
In cases where quality assurance systems exist and the material is already tested for leaching, the fulfilment of end-of-waste requirements would not modify the current situation to a great extent. A significant positive economic impact will be associated with the removal of the waste status.

Where quality assurance systems exist but an upgrade is needed to meet the end-of-waste requirements, a positive economic impact would not be so significant. Additionally, if leaching practices are not established, a neutral or even a negative economic impact may result. This, however, needs to be evaluated in the long term. In the short term the investment is substantial but in the long term and together with improved quality of the product a better acceptance of the product will cause an increase in revenues.

Despite being difficult to quantify, the fact that recycled and secondary aggregates are considered products facilitates user acceptance of the secondary material. The definition of common quality references favours the acceptance of the material guaranteeing a safe use.

3.4.3 Market impact

The supply and demand of secondary and, in particular, recycled aggregates produced from construction and demolition waste is greatly influenced by a combination of factors which explain the variability in recycling rates in Europe. The main factors that affect the market for recycled aggregates are:

- landfill taxation;
- availability and cost of primary aggregates;
- taxation on primary aggregates;
- the existence of national rules regarding quality and technical properties of recycled and secondary aggregates;
- public perception or consumer acceptance.

The recycling of C & D waste varies from 90 % to less than 5 %. This discrepancy can be explained by the different weighting of the above mentioned factors in each country.

An analysis of the situation in different Member States shows that waste management (landfill taxes) and restriction on the use of natural resources (taxation on natural aggregates) are the main reasons for the different recycling rates. Countries with taxes on landfill and primary aggregates extraction have the highest recycling rates.

The existence of national values which guarantee the quality of secondary and recycled aggregates increases consumer confidence. In the Netherlands, one of the countries with the highest recycling rates in Europe, recycled and secondary aggregates have to fulfil the same requirements.

The price of natural aggregates varies in Europe, from EUR 3 to EUR 9/tonne depending on availability, demand and taxation rates. The treatment costs for recycled aggregates vary from EUR 5 to EUR 10/tonne.

Secondary and recycled aggregates cannot, on many occasions, compete on price grounds. Incentive such as landfilling taxes and taxation on natural resources are used to increase the recycling rates.

The introduction of end-of-waste criteria will have an impact in particular on two of the factors which affect the market for recycled and secondary aggregates. End-of-waste leaching requirements and the guarantee that materials meet the technical requirements will increase the confidence of the user in these materials. The removal of the waste status and trading the materials as a product will improve public perception and consumer acceptance of recycled and secondary aggregates.

The end-of-waste criteria will facilitate the trade of secondary and recycled aggregates by defining common minimum quality requirements. Even though there is trade between countries (see sub-chapter 3.2), the transport costs constrains the movements of the aggregates to 50–100 km. With the criteria the trade of recycled and secondary aggregates between countries will probably increase border areas.

For recycled and secondary materials that do not meet the end-of-waste requirements, finding a market will be more difficult. The competition with primary aggregates plus recycled and secondary aggregates which are products, together with the controls due to their waste status will make it harder for these materials to enter in the aggregates market. This could lead to efforts to improve the product quality, the processing and the source separation of the input material in order to obtain a product that meets the end-of-waste requirements.

Recycled aggregates, in particular, are used in lower-grade types of applications such as engineering fill and road sub-base. When the end-of-waste criteria are implemented in countries with low recycling rates it is expected that the production of lower-grades type of aggregates will take place in the beginning. This tendency will develop according to market demand. In some countries with well-established recycling practices, the use of recycled aggregates in more demanding types of applications exists, because the market is saturated with lower-grade types of material.

End-of-waste criteria will facilitate the marketing of recycled and secondary aggregates, but they will not result in a direct increase in the recycling rate. Only a combination with other policies will lead to such an increase.

3.4.4 Legislative impact

Material which fulfils the end-of-waste criteria has to comply with the legal requirements applicable to primary products. Two aspects need to be considered when assessing the legislative impact of the end-of-waste criteria. One is the effect of the legislation associated with the product status that has to be met by recycled and secondary aggregates — the Construction Products Directive (CPD) and the REACH Regulation. The other is the effect of existing national legislation currently applicable to the use of recycled and secondary aggregates.

Construction Products Directive

Aggregates are construction materials that are regulated under European and national legislation associated with construction products. One of the most relevant pieces of European legislation for construction products is the CPD.

The European standards for aggregates differentiate primary, secondary and recycled aggregates. The three types of materials have to fulfil the same technical requirements in order to be used as aggregates in the European common market. For some materials, additional requirements were defined according to the properties of these materials. One of the standards was revised to include additional clauses for recycled aggregates.

With the removal of the waste status, this scenario is maintained. Recycled and secondary aggregates with the waste status have to fulfil product legal requirements to guarantee fitness for use and to be placed in the European market. With the end-of-waste criteria, the same requirements have to be met. As part of the end-of-waste requirements, recycled and secondary aggregates can only cease to be waste if they meet the existing legislation and standards applicable to aggregates.

Concerning the development of the third essential requirement, the European standards are expected to cover the essential requirement ‘Hygiene, health and environment’ in more detail when the standards are revised. Once these additional requirements are defined and implemented in the standards, recycled and secondary aggregates that cease to be waste apart would have to meet these extra requirements in addition to the environmental requirements required by the criteria.

REACH Regulation

The REACH Regulation lays down specific duties and obligations on manufacturers, importers and downstream users of substances on their own, in preparations and in articles. The objective is to ensure a high level of protection of human health and the environment as well as the free movement of substances, on their own, in preparations and in articles, while enhancing competitiveness and innovation. Any manufacturer or importer of a substance, either on its own or in one or more preparations in quantities of one tonne or more per year shall submit a registration to the European Chemicals Agency. REACH focuses on substances. The main principle of the legislation is no data no market.

REACH is based on the principles that it is the responsibility of the industry or importers to generate data on the substances they manufacture or import and to use these data to assess the risks associated with these substances and to recommend appropriate risk-management measures. The registration of substances requires manufacturers and importers to obtain or generate data on their substances and uses and to assess how risks to human health and the environment can be controlled by applying risk-management measures.

REACH foresees two different regimes for substance registration. A transitional regime is foreseen for substances which, under specific conditions, were already manufactured or placed on the market before the entry into force of the regulation. Such substances are called phase-in substances and could benefit from extended periods for registration. In order to be considered phase-in substances they have to be preregistered before 1 December 2008.

All substances which do not fall under phase-in conditions are non-phase-in substances. These substances do not benefit from the transitional regime and need to be registered before they can be manufactured, imported or placed on the EU market.

Once a substance is preregistered the manufacturer or the importer has to participate in the Substance Information Exchange Forum (SIEF) according to the sameness of the substance preregistered. The forum allows potential registrants of the same phase-in substance and downstream users to share information avoiding duplication of studies.

The importer or the manufacturer of the substances can opt to joint submit the registration dossier. The intention is to save money by cooperating and sharing the costs of data generation in the preparation of the dossier. The information is submitted by one lead registrant on behalf of the others.

In principle, REACH applies to all substances. However, the regulation exempts certain substances that are adequately regulated under other legislation or present low risks to human health and the environment.

Primary aggregates are exempted from registration, downstream user obligation and evaluation, because they fall into the exemption in Annex V, substances which occur in nature, if they are not chemically modified. The raw materials used in the production of primary aggregates are naturally occurring materials or minerals (e.g. stone, sand). The minerals can be used immediately after extraction, for example sand, or have to be processed, crushed and sieved. The production process involves only physical transformation of the mineral according to technical specifications. The chemical nature of the mineral is maintained.

REACH and recycled aggregates produced from construction and demolition waste

According to a new version of a document prepared by the Commission to clarify REACH obligations of waste and recovered substances, recycled aggregates may be considered as articles. The main function of aggregates is to provide stability and resistance to degradation/fragmentation. If, to meet this function, the shape, surface, or design is more important that the chemical composition, then recycled aggregates can be considered articles. This can only happen if the recycled materials were deliberately produced according to certain characteristics e.g. size and shape.

The end-of-waste criteria for aggregates requires that recycled aggregates derived from construction and demolition waste can only cease to be wastes if the material meets technical requirements for aggregates to be used in construction works. Therefore the article definition would apply for recycled aggregates meeting the end-of-waste criteria. According to the same document, in case that the shape, surface or design does not determine the function of the materials to a greater degree than its chemical composition, then recycled aggregates should be seen as substances or as preparations.

REACH and secondary aggregates

Secondary aggregates are produced from secondary material generated in parallel to an industrial process. This case study focuses on ashes from coal combustion and slags from iron and steel production. Both industrial processes involve a chemical transformation of the raw materials.

Once these secondary materials cease to be wastes they are subject to REACH. They have to be registered and information on safe handling needs to be prepared. Secondary aggregates are the result of a chemical process and should be registered as substances. The chemical composition varies according to the conditions of the industrial process and raw materials used. Due to the variability and the number of substances present in secondary aggregates, the UVCB classification should be the more appropriate.

The importers and manufactures of secondary aggregates should preregister their substances in order to benefit from the extended registration period. Ashes and slags are already listed in the European Inventory of Existing Chemical Substances (EINECS), and therefore fulfil the phase-in substances criteria.

Impact on existing national legislation

The waste legislation foresees that Member States shall develop general rules for each type of recovery activity, laying down the conditions under which the activity in question may be exempted from the permit requirements. Member States have developed specific regulations for secondary materials to be used in construction works based on the waste legislation. With the end-of-waste criteria, recycled and secondary aggregates are no longer under the waste legislation.

If Member States would like to maintain the same requirements, or define requirements associated with the use of the recycled and secondary aggregates, they would have to draft the legislation in the context of recycled and secondary aggregates as products and not as wastes.

One Member State has developed legislation for construction materials to be used in contact with soil and water. No distinction is made between primary or secondary materials, and both have to fulfil the same requirements. In this case the removal of the waste status would not modify the present situation.

3.5 Conclusion

This pilot case aimed at helping the development of the general end-of-waste methodology by carrying out the development of end-of-waste criteria for aggregates. From this case study, some relevant aspects were identified.

Depending on the waste stream, the generation of the input material is essential to deal with the environmental and health risks associated with the waste stream.

For recycled aggregates derived from construction and demolition waste the generation of the material is the most relevant step. The removal of hazardous and non-hazardous materials before the demolition is the most effective way ensure that unwanted materials are not present in the input material, and consequently in the recycled product.

For secondary end-of-waste aggregates derived from materials arising from industrial processes, the composition of material is strongly dependent on the process conditions and raw materials used; however, the main objective is the primary product production. Modifications in the production process and raw materials are only accepted if the primary product production is not affected. Therefore imposing end-of-waste conditions is not viable.

Depending also on the characteristics of the waste stream, the recovery process is relevant for defining end-of-waste criteria because it influences the composition of the recycled product. The processing removes unwanted substances, minimising the risk of contaminants. Minimum processing requirements, in this case associated with recycled product composition, are defined for recycled aggregates to cease to be waste.

For secondary aggregates from iron and steel slags and ashes from coal combustion, the processing does not influence to a great extent the composition and environmental risks associated with secondary aggregates. Therefore, the recovery process is not relevant as part of end-of-waste conditions.

The product requirements step, in particular environmental requirements, is relevant when the environmental risks associated with recycled and secondary aggregates still exist after collection/generation and the recovery process. In this case, the definition of the end-of-waste leaching requirements to be met by recycled and secondary aggregates provides guarantee that no additional environmental impact will occur when recycled and secondary aggregates cease to be waste.

The fulfilment of technical requirements in order to guarantee that the material is suitable to enter in the aggregates market is fundamental for the consumer acceptance and certainty of use.

The definition end-of-waste leaching requirement is one of the key aspects, which raised some discussion during the pilot case development. One option is to use as leaching requirements those established to define inert waste in the Landfill Directive. The applicability of those leaching limit values to recycled and secondary materials is questioned by some of the experts involved in this case study. The values were founded on landfill scenario and drinking water criteria. However, Member States have used similar approaches for defining national leaching limit values for secondary materials, showing that is a viable approach.

The other possibility is to derive new European end-of-waste pollutant limit values for recycled and secondary aggregates to cease to be a waste. This is a complex issue due to the fact that there are different test methods and approaches to the same problem among Member States. This approach needs to be undertaken on a different level, with relevant expertise on leaching, risk assessment, modelling and testing methodologies. Most probably a special working group with such expertise will need to be organised.

Leaching methodologies are to be used for evaluating the leaching behaviour of the material according to the long-term use and exposure conditions of the recycled and secondary material. They must predict as far as possible the real impact of using recycled and secondary aggregates. Further work is needed in this field for evaluating the long-term behaviour of recycled and secondary materials. The work should be complementary to the work developed in TC 351 for the implementation of third essential requirement of the Construction Products Directive.

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CHAPTER 4 Metal scrap case study

4.1 Introduction

4.1.1 Objective

This part of the report presents the case study on iron and steel and aluminium scrap within the JRC-IPTS end-of-waste project.

The objective of this case study, as of the other two (on aggregates and compost), was to support the development of a methodology for proposing end-of-waste criteria under a revised Waste Framework Directive. It achieved this by demonstrating how a set of end-of-waste criteria for scrap can be developed and what such criteria may look like under a certain set of basis conditions for end-of-waste criteria.

The methodology development and the case studies were closely linked and iterative. The cases studies served to test early versions of the methodology, provided feedback for the revision of the methodology, and were then further developed by applying the new versions of the methodology.

The proposals developed in this case study are merely research-based showcases and do not necessarily represent the position of the European Commission.

The study merely tests the feasibility of end-of-waste criteria; however, it does not prejudge any policymaking process and whether end-of-waste criteria for scrap metal should be proposed.

4.1.2 Scope and methodology

This study on metal scrap focuses on two types of metal scrap, i.e. ferrous (iron and steel) scrap and aluminium scrap. For both types of scrap metal the sources range from various industrial sectors to household appliances. Whilst this case study was limited in focus to ferrous and aluminium scrap, this does not imply that other scrap metals could not, in the future, be studied with a view to developing end-of-waste criteria for them.

Two expert workshops and site visits have taken place in the course of the case study. These workshops have brought together the different perspectives as well as concerns of the metal scrap industry and reached a fairly good common understanding of the key questions addressed in the study. Several site visits have also been conducted with the assistance of industry associations in various Member States. In total nine plants were visited including a large company operating worldwide and a small-scale family run plant. The visits included: a ferrous scrapyard with limited pretreatment process; three integrated all metal recycling plants, two integrated all metal recycling plants with specialised media separation process; two non-ferrous recycling plants with special focuses on input material; one aluminium refinery.

This paper summarises the research work carried out for this case study and it presents and discusses a proposal containing the content of possible end-of-waste criteria for scrap metal and important issues related to the criteria and its implementation.

4.1.3 Case study structure

The scrap case study chapter consists of three main sub-chapters.

The first part provides an overview of the metal scrap sector. It analyses scrap sources differentiating between new and old scrap and it describes the scrap metal recycling processes depending on the source of the material, identifying the main health and environmental related issues. It follows a description of the industry structure, specifications and standards used by industry and related legislation and regulation.

The second sub-chapter is the central part of the case study. It identifies the reasons for the end-of-waste criteria for scrap, i.e. the advantages they may deliver compared to the current situation, analyses if and how the basic general conditions for the end-of-waste criteria can be fulfilled and it proposes a set of scrap end-of-waste criteria for different groups of scrap according to their characteristics.

The last sub-chapter assesses the impacts that the proposed end-of-waste criteria for scrap metal would have compared to a ‘no action scenario’. The assessment covers the environment and health impact, the economic and social impact and the legislative impact.

It concludes with a number of considerations regarding the implementation of the criteria.

4.2 Analysis

Scrap metal is generated during metal product fabrication or when a metal-containing product reaches its end of life. Due to the high value of metal, both ferrous and aluminium scrap have largely been recovered since the existence of the metal production itself. Given the chemical and physical properties of the material, metal produced from metal scrap can, in almost all applications, compete with primary metal produced from ore. However, the amount of scrap collected and finally recovered depends on various factors, such as the collection system, the possibility and techniques used for the collection, etc., as well as a variety of legislation.

The scrap recycling industry consists of scrap collection and sorting, distribution, treatment and processing. With a long history of recycling, the metal scrap industry is well established and has achieved high efficiency and level of integration along the recycling chain.

Recycling of metal scrap is highly attractive due to the environmental issues related to resource (primary ore) exploration and high energy intensity of primary metal production.

The development of end-of-waste criteria for metal scrap takes into account the characteristics of waste streams, as well as the structure of the industry, the flow of trade, the existing regulations and standards/specifications. End-of-waste criteria should aim at encouraging better recycling and the overall performance of the industry. The following sections provide the background of the industry as well as the issues that concern metal scrap as waste throughout the entire recycling chain.

4.2.1 Characteristics of metal scrap

Logically, the main scrap sources are those products for which metal is a main constituent namely, vehicles (including ships and aeroplanes), metal products for construction, machinery, electrical and electronic equipment, cables, packaging such as used beverage cans and foil. It was not possible, from the point of view of data and information as well as practical resources for this case study, to cover all the possible sources of metal scrap, and therefore, only the above mentioned main sources of scrap are discussed hereafter.

4.2.1.1 Scrap source

Scrap is first distinguished as new scrap or old scrap depending on when it becomes scrap in its life cycle. Scrap metal is further distinguished according its specific source.

4.2.1.2 New scrap

New scrap generated during initial manufacturing processes is completely recycled either on-site or sent directly to a remelter/refiner or a steelworks. Since the composition of the scrap is well known, in principle it does not need any pretreatment process before it is remelted, although cutting to size might be necessary.

In the communication from the Commission 'Interpretative Communication on waste and by-products' (COM(2007) 59 final), an example of a by-product is given as being 'offcuts and other similar materials'. There it is stated:

'… Use is certain, as part of an integral production process and without further processing other than being adapted to the appropriate size for being integrated into the final product. In more general terms, excess material from a primary production process, or material that is deficient only in a cosmetic way but that is materially similar to the primary product, such as rubber compound and vulcanisation mix, cork shavings and pieces, plastic scrap and similar material may be seen as by-products. For this to be the case they must be able to be reused directly either back in the primary production process or in other integrated productions where reuse is also certain. Materials of this type can also be considered to fall outside of the definition of waste.'

Following this theme, new scrap could be considered as by-product and not waste. Even new scrap with paint or coating (with the exception of cable which does need treatment prior to input into a furnace) does not need any waste-related pretreatment before sending to the furnaces, since many furnaces can melt such new scrap directly and, if required, decoating can be performed in a thermal process immediately prior to feeding to the melting furnace.

4.2.1.3 Old scrap

Old scrap is collected after a consumer cycle, either separately or mixed, and it is often contaminated to a certain degree, depending highly on its origin and collection systems. Since the lifetime of many metal products can be more than 10 years and sometimes more than 50 years, for instance products for building and construction, there is an accumulation of metal in use since the beginning of the industry.

<u>Aluminium scrap</u>

According to the industry association, currently around 540 Mtonnes of aluminium products are in use and nearly 8 Mtonnes of old aluminium scrap were generated worldwide in the year 2004. 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 and the improved collection of packaging materials such as beverage cans. In the EU (data for EU-25 only), the total recycled old scrap was 2 Mtonnes in 2004 and the total aluminium in use amounted to nearly 120 Mtonnes. The key sources of aluminium scrap and its characteristics are summarised in the following paragraphs:

Vehicles and transportation

The automobile industry is the largest overall market for aluminium application and the largest source of aluminium scrap. When a car comes to its end of life, it is collected and dismantled. The total amount of aluminium scrap that is collected depends on the yearly number of end-of-life-vehicles (ELVs) and their aluminium content. The average lifetime of vehicles is estimated to be 12–15 years; however, many vehicles may be used for longer, especially in developing countries and in the case of exported used cars from Europe. The current estimation shows that the transportation sector accounted for 44 % (ca 3 Mtonnes) of total recycled aluminium, 12 % of which is estimated to originate from ELVs. This can be compared with the sector's current consumption of aluminium of around 10 Mtonnes. The rate of collection of end-of-life light vehicles in the US, Europe and Japan is estimated being around 85 %. Based on past data and information, it is estimated that there is around 150 Mtonnes of aluminium inventory in the entire transportation sector.

Construction and building

In some countries, especially those without an automobile industry, the building and construction sector is probably the largest market for aluminium, consuming some 2 and 9 Mtonnes of aluminium products per year in Europe and the world respectively. However, it may vary considerably from country to country due to the level and type of sector activities. The total stored aluminium product in the sector is the largest since the beginning of industrial application of aluminium, amounting to nearly 170 Mtonnes worldwide. However, as already mentioned, due to the very long lifetime of buildings, its contribution to recycled scrap was only 7 % in 2004, i.e. around 0.5 Mtonnes in total.

The main use of aluminium in this sector is to provide materials for roofing and cladding, and window and door frames, as well as small-size applications such as shutters, door handles, ceiling partitions, etc. A study on the collection of aluminium scrap from building deconstruction and demolition in six European countries indicates that the collection rate was from 92 % to 98 % even though the aluminium content in building (by mass) is below 1 %. While the collection of the small-sized items depends largely on the demolition method, the large-sized items are often collected separately to be sold directly for reuse or sent to a recycling plant.

Packaging material

Aluminium packaging waste is a large short-term source of scrap. Most of the products used in food packaging have less than one year of lifetime. The current consumption is close to 5 Mtonnes/year. The sector contributes nearly 28 % of recycled aluminium, second after the transportation sector. The overall rate of aluminium recycling in the sector is around 36 %, mainly from beverage cans, although the rate varies greatly from country to country.

Two different types of aluminium product are usually distinguished in this sector, i.e. rigid and semi-rigid, and flexible packaging, with the former having high aluminium content and the latter low in aluminium content. Used beverage cans (UBCs) are the most recycled among all the aluminium containing products of the sector, while the others are recovered to a much lesser extent.

Cable and wire

When buildings and installations are demolished, renewed and/or upgraded, scrap is generated. However, no data is available to estimate a total amount. Since the current demand is mainly driven by new installations in developing countries, the available scrap from this sector may be expected to rise in future. According to BIR, in 1997 worldwide, cables generated over one million tonnes of scrap metal, the majority of which is copper, although power transmission cable uses aluminium as the conducting metal.

Electrical and electronic equipment (EEE)

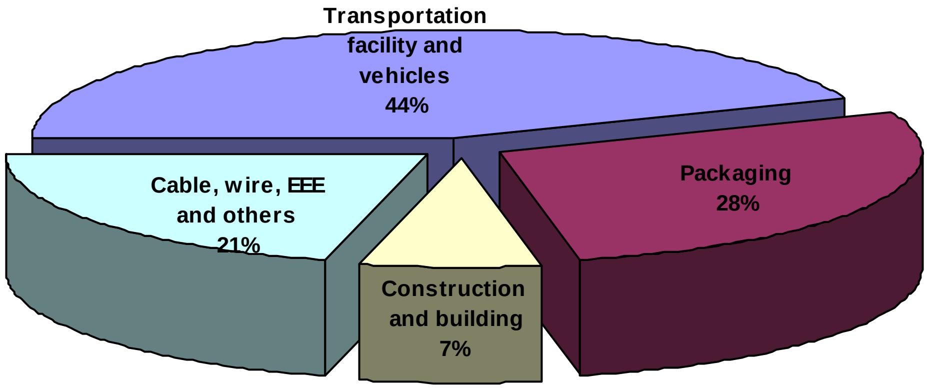
EEE includes a wide range of complex products: large household appliances (refrigerators, washing machines, stoves); small household appliances (vacuum cleaners, toasters, hairdryers); information and telecommunications equipment (computers and peripherals, cellphones, calculators); consumer equipment (radios, TVs, stereos); lighting (fluorescent lamps, sodium lamps); electrical and electronic tools (drills, saws, sewing machines); toys, leisure and sports equipment (electric trains, video games); medical devices (ventilators, cardiology and radiology equipment); monitoring instruments (smoke detectors, thermostats, control panels); automatic dispensers (appliances that deliver hot drinks etc.).

It is estimated that each EU citizen currently produces around 17–20 kg/year of waste from EEE (WEEE) which adds up to 9–10 million tonnes at the Community level. Expected growth rates are from 3 % to 5 % each year. This means that in five years time, 16–28 % more WEEE will be generated and in 12 years the amount is expected to double. This rapid growth rate is due to the fast pace of technological development, especially in information technology, which has resulted in the more frequent replacement of electrical and electronic equipment by industry.

An estimate of the average composition of WEEE in Europe shows that iron and steel are the most common materials by weight found in electrical and electronic equipment and account for almost half of the total weight of WEEE. Aluminium as one of the non-ferrous metals represents approximately 4.7 % of the total. The amount of aluminium scrap from e-waste can thus be estimated around 400 000 tonnes/year in the EU. However, the collection rate is unknown, and the actual amount of scrap recovered is expected to be less.

The various sources of aluminium scrap are presented in Figure 25.

Figure 25: Sources of aluminium scrap



<u>Iron and steel scrap</u>

Since 2004, the EU-25 has consumed in total around 100 million tonnes of iron and steel scrap each year, which equates to about 54 % of the steel produced. Taking into account that exports of scrap total around 9–10 Mtonnes and imports 7–8 Mtonnes, the average net exports have been around 2 Mtonnes/year. The main sources of iron and steel scrap are the construction and transportation sector, which together accounted for 42 % of the total steel consumption in 2006. Mechanical engineering, tube and metalware account for another 40 % of the total and are also the main sources of old scrap. No detailed information and data are available regarding the sources of steel scrap in the Member States. Information collected in a study by Okopol shows that, construction, mechanical engineering and vehicles generated 34 %, 27 % and 21 % respectively of the total scrap in 1997.

Stainless steel scrap as part of ferrous scrap should be included in this study; however, little data and information were gathered on stainless steel scrap, and it is therefore not assessed here in detail.

Vehicles and transportation:

Based on a study from International Copper Study Group (ICSG) in 2004, information on a stakeholder consultation carried out in 2005 and a study by Wuppertal Institute, around eight million cars are being recycled annually in the EU. Using the 2000 average material composition of the European car fleet, it is estimated that if all steel is recycled, around 6 Mtonnes of steel scrap are generated from cars, i.e. 6 % of the 2005 steel scrap consumption. From all the ELVs, Veolia reported that total recovered ferrous scrap was 11 Mtonnes in Europe, representing 11 % of all scrap sources (note: this figure in comparison to that in 1997 Okopol study seems different, even taking into account other type of vehicles).

Construction and building:

Steel has been used as beams, reinforcement bars, and other structural parts in building and construction since its industrial production. Large amounts of steel scrap could be generated during the demolition of a building; however, the amount varies greatly from the type of building and its geographical location. On average, steel accounts for slightly less than 1 % of the mass of a residential building. Almost all steel parts are recovered, with good quality beams for direct reuse and the rest for recycling in a steelworks. An estimate in the United Kingdom shows that some 90 000 tonnes of iron and steel were recovered from construction and demolition waste in 1998 in the United Kingdom.

Large equipment and machinery:

This category covers the industrial and agricultural machinery and structure, such as earth-moving and quarrying equipment, cranes, farm vehicles and machinery, storage tanks, tools, etc. No detailed data are available.

Electronics and electrical equipment:

As discussed previously, on average, steel accounts for almost half of the content on a weight basis in electrical equipment and this would potentially generate some 4 Mtonnes of steel scrap each year in Europe. However, without information on collection rates, it is difficult to estimate the actual amount of steel scrap from WEEE.

Packaging material:

Steel packaging includes food cans, beverage cans, aerosols, etc. According to APEAL, over 2.3 Mtonnes of steel packaging was recycled in 2005, which is about 2 % of the total scrap recycled in the EU.

4.2.2 Metal scrap management

4.2.2.1 Management alternatives

As already mentioned, due to the high value of metal scrap, it is recycled or reused whenever possible. According to EAA, in 2004 worldwide around 16 Mtonnes of aluminium scrap are recycled annually, more than half of which is old scrap. The rest of the old scrap generated, about 7 Mtonnes, is not registered statistically; however, it is expected that more than 50 % is recycled and only a small amount of unrecoverable scrap is being landfilled. This is partly due to limitations of current treatment techniques. The figure for iron and steel scrap is reported to be 29 Mtonnes according to a study by the European Topic Centre on Waste and Material Flows (in this report it is estimated that out of nearly 112 Mtonnes of scrap in 2000, 86.5 Mtonnes was old scrap).

Furthermore, in some countries, when metal containing products cannot be easily collected separately, for instance flexible metal packaging, the majority of them will be within mixed waste which may be incinerated for energy recovery, with the incineration slag processed for metal recovery. However, the chain of technologies which can recover metal from incinerated household waste is not installed throughout Europe and this, coupled with the issue of transfrontier shipment of waste, results in some potentially recyclable metal being lost.

4.2.2.2 Scrap metal recycling process

In general, scrap recycling consists of collection, sorting, shredding and/or sizing, media separation and final melting at the steelworks or refineries/remelters. This process can be summarised as below.

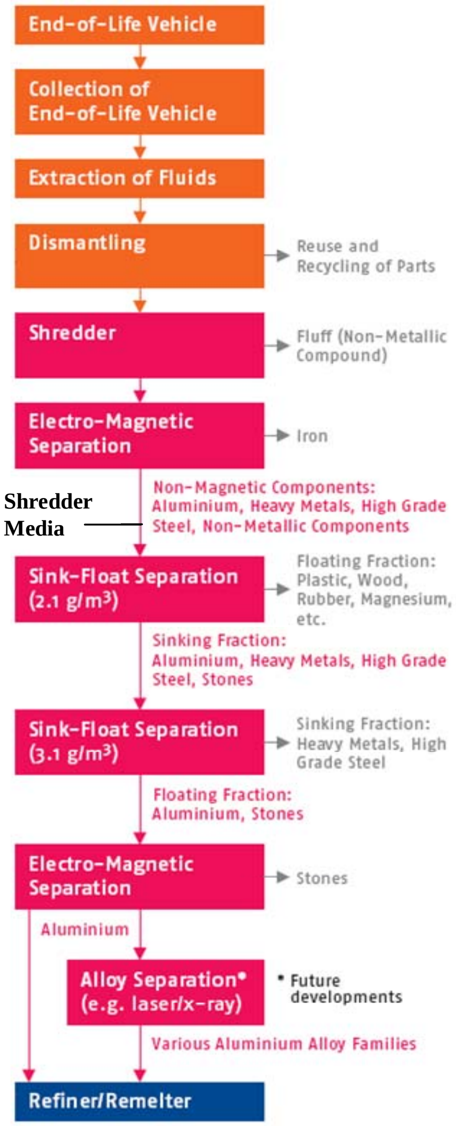
- Scrap metal is collected either separately or mixed and then sorted in the scrapyard and then sold to scrap treatment plants or sent directly to a refiner/remelter.
- Arriving at the scrap treatment plant, different types of metals are further separated and prepared for shredding/sizing. Shredding and sizing is often needed for a further stage of separation. First, while shredding and cutting, magnetic separation would single out the ferrous metal, then using several media separation technologies, the non-ferrous metal is separated first from non-metal elements and then different non-ferrous metal are separated.
- If shredded scrap metal needs to be dried or to be further cleaned of possible contaminants such as oil, grease, lubricants, lacquers, rubber, and plastic laminates, this could be done at the scrap treatment plant but for thermal treatment, it is more energy efficient to perform this at the refinery or remelter and avoid double heating.
- At the steelworks, iron and steel scrap are often charged directly to the furnaces. At the aluminium refinery, scrap metal is first cleaned, if necessary, from contaminants at below

melting temperature in kilns and then charged to the furnace going through melting, fluxing/refining, and tapping.

From this it can be seen that some scrap is already very clean but other scrap may need various treatment steps to be fit for direct use in the remelting process.

Since the main sources of both steel and aluminium scrap are basically the same and they are treated in the same plants and separated at certain stages, the treatment of the two types of scrap is discussed together. The following origins of scrap metal are presented here in detail (BIR, EAA, ELDAN recycling, and Novelis are the main references). Although not all the origins of scrap are included here, it is believed that their treatment process resembles those that are described in Figure 26.

Figure 26: An example of metal treatment



<u>End-of-life vehicles:</u>

Using passenger cars as an example, currently in the EU when a car reaches its end of life, it is brought to a specific collection point, which in some cases could also be a generic scrap treatment plant. ELVs are treated (depolluted) according to a certain procedure guided by the ELV Directive, as shown in the diagram. ELVs are first decontaminated by removing various fluids and parts. The rest of the car, including the body, the interior, etc., is fed into a shredder. In the shredding process, magnetic separation is used to remove the magnetic ferrous fraction, leaving non-ferrous metals and non-metallic materials to pass to further stages, i.e. dense media separation and eddy-current separator, for the segregation of one type from another. The separated ferrous part contains as much as 98 % metal. More than 99 % of the non-ferrous metal can be recovered. Further advanced technology for the separation of alloys is being developed for industrial application. To a certain extent, other recyclable fractions such as glass and plastics are also recovered at this stage.

There are two main types of residue generated in these processes: the airborne dust (fluff), caught by the shredder dust collection system (consisting of upholstery fibres, dirt, rust, paint, etc.), and the non-metallic residues separated from the recovered material streams by the media separation plant (consisting of unusable rubbers, plastics, stones, etc.). The dust and the separated residues together usually represent about 17 to 25 % of the weight of an average vehicle. In the past, they have been landfilled, representing no more than 0.2 % of total landfill waste in the EU. However, with the implementation of the ELV Directive, which requires 85 % (increasing to 95 % in 2015) of an ELV to be reused, recycled, or recovered, these residues are progressively being reduced.

Whilst 'sink-float' separation is shown here in the diagram, where typically a ferrosilicon suspension is used to achieve the separation of materials of differing densities, followed by a washing stage, new alternative dry technologies are being developed using a variety of sensors and separation techniques.

Used beverage cans

In most countries, used beverage cans (UBCs) are made both from steel and aluminium and they are collected by local authorities as part of the municipal solid waste, although increasingly, industry is involved in the collection of the UBCs. For example, in the United Kingdom, there are separate containers for UBCs deposit, as well as special collection points for bringing in UBCs which can be sold on a weight basis. At the collection point, steel cans and aluminium cans are separated for baling and then sent to refineries. The recycling process of aluminium cans is shown in Figure 27.

Figure 27: The recycling process of aluminium cans

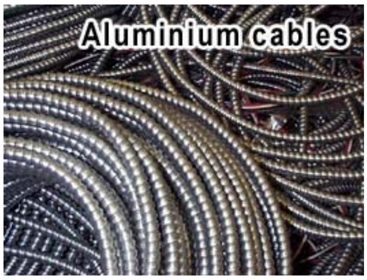
On arrival at the refinery, the baled aluminium can is first shredded into small-sized pieces, and then passed through a magnetic field to remove any remaining steel contaminants. Next, the shreds need to be cleaned of paint, ink, coating, etc. by blowing in hot air at a temperature of 500 °C. After the decoater, the shreds are fed into melting furnaces. At this stage, salt is usually added to remove the impurities and to improve the quality of the products. The molten aluminium is then cast into ingots.

Cables and wires

Demolition and civil engineering companies are the collectors of used cables and wires, which may be directly sold to a scrap treatment plant or to a scrap trader. There are many different types of cable. Outside power distribution uses aluminium core cable and most other type of cables used in building, communication, electronics and automotive normally use copper core. In general, cable and wire covered with thick plastic coating (often PVC) is not directly suitable for feeding to a melting furnace due to the plastic to metal ratio.

According to BIR, the predominant way of recovering the metal from cable scrap in the developed countries is automated cable chopping. Most cable chopping plants process only copper cable scrap, a few only process aluminium cable scrap, and some operate both a line for aluminium and another for copper cable scrap.

Figure 28: An example of aluminium cables

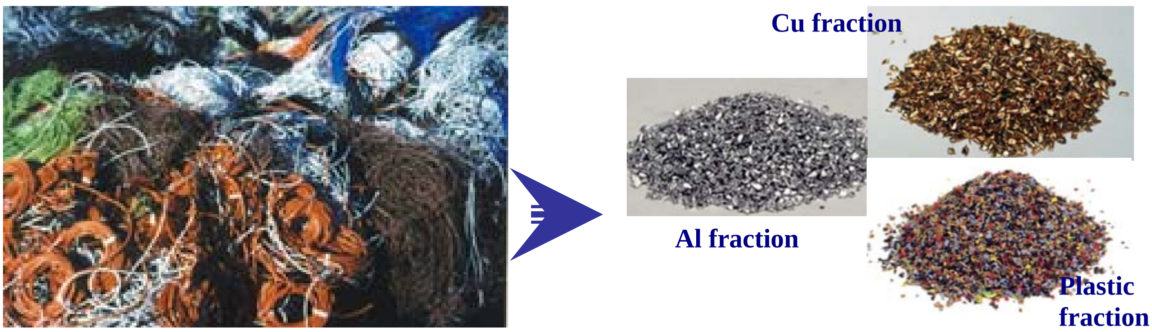


The following steps are common in cable scrap chopping process:

- Pre-sorting: to separate cable scrap by type of insulation, by conductor diameter, etc., to prepare it for feeding into the shredder. Pre-sorting also includes sorting copper from aluminium containing cable and removing unsuitable cables before entering the automatic chopping system. As shown in the picture, pre-sorting can already result in fairly clean scrap. The pre-sorting allows the maximum value for the recovered metal scrap to be obtained and makes further separation of plastics easier.
- Cable chopping: is usually desirable for processing long cable sections. It is the first step in reducing the size of the cable. Compared to shredding, cable chopping produces little, if any, filter dust.
- Granulation: is carried out twice so that the cable chops are of a sufficiently fine size to ensure that most of the insulation is liberated from the cable; inevitably, however, small amounts of metal remain embedded in plastic.
- Screening: enhances the recovery of metal; some chopping lines also use vibrating screen to yield the desired chop size — the smaller the chop size is, the more efficient the removal of the metal.
- Density separation: similar-size chop fractions that collect on the screens are then discharged and fed to an air table where they are fluidised and separated into two fractions: clean metal products and essentially metal-free tailings. Generally, 'middling' fractions are reprocessed again in the system or can be re-tabled.

The metal content of residue streams can vary from less than 1 % to more than 15 %. If a dry electrostatic system is used, the metal content may be reduced to less than 0.1 %, which will consequently increase the value of the recovered plastic.

Figure 29: An example of ordinary dry cable scrap before and after treatment



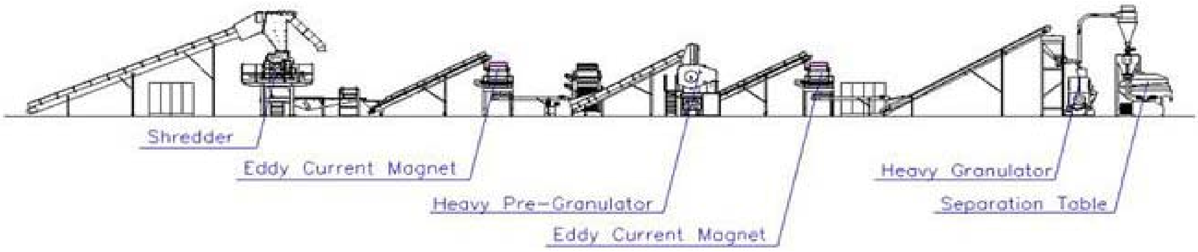
As an example, Figure 29 shows the before and after treatment of ordinary dry cable scrap, which is usually a mixture of copper or aluminium conductors with rubber, plastic or paper insulation. They may also have steel or lead armouring. Pre-sorting in such a case is very difficult.

Electronics and electrical equipment

This waste stream covers a wide variety of end-of-life products mainly from households and offices. The WEEE Directive requires the responsibility of producers in recycling and waste prevention; however, users and local authorities play an essential role in waste collection and separation. The WEEE Directive also requires that hazardous components, such as batteries, printed circuit boards, liquid crystal displays, etc., are removed with proper technologies. This is done at different stages of the treatment process depending on the implementation of the directive in Member States.

After this depollution step, WEEE consists chiefly of a mixture of metal, plastics and glass. From here, the treatment of WEEE in general has the following steps, though the process may vary with different combinations of: shredding, granulating (more than once), magnetic separation, and eddy-current separation (more than once), there is also the possibility of density separation on the separation table and/or hand separation (Figure 30).

Figure 30: An example of WEEE treatment



The stainless steel, Al and Cu fractions are separated from other ferrous metal and other non-ferrous metal during these processes and can be sent directly to the steelworks or refineries. The metal content in the plastic could be high; however, it is possible to further recover these metals later during the plastic recycling process or, if the plastic is incinerated, from the bottom ash of the incinerators.

The preparation and treatment of different WEEE may have different requirements. For example a fridge needs to be treated in an enclosed environment to avoid the emissions of CFC gases.

Scrap metal from construction and demolition

Regulations and standards related to construction and demolition have been developed in the past years mostly in favour of selective demolition, which has been proven to be most effective for recycling various types of waste streams. For cost reasons, metal scrap is separated whenever possible along the dismantling process and is sold for direct reuse or to traders or treatment plants. Since, by weight, aluminium and steel have different prices, further separation is often performed on-site. Steel elements inside concrete may first be sent to recycling centres for crushing and separation with magnets before being returned to the metal industry.

4.2.2.3 Environmental and health aspects

The environmental impact of waste management and the end-of-waste criteria should be evaluated from a life cycle point of view. Throughout the recycling chain, the key environmental impacts of scrap recycling occur at the steelworks or refineries/remelters. Scrap treatment, sorting, separating and baling, are mainly mechanical processes with dust as the main air emission and, thus, have limited environmental impact. While some individual scrap sources should be examined in detail due to their specific characteristics (discussed later in the report), the potential environmental issues in scrap management are summarised here along the recycling chain.

Risks related to scrap transportation and storage
Scrap metal in itself does not pose any risk to the environment, i.e. there are no environmental risks in transportation and storage of metal itself. However, if metals are contaminated with oil or mixed with other waste, this may be considered hazardous in relation to transportation or storage. For example, oil or any other liquid attached to scrap metal, when exposed to rain, may cause contamination to its surrounding environment. If scrap metal is collected mixed with other type of waste, the shipment of such scrap cannot be guaranteed free of risks so such mixtures are controlled by waste regulations, e.g. the Waste Shipment Regulation.

Energy use and GHG emissions
Treatment of scrap metal, i.e. shredding and media separation, consumes electricity and therefore has indirect GHG emissions. The production of secondary aluminium is estimated to consume 10 MJ/kg, which is responsible, on average, for less than one tonne of CO_2 emission per tonne of metal production. The production of steel from scrap is integrated in the steelworks and thus the use of energy and emissions are not reported separately. However, energy use in the processing of both types of scrap is much less in comparison to production of metal from ore or bauxite which explains why scrap is so attractive to the metal industry.

Other air emissions in scrap treatment
Dust and air emissions from scrap treatment are generally at low level. For example, in 2004, AEA Technology carried out an analysis of shredder waste on behalf of the UK government. The conclusions were that the levels of polychlorinated biphenyls (PCBs) in shredder waste were very low (1 mg/kg) and, therefore, the emission of other persistent organic compounds, minimal.

However, several hazardous air pollutants are possibly associated with the secondary metal production in a furnace, e.g. benzene, styrene, dioxins and furans, hydrogen chloride, hydrogen fluoride, and chlorine, metals, arsenic, lead, and chromium. These substances are usually controlled according to permits under the IPPC Directive irrespective of whether the scrap is waste or not.

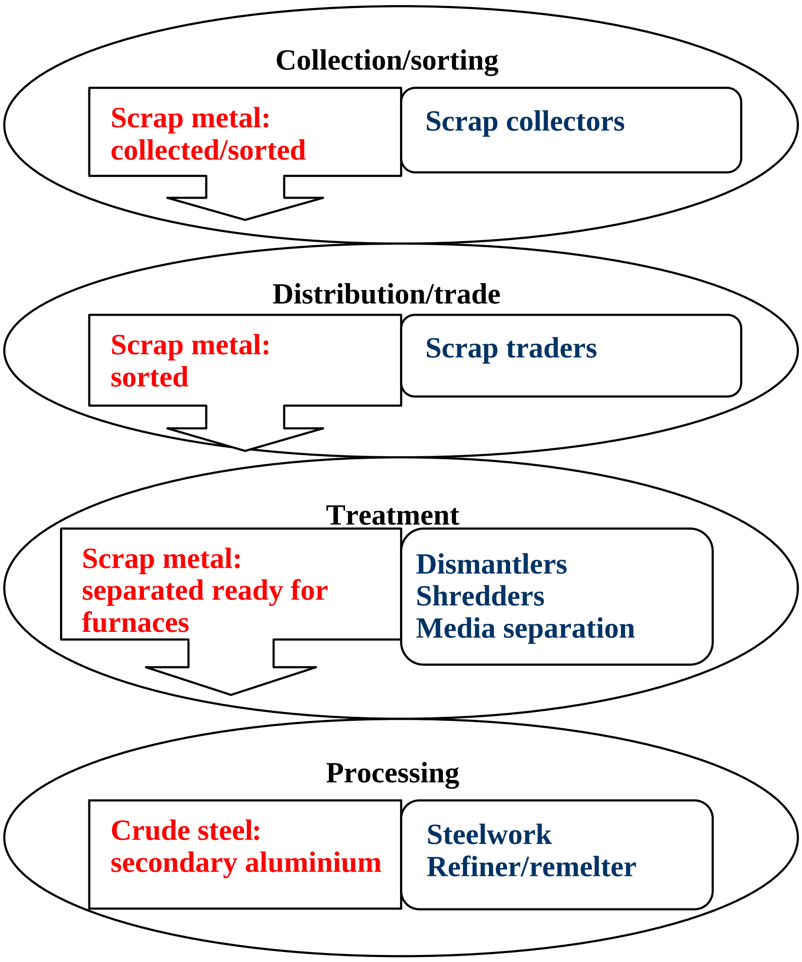
Chemicals and waste in secondary process
For improving the product quality in some secondary aluminium production, salt is added to the molten scrap, resulting in salt slag and skimming, which consist of fluxing agents, impurities, and/or oxidised and non-oxidised aluminium. There can be as much as 500 kg of salt slag generated per tonne of metal production. The salt in slag is recovered and recycled on-site to be used again, and aluminium metal is also recovered. The remaining residues are, whenever possible, used in cement production or landfilled.

The melting of steel scrap mainly uses electric arc furnaces (EAF), and in this process slag and dust are generated. On average, 100–150 kg/tonne (liquid steel) of slag and 10–20 kg/tonne (liquid steel) of dust is generated. The major components of EAF slag are lime, silica, and oxidised metal elements. Dust may contain high levels of zinc, lead and cadmium, and that from stainless steel processes has additional chromium, nickel and molybdenum elements. In recent years, due to waste management regulations, the percentage of dust to landfill has been decreasing with majority of dust treated for recovery of its remaining metal content. Slag is used in steel making, or is assessed for its suitability for being used as aggregates in building and road construction.

4.2.2.4 Economic aspects

In 2003, the total scrap metal trade (import + export) of the EU was 59 Mtonnes, which is the largest regional market accounting for nearly 40 % of the world total. Due to resource availability and energy savings, scrap metal is desired wherever technology permits. Moreover, demand is growing; for example, EAF steelmaking capacity has been growing at an average 4.7 % per year for the last decade.

Figure 31: An example of metal scrap cycle (collection, distribution, treatment and processing)



With the demand for scrap rising in all countries, the price for scrap metal has increased over recent years. Information shows that the competition for non-ferrous scrap metal was more pronounced. China and India have not only become two of the largest importers of aluminium scrap but also are where the largest recycling plants are built. As the collection rate is increasing in all the sectors in the EU, it is expected that the amount of scrap arising will continuously increase.

4.2.3 Scrap and secondary material industry

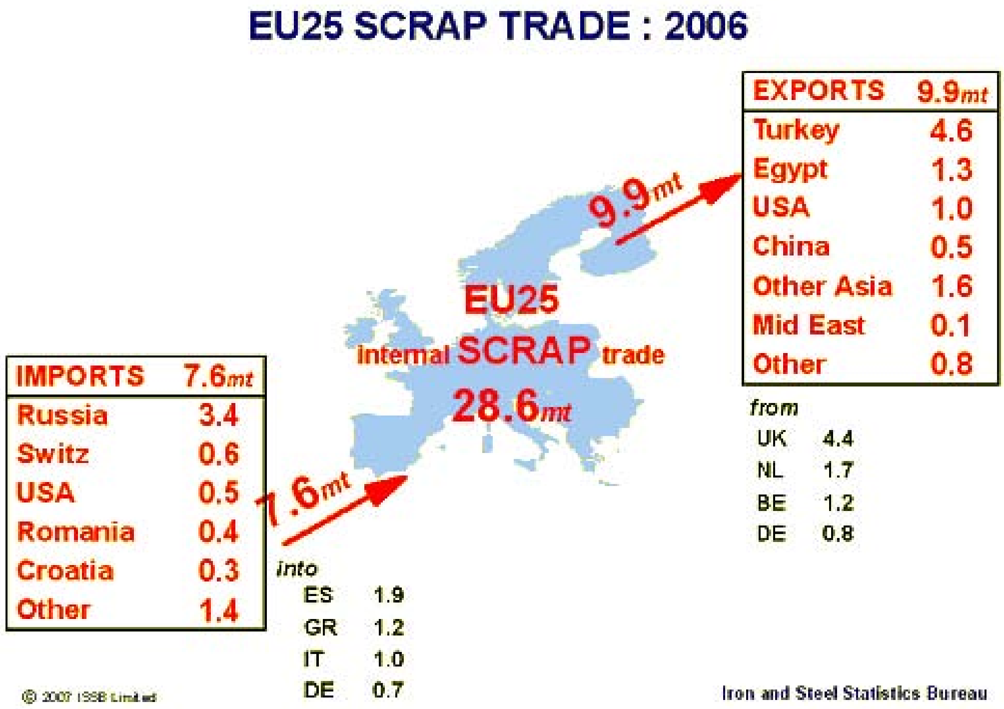
4.2.3.1 Industry structure

The scrap recycling industry consists of scrap collection and sorting, distribution, treatment and processing, as shown in Figure 31. Along this recycling chain, scrap is cleaned to become secondary material for final metal products. In the steel industry, scrap processing is an integrated part of the primary steel production, while secondary aluminium production is distinguished from primary aluminium production.

Depending on the type of product and the country, the collection system can vary. Large sized and quantity end-of-life products, such as those from construction and demolition, are usually transported directly to the scrapyard or scrap treatment plants. Both ELVs and WEEE place the responsibility of recycling, hence scrap collection, on the producers. Small products such as packaging materials are collected by the local authorities, which means that, in this case, collection is not in the hand of the scrap metal industry, though some industry initiatives are taken in the case of UBCs, e.g. collection centre, scrap terminals, where steel and aluminium cans are separated and baled for transportation to treatment plants or refineries.

Scrap trade within the EU as well as import and export to other countries has been established for decades. Within the EU it is difficult to estimate the total quantity of the scrap being shipped, though an internal steel scrap trade of 28.6 Mtonnes is recorded in 2006, as illustrated in the figure below. The export and import of steel scrap totalled (export + import) 16–19 Mtonnes in the last few years and the amount of aluminium scrap (new and old) shipped within Europe was estimated being 5 Mtonnes in 2004. Scrap trade may be done in any bilateral way between collector, broker, treatment plant or refiner/remelter.

Figure 32: Scrap trade in 2006 for EU-25



The European steel recycling industry (at the treatment stage) is fairly concentrated, with seven companies providing some 40 % of the total steel scrap delivered to the steelworks. According to BIR and EFR, there are around 220 shredders and 40 media separation plants in the EU-25. Half of the scrap recycling companies is considered to be large and medium-sized handling over at least 30 000 tonnes of scrap per month.

There is no information as to the number of plants dealing with aluminium scrap; however, it can be assumed that the shredder and media separation plants mentioned above are also the main providers of treated aluminium scrap. Different from the steelworks, the secondary aluminium processors, i.e. refiners and remelters, are mostly small and medium in size and, according to EAA/OEA, there were 153 refining and 123 remelting plants in Europe in 2003.

4.2.3.2 Specifications and standards

Currently, specifications and standard classifications for metal scrap exist at all levels, international, European, national, as well as between individual parties. It is clear that, for reasons of marketing and trading, standards and specifications are needed not only to set the price but also as a reference for classification and controlling the quality. In many cases based on the production need, scrap is processed according to the bilateral specifications agreed upon between the scrap processor and smelters and refiners.

ISRI: Plate and Structural (equivalent to the UK scrap standard: Grade OA)

Consists of cut structural and plate arisings, predominantly 6 mm thick in sizes not exceeding 1.50 m × 0.60 m × 0.60 m (or as otherwise agreed) prepared in a manner to ensure compact charging. May include properly prepared wagon material less than 6 mm thick. Excludes tube and hollow section.

Traded scrap metal is basically classified according to several properties, most notably:

- chemical composition of metal, e.g. low alloyed, stainless;
- level of impurity elements, e.g. S, P and Cu for steel scrap;
- physical size and shape;
- homogeneity, i.e. the variation within the given specification.

NARI standards Example I
Developed by the Institute of Scrap Recycling Industries (ISRI), this standard provides the norms for classification of ferrous and non-ferrous scrap metal and is used internationally.

European Standard EN 13920 on aluminium and aluminium alloy scrap
The EN standard covers all types of aluminium scrap and provides the norm for scrap classification. There is no EN standard for steel scrap.

National standard classification
Some countries have their own classifications for aluminium and/or steel developed by the national industry associations, for example, Belgium, Germany, Spain, France and the United Kingdom.

European Steel Scrap Specification
In the case of steel, EFR and EUROFER developed the European Steel Scrap Specification. The specification covers the requirements from the safety perspective, the excluded elements for all grades from a cleanliness point of view, and the tolerance for residual and other metallic elements. It also provides a detailed description of these specifications by category, which corresponds to the type of scrap.

Bilateral contract/specification
As already mentioned, there are also specifications made as agreements or contracts in trade between two parties. Such a specification is usually based on a standard classification with additional requirements suitable for the desired production process or product. In this case, the specifications are being continuously reviewed and, if necessary, modified.

4.2.3.3 Legislation and regulation

The management of waste scrap metal is currently under the waste regulations in the EU, e.g. the Waste Framework Directive and EU Waste Shipment Regulation. Scrap treatment plants (shredders, dismantlers, media separation plants) are operated under a permit for waste treatment, although the details of their permits vary among Member States. The production of secondary metal at refineries and remelters and the associated treatment of scrap metal on-site are subject to the IPPC Directive. The current discussion on the possible extension of the scope of the IPPC Directive in relation to waste treatment activities has suggested the inclusion of separate installations for scrap metal treatment.

The shipment of metal needs to fulfil requirements based on the Waste Shipment Regulation, which was revised and entered into force July 2007. Most types of scrap metal belong to list B of Annex V, covering wastes which are not covered by Article 1(1)(a) of the Basel

Convention, and, therefore, not covered by the export prohibition, when transportation and shipment (to non-OECD countries) is concerned. The EU has sought responses from non-OECD countries detailing those wastes they would accept and under what conditions. Where there is no reply, the EU imposes additional notification requirements. There is some evidence that this is reducing the willingness of some overseas customers to trade with EU suppliers.

Certain metal-containing waste streams are regulated under specific directives, such as the WEEE, ELV and Packaging Directives. In these directives, the following elements regarding the treatment and process of the two types of waste are described and they ensure proper handling of the waste stream:

- separate collection;
- permits for waste treatment operations;
- compliance with minimum standards for recycling and treatment of WEEE;
- minimum technical requirements for the treatment of ELVs.

The above detailed examination of the scrap metal recycling process, which sets out the established nature of the industry and the current legislative framework, is the important first step to understand if there is a need for end-of-waste criteria.

Recycling of metal scrap is very well established in Europe and the introduction of the end-of-waste criteria would only have limited impact on the amount of metal recycled. However, end-of-waste criteria would mean that waste-related regulations would not apply once the scrap metal ceases to be waste; therefore, its introduction could reduce the legislative burden and administrative costs, especially in terms of shipment and trade, whilst ensuring that they will not lead to adverse environmental or health impacts.

4.3 End-of-waste criteria

4.3.1 Rationale for end-of-waste criteria

Based on the background in the previous section, several important features of the industry are highlighted here to serve as the basic rationale for the conceptualisation and construction of the proposed end-of-waste criteria, i.e. the key issues to be considered in designing end-of-waste criteria for scrap metal.

4.3.1.1 Well established and integrated in the metal industry

The metal scrap industry is well organised as an integrated part of the metal industry. From scrap collector to remelter/refiner, metal scrap is traded under either national or industry standards or specifications. Both standards and specifications are used as market references to identify and classify the product. They define the acceptable size of the scrap, level of tolerance for trace elements, metal content (maximum percentage of all contaminants), etc. Depending on the final product, different specifications are used and when the design and requirement of a product change, the specification may change accordingly. Metal scrap must be processed and delivered according to these specifications from scrap processor to steelworks or remelter/refiner. Such a system explicitly serves as a quality assurance system between companies along the supply chain. Thus end-of-waste criteria should not seek to change the efficiency and organisation of the industry, but should be consistent with existing standards and regulations.

4.3.1.2 A mechanical process, no chemical change

The purpose of mechanical processing is to separate impurities from the metal. Free 'alien' objects such as paper, plastic, wood, etc., can be removed through manual or simple mechanical separation. From the technical details described in this paper, it is clear that the transformation of the waste scrap metal into secondary material with desirable purity and characteristics occurs along the treatment process depending on the origins of the scrap. Therefore, the end-of-waste criteria should clarify when this transformation occurs and how the waste scrap should be processed in order to reach this point.

However, there are some elements in the metal scrap that cannot be separated and will remain in the final products. Many metal products are in the form of alloys, and the alloying elements cannot be separated. When necessary, different alloys are separated at the origin of the scrap, which, in many cases, implies the type of alloy. In the case of aluminium, treated scrap metal is analysed for the precise metal content at the refinery/remelter, so they can be fed into furnaces separately or in certain mixtures to achieve a desired composition of molten metal. Trace quantities of free metal elements such as magnesium can be difficult to exclude and can only be tolerated to a certain extent in the final product metal. The current solution for this, in the case of aluminium scrap, is to dilute the molten metal with purer aluminium.

For ferrous scrap, magnetic and eddy-current separation is the main treatment process and sometimes shredding is included for the purpose of better magnetic separation. No other treatment is carried out before scrap is sent to furnaces. Trace amounts of copper (either free copper or tramp copper bound in steel) may remain in the scrap, which can only be tolerated to a certain extent in steel-making.

Whilst the level of such impurities is generally controlled by specifications, the end-of-waste should also consider the issue of impurities to make sure that the existence of them will not create risks to the environment outside the waste legislation.

4.3.2 Conditions for end-of-waste criteria

According to the latest draft of the revised Waste Framework Directive, Article 6, '*certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery operation and complies with specific criteria to be developed in accordance with the following conditions:*

(a) the substance or object is commonly used for a specific purpose;
(b) a market or demand exists for such a substance or object;
(c) the substance or object fulfils the technical requirements for the specific purpose referred to in (a) 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.'

In the case of scrap metal, compliance with the first two conditions is evident from the existing structured market and the classifications of scrap metal used for trading. Scrap metal will become input material for various sectors of the metal industry and it is eventually processed into metal products or products containing metal (metal scrap is commonly used as a feedstock to a melting furnace in the production of mass metal). As already discussed, the market and demand for both steel and aluminium have been increasing in the last decades, and are expected to increase further.

The third condition implies that end-of-waste criteria need to ensure that, at the point of ceasing to be waste, any technical requirement related to the use are fulfilled and the recycled material should comply with applicable legislation and standards as product. In the case of metal scrap, this means that at the moment of end-of-waste, scrap metal should also fulfil specifications or standards. As discussed, metal scrap is traded either based on standards or specifications which are often included as part of the business contract; therefore, in principle, whenever scrap is transported from scrap treatment plants to the steelworks or refiner/remelters, it meets a specification or standard. It should be noted, however, that in the case of dimensional requirements for pieces of scrap, minor deviation from any of the dimensional specifications may not be a barrier to its direct use as otherwise intended.

From a life cycle point of view, metal recycling has unquestionable environment benefits. The use of scrap metal in the furnace is regulated as far as emissions are concerned by the IPPC Directive regardless of whether the scrap is a waste or not. There is, therefore, no adverse environmental or human health impact due to the use of scrap as non-waste. The application of all end-of-waste criteria for metal scrap shall be carried out within a quality assurance system which ensures all quality criteria are respected.

4.3.3 Outline of end-of-waste criteria for scrap metal

In summary, the above analysis implies that there are two essential issues in defining end-of-waste criteria for scrap metal. Firstly, not to disrupt the current supply system and to identify, in this current recycling chain, the point where separation is sufficient to ensure no environmental risks when scrap is transported without it being controlled as waste. Secondly, to maintain the importance and flexibility of the specifications and to ensure end-of-waste criteria are compatible with the specifications.

Based on this, it is proposed that the end-of-waste criteria should consist of three elements:

1. the identified source of the scrap metal;
2. the minimum required treatment process;
3. the general technical requirements on the output material.

This means that scrap metal with clearly identified origin, processed according to the minimum required treatment, and fulfilling the general technical requirements, would cease to be waste. The following sections will discuss in detail these three elements.

4.3.3.1 Sources of scrap metal

Apart from metal which is reused directly, such as old construction beams removed during demolition, metal scrap is collected in varying quantities, processed and eventually recycled into products. From metal scrap to products, the contaminants are removed step by step, for making the scrap suitable for the remelting and refining furnaces, whilst satisfying the required quality for metal applications. As it is now, the recycling process, the logistics and choice of machinery and equipment, depends on the type of the contaminants to be removed, which is determined by, most of all, the source of the metal scrap, as well as the means of collection.

Potential sources of scrap metal
A good reference for examining and categorising the origin of metal scrap is the EC's published European Waste Catalogue (EWC), which covers all possible waste streams and is listed according to the source. As the first element of the end-of-waste criteria, the source of scrap metal should be identified based on the EWC. The following Table 47 lists all the relevant source of scrap metal in the EWC at six-digit level:

Table 47: European Waste Categories for metals

EWC codes	**Characterisation**
10 INORGANIC WASTES FROM THERMAL PROCESSES	
10 02 wastes from the iron and steel industry 10 02 01 waste from the processing of slag 10 02 02 unprocessed slag 10 02 05 other sludges 10 02 06 spent linings and refractories 10 02 07* solid waste from gas treatment of electrical arc furnaces containing dangerous	All the possible metal-containing waste under this category, mostly slag and dross, are collected and further processed for metal recovery. They are recycled either on-site or at the secondary refinery and at the same time salt is recovered which indicates that the final

substances 10 02 08 solid waste from gas treatment of electrical arc furnaces other than those mentioned in 10 02 07 10 02 09 solid waste from gas treatment of other iron and steel processes 10 02 10 mill scales 10 02 11* waste from cooling water treatment containing oil 10 02 12 other waste from cooling water treatment 10 02 13* sludges from gas treatment containing dangerous substances 10 02 14 sludges from gas treatment other than those mentioned in 10 02 13 10 02 99 wastes not otherwise specified 10 03 wastes from aluminium thermal metallurgy 10 03 01* tars and other carbon-containing wastes from anode manufacture 10 03 02 anode scraps 10 03 04* primary smelting slags/white drosses 10 03 05 alumina dust 10 03 06 used carbon strips and fireproof materials from electrolysis 10 03 07* spent pot linings 10 03 08* salt slags from secondary smelting 10 03 09* black drosses from secondary smelting 10 03 10* waste from treatment of salt slags and black drosses 10 03 11 flue gas dust 10 03 12 other particulates and dust (including ball mill dust) 10 03 13 solid waste from gas treatment 10 03 14 sludges from gas treatment 10 03 15* skimmings that are flammable or emit, upon contact with water, flammable gases in dangerous quantities 10 03 16 skimmings other than those mentioned in 10 03 15 10 03 99 wastes not otherwise specified	recycled metal is often not transported further for refining/remelting. With such recycling integral to the principle process, there is little sense to consider end-of-waste criteria for these wastes. Furthermore, little information was collected during the case study regarding what kind impurities may exist in these wastes and, therefore, the wastes under EWC 10 have not been further considered for end-of-waste at this time.
12 **WASTES FROM SHAPING AND PHYSICAL AND MECHANICAL SURFACE TREATMENT OF METALS AND PLASTICS**	
12 01 Wastes from shaping and physical and mechanical surface treatment of metals and plastics	The four types of scrap metal under this category are generated in metal workshop or fabrication plants. They are collected on the

12 01 01 ferrous metal filings and turnings 12 01 02 ferrous metal dust and particles 12 01 03 non-ferrous metal filings and turnings 12 01 04 non-ferrous metal dust and particles	spot and kept separate for transporting to remelters and refiners. New scrap stampings are essentially offcuts in order to make the final products, they have exactly the same chemical and physical characteristics as the products and can be considered by-products and not waste. One particular case is turnings and borings which are generated using specialised cutting fluids for engineering purposes. In their initial state these turnings and borings have a substantial amount of fluid mixed with the metal and this would pose a risk of pollution if stored and transported without special measures. However, it is current practice to centrifuge the material to recover the valuable cutting fluid and this can result in a scrap metal with minimal level of contamination posing little or no environmental risk during storage or transport.
15 **WASTE PACKAGING; ABSORBENTS, WIPING CLOTHS, FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED**	
15 01 04 metallic packaging	This subcategory of metal scrap is generated by separate collection of municipal waste or industrial packaging waste at source (separate deposition). They are often first transported to a recycling centre, where they need to be checked for their suitability to be feedstock for remelters and refiners and sometimes they may need further separation into ferrous and non-ferrous metal.
15 01 06 mixed packaging 15 01 11* metallic packaging containing a dangerous solid porous matrix (for example asbestos), including empty pressure containers	Mixed packaging may also contain metal; however, as an integrated part of the packaging material/product, they cannot be separated manually from other material such as plastics, board, etc.
16 **WASTES NOT OTHERWISE SPECIFIED IN THE LIST**	
16 01 end-of-life vehicles from different means of transport (including off-road machinery) and wastes from dismantling of end-of-life vehicles and vehicle maintenance (except 13, 14, 16 06 and 16 08) 16 01 04* end-of-life vehicles 16 01 06 end-of-life vehicles, containing neither liquids not other hazardous	Metal scrap under these subcategories, as indicated by their names, originates from ELVs and WEEE, which are complex products made of various materials. Often special pretreatment, such as dismantling, depollution, etc., are necessary and is covered by the ELV and WEEE Directive. Metal scrap contained in these wastes can only be

components 16 01 17 ferrous metal 16 01 18 non-ferrous metal 16 02 wastes from electrical and electronic equipment 16 02 10* discarded equipment containing or contaminated by PCBs other than those mentioned in 16 02 09 16 02 11* discarded equipment containing chlorofluorocarbons, HCFC, HFC 16 02 12* discarded equipment containing free asbestos 16 02 13* discarded equipment containing hazardous components other than those mentioned in 16 02 09 to 16 02 12 16 02 14 discarded equipment other than those mentioned in 16 02 09 to 16 02 13 16 02 15* hazardous components removed from discarded equipment 16 02 16 components removed from discarded equipment other than those mentioned in 16 02 15	separated through several steps in a treatment process.
17 **CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)**	
17 04 metals (including their alloys) 17 04 02 aluminium 17 04 05 iron and steel	Metal scrap from the construction and demolition waste is separated during the demolition process because of their economic value. The scrap is often transported to a scrapyard for cutting/sizing before being sold to a secondary processor or steelworks.
17 04 07 mixed metals 17 04 10* cables containing oil, coal tar and other dangerous substances 17 04 11 cables other than those mentioned in 17 04 10	Although metal scrap under these sub-categories also comes from C & D waste, it exists in a mixture with other materials, such as other types of metal and plastics. The separation of metal requires several steps of treatment process.
19 **WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTE WATER TREATMENT PLANTS AND THE PREPARATION OF WATER INTENDED FOR HUMAN CONSUMPTION AND WATER FOR INDUSTRIAL USE**	
19 01 wastes from incineration or pyrolysis of waste 19 01 02 ferrous materials removed from bottom ash	Metal material recovered from bottom ash can be ferrous and/or non-ferrous. Ashes from municipal waste incineration plant may contain various type of waste, and the mechanical separation of metal from contaminants may involve several steps of the treatment process.
19 10 wastes from shredding of metal-containing wastes	Metal scrap described here is not directly linked to its original source. It is the result of

19 10 01 iron and steel waste 19 10 02 non-ferrous waste 19 12 wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, palletising) not otherwise specified 19 12 02 ferrous metal 19 12 03 non-ferrous metal	the treatment processes of waste such as WEEEs and ELVs. Therefore, the 19 10 and 19 12 are not considered as origins of scrap source, but as processed metal scrap at a certain stage, where the scrap may or may not already fulfil end-of-waste criteria.
20 **MUNICIPAL WASTES (HOUSEHOLD WASTE AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES) INCLUDING SEPARATELY COLLECTED FRACTIONS**	
20 01 separately collected fraction (excluding packaging waste) 20 01 40 metals	Similar to packaging waste, this subcategory of metal scrap is generated and separated from collected municipal waste. The metal scrap may be collected in separate container (separate deposition) at source, or, more often, they are first transported to a recycling centre and are separated there. In any case, they need to be checked for their suitability as feedstock to remelters and refiners or steelworks and might need for further separation of ferrous and non-ferrous metal.
20 01 23 discarded equipment containing chlorofluorocarbons 20 01 35* discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components 20 01 36 discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35	Metal scrap under these subcategories, as indicated by the names, originates from equipment and WEEE, which are complex products made of various materials. Often special pretreatment, such as dismantling, depollution, etc., are necessary and is covered by the ELV and WEEE Directive. Metal scrap contained in these wastes can only be separated through several steps in a treatment process.

Note: EWC codes 02 01 10 (waste metal from agriculture, horticulture, aquaculture, forestry, hunting and fishing) and 03 03 07 (mechanically separated rejects from pulping of waste paper and cardboard) were not assessed in this case study.

Proposed grouping according to sources

Based on the above description of the characteristics of different sources of metal scrap, it is possible to group those that are suitable for end-of-waste into three groups. The purpose of the grouping not only clarifies the stage of separation of metal scrap along the recycling process, but also identifies the further treatment processes required. These three groups are as follows.

Group I: Those that are separated at source or while collecting and remain separate: the scrap (either ferrous or aluminium) may need only normal industrial processing such as sizing, sorting by type of alloy, or thermal treatment for decoating, prior to the remelting process. This group includes material from EWC 12 01 01–04, some of the old scrap from construction and demolition waste as defined under EWC 17 04 02 and EWC 17 04 05. However, turnings and borings could only be included in this group if they are treated at source (normally centrifuged) to remove cutting fluids so that special measures against pollution are unnecessary for transportation and shipment.

Group II: Those that are separated at a collection centre by sorting to reach a status comparable to Group I. This group covers packaging waste, EWC 15 01 04, and municipal waste, EWC 20 01 40. In some cases, the set-up of the collection system makes further sorting less necessary; however, due to the uncertainty of the origin of the metal scrap, an inspection at the collection centre is necessary.

Group III: Those that are and can only be separated at a pretreatment plant after more than one process: most post-consumer metal scrap is in a mixture with one or more non-metal waste or other metals. For this group, magnetic and media separation processes are necessary. The group includes mixed packaging (EWC 15 01 06 and 15 01 11), several categories under the end-of-life vehicles (EWC 16 01) and WEEE (EWC 16 02), construction and demolition waste (EWC 17 04 07, 17 04 10, and 17 04 11), bottom ash from waste incineration facilities (EWC 19 01 02), and some of the separate collected metal containing municipal waste (EWC 20 01 23, 20 01 35, 20 01 36).

The grouping results in the earliest distinction of the metal scrap in terms of its physical purity without taking into account its other characteristics, for example, the size (suitable for furnace) and the type of alloy. The grouping will have the following implications:

- transportation of scrap contaminated with oil or liquid should continue to be covered by regulations such as the Waste Shipment Regulation and therefore they remain as waste;
- different groups will have different criteria for the end-of-waste status, and so the second end-of-waste criteria will differ based on this grouping;
- the argument of grouping is only based on the information regarding the source of the metal scrap, no testing is required.

4.3.3.2 Minimum required treatment processes

In all cases scrap metal would cease to be waste when all criteria relevant to source and processing are fulfilled and when it is placed on the market.

Group I
The only necessary requirement for metal scrap in this group is that it should remain separated at the collection centre and when transported.

For efficiency in transportation, small pieces of scrap should be compacted as much as possible in the form of bales or pellets.

For clean new scrap, according to the interpretative communication COM(2007) 59 some may be treated as by-products, which is ,therefore, out of the scope for end-of-waste.

For scrap covered with paint, metallic coating, or lacquer, thermal treatment, when necessary, will take place at the refinery. From the environmental aspect it makes no sense to heat twice and waste energy. In the case of scrap metal processing it is normal industry practice to return offcuts directly to the furnace and any coating or oil on the surface of the offcuts is easy handled by the furnace and actually contributes to the fuel demand. The transportation of these types of scrap does not incur risks to and any adverse impact on environmental and health. It is noted that cable covered with plastic and the like does not belong to this group as it requires specific processing to become suitable for direct feeding to a melting process.

Group II

Metal scrap in this group comes mainly from households, and the typical example here is UBCs. Due to greater risk of mixture at collection, additional minimum requirements are justified for metal scrap in this group compared to Group I. Apart from separation through collection and sorting, the scrap should be clean from visible contaminants. Another criterion is that the scrap, often light and in the form of small containers, should be as compact as possible for transportation. Sometimes, at the recycling site, this scrap may be shredded and baled for proper size or transportation.

In the case of UBCs, depending on the collection system of a region, metal scrap can be collected in separate containers or brought to a collection centre. However, they can also be collected among other municipal waste and further singled out at the scrapyard. In both cases, there is first a need to ensure that UBCs are cleaned of other non-metal contaminants and, secondly, to separate into steel cans and aluminium cans. The cleaning process could involve manual sorting and separation, magnetic separation, washing and drying.

Industrial oil and painted drums are also part of the separated collected metal packaging wastes. They are first pretreated (depolluted) at the site of collection or a waste treatment plant and then compacted and transported to steelworks.

For efficient transportation and in order to avoid any unnecessary loss of the scrap during transportation, the cleaned scrap should be baled or compacted with other means. This requirement is more explicit for light metal scrap in this group because old scrap is often moved over longer distance than new scrap (in Group I), and it may also be traded passing through different entities.

Description of the processes (carried out at recycling plants under waste regulation).

- Sorting: this is a chiefly manual process to pick out the scrap metal, according to the type of metal and sources, from the mixed waste.
- Separating: when there is the risk of mixed ferrous and non-ferrous metal, magnetic separation should be done through a simple magnetic device, such as magnetic conveyor, via mechanical or manual separation.
- Cleaning and depolluting: if necessary, the sorted scrap should be washed and then dried to have minimal moisture or pretreated (e.g. thermal treatment) to eliminate residues such as oil, paint.
- Compacting: baling should be done with baling machine or when sizing is taken place using a shredder such that the resulting material is naturally compacted.

Group III

Metal scrap contained in this group are an integral part of the end-of-life products, e.g. ELVs, WEEE, cables, etc., and cannot be (easily) removed without the help of equipment or machinery. The minimum requirements vary for each category in the group. Often, more than one pretreatment process is necessary for separation of the metal scrap.

In principle, the metal scrap originating in this group will complete the necessary processes when the steel scrap is separated by magnetic separation and aluminium by media separation (e.g. eddy-current or dense media separation), i.e. when metal containing waste is separated via several mechanical treatments and transformed into metal scrap consist of one type of metal (alloy or not) and/or mixed non-ferrous metal.

For the ferrous fraction, magnetic separation is the minimum process that is required. For the non-ferrous fraction, apart from magnetic separation from ferrous metal, media separation should be used to ensure that non-metal fractions are removed. Therefore, depending on the facility and equipment of a plant, it can choose to have mixed non-ferrous metal as the last stage of separation in the plant or further separate mix non-ferrous metal into single metal scrap.

Description of the processes.

- Shredding and magnetic separation: by using standardised mechanical equipment, i.e. a shredder, the scrap metal is shredded into required size for effective magnetic separation. Most shredders incorporate magnetic separation. Depending on the inputs, this process can be repeated in order to achieve proper separation and the technical requirements of the ferrous metal fraction.
- Separation (e.g. eddy current or dense media): after separation from the ferrous metal, the non-ferrous scrap and non-metal fractions needs to be further separated. This may require further granulation using standardised mechanical equipment. Media separation may employ various methods. For example, it may use fluids with different densities to single out, first, the light metal and non-metal fraction and then to separate different non-ferrous metals; the first fraction is further separated into two fractions: metal and non-metal, by employing eddy-current technology, which induces temporary magnetic energy to non-ferrous metal thus magnetically separating it from the non-metal fraction. Complicated end-of-life products, such as electronic equipment, may need several stages of media separation to complete a proper separation and achieve the technical requirements.
- In the case of cable, different types of cable are first sorted and chopped into small pieces then granulation is carried out to ensure that most of the insulation is liberated from the cable. After that density separation is applied to separate the metal fraction and the tailings (plastics).

<u>An example of implementation into groups</u>

Aluminium scrap which is classified according to the EU standard on aluminium, EN 13920-1:2002 can be an example of implementation into Group I, II and III. The standard EN 13920 is divided into 15 parts (Table 48, column 1.) and each part specifies different kinds of aluminium. Each part can be fitted into proposed Group I, II and III of end-of-waste (Table 48, column 2).

Table 48: An example of implementation of aluminium scrap classified according to EN 13920 to proposed groups (Group I, II and III) of end-of-waste

Parts according to the EU standard on aluminium (EN 13920-1:2002)	**Proposed group according to end-of-waste criteria**
Part 2 Unalloyed aluminium scrap	Group I or II
Part 3 Wire and cable scrap	Wire and cable scrap still with the coating is considered as Group III
Part 4 Scrap consisting of one single wrought alloy	Group I or II
Part 5 Scrap consisting of two or more wrought alloys of the same series	Mainly Group II
Part 6 Scrap consisting of two or more wrought alloys	Mainly Group II
Part 7 Scrap consisting of casting	Mainly Group II
Part 8 Scrap consisting of non-ferrous materials from shredding processes destined to aluminium separation processes	Not an original waste source and therefore not considered in the grouping
Part 9 Scrap from aluminium separation processes of non-ferrous shredded materials	Not an original waste source and therefore not considered in the grouping
Part 10 Scrap consisting of used aluminium beverage cans	These often occur in separate collection and among municipal waste and they belong in the Group II
Part 11 Scrap consisting of aluminium-copper radiators	These often occur in separate collection and among municipal waste and they belong in the Group II
Part 12 Turnings consisting of one single alloy	Cover turnings and set maximum limits on moisture and oil which is consistent with treatment of turnings to remove free cutting fluid
Part 13 Mixed turnings consisting of two or more alloys	
Part 14 Scrap from post-consumer aluminium packaging	It usually has a very low metal content and is therefore not suitable for end-of-waste.
Part 15 Decoated aluminium scrap from post-consumer aluminium packaging	Group III

Part 16 Scrap consisting of skimmings, drosses, spills and metallics	Should remain waste until the metal content in them is fully recycled

4.3.3.3 Technical requirements

The third element of end-of-waste criteria for scrap metal covers several technical requirements and can be reported in a simple style. It includes setting minimum values of the metal content in the scrap after completing the minimum required treatment processes.

Steel scrap

In the case of ferrous scrap, recovered scrap should have a metal content, in the form of free metal element or alloy, which should be no less than the attainable scrap purity by the correct application of the minimum required treatment described above. Whilst some copper can be tolerated in ferrous scrap, the maximum amount of copper in the scrap should be limited to the value derived from best current practice.

The metal content can be expressed in two ways: metal content as percentage of the total mass or the rate of metallic yield.

When scrap has undergone the minimum required treatment process as described in Section 4.2.3.2, it should, in principle, have high purity in terms of metal content. The metal content should be required to guarantee that the material can be directly used as an input to metallurgic production processes to avoid potentially negative influences on environment. However, to complement the minimum required processing to reach end-of-waste status and to ensure that the material is directly fit for further use without a further waste recovery process, it is considered essential to include some measure of minimum metal content.

The metal yield refers to the quantity of metal after refining compared to the total input mass of scrap. This takes into account the oxidised and other unrecoverable form of metal that may exist in the scrap. Other factors, such as the size and thickness, also affect the yield. In the case of steel scrap, it is not part of the EU-27 steel scrap specification. In order to be consistent with the existing specification and standards, the end-of-waste criteria should not put additional requirements to the metal yield.

However, an overall metal content could be given as a basic requirement. When scrap ceases to be waste, metal will be considered as substance and alloys as preparations under REACH. As a mono-constituent substance under REACH, the main constituent, i.e. metal, must have a content of 80 % or more on a weight basis. This could be used as a general requirement for the minimum metal content.

Shredder and media separation equipment are continuously improving in terms of their technical performances, i.e. better separation of different metal and non-metal fractions. Currently, the ferrous fraction after proper shredding and magnetic separation often reaches metal content of greater than 95 %. For the non-ferrous fraction, after proper steps of media separation the content of aluminium alloy or aluminium alloy with another non-ferrous metal is usually higher than 98 %. Cable processing equipment can effectively separate aluminium alloy or aluminium alloy and copper from the plastic coating, glue, etc., and results in metal content of higher than 98 %.

There is a certain unavoidable level of impurities, which cannot be removed completely with the minimum required treatments described above in Section 4.3.3.2. Any impurity should be identified to ensure that there are no hazardous elements in the scrap. Oil is not expected to be part of the impurity since, as discussed, all scrap should be essentially free of oil in order to be transported as non-waste. When scrap ceases to be waste, it will be placed under the REACH legislation, under which impurity needs to be addressed. This is further discussed later in the report.

As a final technical requirement, industrial standards or specification must be met, as stated as one of the four conditions for end-of-waste. In the case of metal scrap, whenever they are traded among scrap processor, scrap broker, and steel-maker or refiner/remelter, they are done according to standards or specifications. Whilst the choice of standards or specifications is left to the decision of the business agreement, the fulfilment of them needs to be stated when end-of-waste status is declared. In the case of specifications on size or dimensions of scrap, some minor deviation from the specification may be tolerated and the scrap may be deemed to sufficiently meet the specification for the purposes of reaching end-of-waste status.

Aluminium scrap

With a similar approach, the minimum value for free aluminium, which excludes oxidised aluminium and aluminium alloy in the scrap, can be derived. Again based on the best current practice, the maximum value of Mg or any other metal contaminants should be defined. In some cases, the scrap process generates a mixture of aluminium with another non-ferrous metal, for example Cu (free or tramp element), and there is no further need to separate the two since they both are input raw materials for the production of certain types of alloys. The minimum value should therefore be set as the total of both metals. In the case of aluminium, as one of the key technical requirement, this has already been clearly defined in the European Standard EN 13920-1:2002. This European standard specifies general requirements and guidelines for the delivery and classification of the different categories of aluminium scrap, including quality requirement, sampling and tests. Special requirements and guidelines for each of the scrap categories are specified in prEN 13920-2 to prEN 13920-16.

For aluminium scrap, also as part of the technical requirements, the type of alloy and the mixture of non-ferrous metal should be described. All this technical information is, in fact, part of current industrial specifications or specifications between the buyer and the seller, which means that the treatment plants do not need any additional procedure or test to generate the information.

4.3.4 Set of end-of-waste criteria for scrap metal

To summarise the above discussion, the end-of-waste criteria are the following, and an illustration of the proposed end-of-waste outline is shown in Table 49 and Figure 33.

Table 49: End-of-waste criteria for metal scrap.

	The criteria	Explanations	Reasons
Input material	**No other types of waste shall have been used as input than those included in the following Groups:** **Group I: waste types 12 01 01, 12 01 02, 12 01 03, 12 01 04, 17 04 02 and 17 04 05 under the classification of the European Waste Catalogue.** **Group II: waste types 15 01 04 and 20 01 40 under the classification of the European Waste Catalogue.** **Group III: waste types 15 01 06, 15 01 11, 16 01, 16 02, 17 04 07, 17 04 10, 17 04 11, 19 01 02, 20 01 23, 20 01 35 and 20 01 36 under the classification of the European Waste Catalogue.**	Group I includes wastes from shaping and physical and mechanical surface treatment of metals; aluminium, iron and steel fractions of construction and demolition wastes. Group II includes metallic packaging waste; separately collected metal fractions of municipal wastes. Group III includes mixed packaging waste; metallic packaging waste requiring removal of dangerous components; end-of-life vehicles; wastes from electrical and electronic equipment; mixed metal fractions of construction and demolition wastes; cables from construction and demolition wastes; ferrous materials removed from bottom ash.	Only the types of waste that are included in these groups allow obtaining scrap that: o is commonly used for the production of aluminium, iron or steel; o after appropriate treatment, can be used without overall adverse environmental or human health impacts. For other types of metal containing waste it is not clear that these conditions are met. The distinction in the three groups is made according to the types of treatment processes required (see criteria on processing).
Processing	**The waste input materials shall have undergone at least the following treatment processes.** **(a) Input materials of waste types from Group I shall have been segregated at source or during collection to**	Regarding (a): for example, scrap metal generated in metal workshops can be collected on the spot and kept separate for transporting to	Condition (d) of Article 6(1) of the WFD demands that end-of-waste criteria shall ensure that the use of the substance or object will not lead to overall adverse environmental or human health impacts.

	The criteria	Explanations	Reasons
	yield either pure aluminium scrap or iron and steel scrap. The scrap shall be kept separate from other wastes until it is used. **(b) Input material of waste types from Group II shall have been sorted according to the type of metal (i.e. yielding separate aluminium or ferrous scrap) and non-aluminium or non-ferrous components shall have effectively been separated out. If needed, cleaning or depolluting processes shall be applied so that the resulting scrap is free of visible contaminants.** **(c) Input material of waste types from Group III shall have undergone advanced treatment processes to separate effectively aluminium and ferrous scrap and to separate of the non-ferrous or non-aluminium components. The resulting scrap shall be clean from visible contaminants.** **Hazardous waste shall not cease to be waste unless it has effectively been treated in a way that eliminates any hazardous properties according to Annex III of Directive 2008/98/EC on waste (for example, any liquids or other hazardous components must have been removed from ELVs).** **Input materials that originate from end-of-life vehicles or waste electronic or electric equipment shall**	remelters and refiners. Regarding (b): cleaning or de-polluting means that the sorted scrap is washed and then dried or pretreated (e.g. thermal treatment) to eliminate residues such as oil, paint. If used beverage cans are used as input, they shall have been cleaned of other, non-metal contaminants and have been separated effectively into steel cans and aluminium cans. Adequate treatments for achieving this include manual sorting and separation, magnetic separation, washing and drying. If industrial oil and paint drums are used as input they shall effectively have been cleaned of oil and paint. Regarding (c): advanced treatment includes processes such as shredding and magnetic separation, eddy-current separation or media	This implies that the material must have gone through all necessary treatment processes that allow transporting, handling, trading and using the scrap without increased environmental and health impact (or risks) compared to a situation where the waste status is maintained. The required treatment processes to achieve this differ depending on the group of waste types from which the scrap has originally been obtained.

	The criteria	Explanations	Reasons
	have completed all pretreatments, such as dismantling, depollution, etc., as required by the ELV Directive and the WEEE Directive. **(d) The scrap shall have been compacted in the form of bales or pellets if this is needed to transport the scrap safely or allows reducing substantially the required transport volume.**	separation. For the ferrous fraction, magnetic separation is the minimum process that is required. For the non-ferrous fraction, apart from magnetic separation from ferrous metal, media separation shall have been used to ensure that the non-metal fraction is removed. In the case of cable, different type of cable shall first be sorted and chopped to small pieces, then be granulated, and after that density separation shall be applied to separate the metal fraction and tailings (plastics). Regarding (d) compacting: baling should be done with a baling machine or when sizing takes place using a shredder such that the resulting material is naturally compacted.	

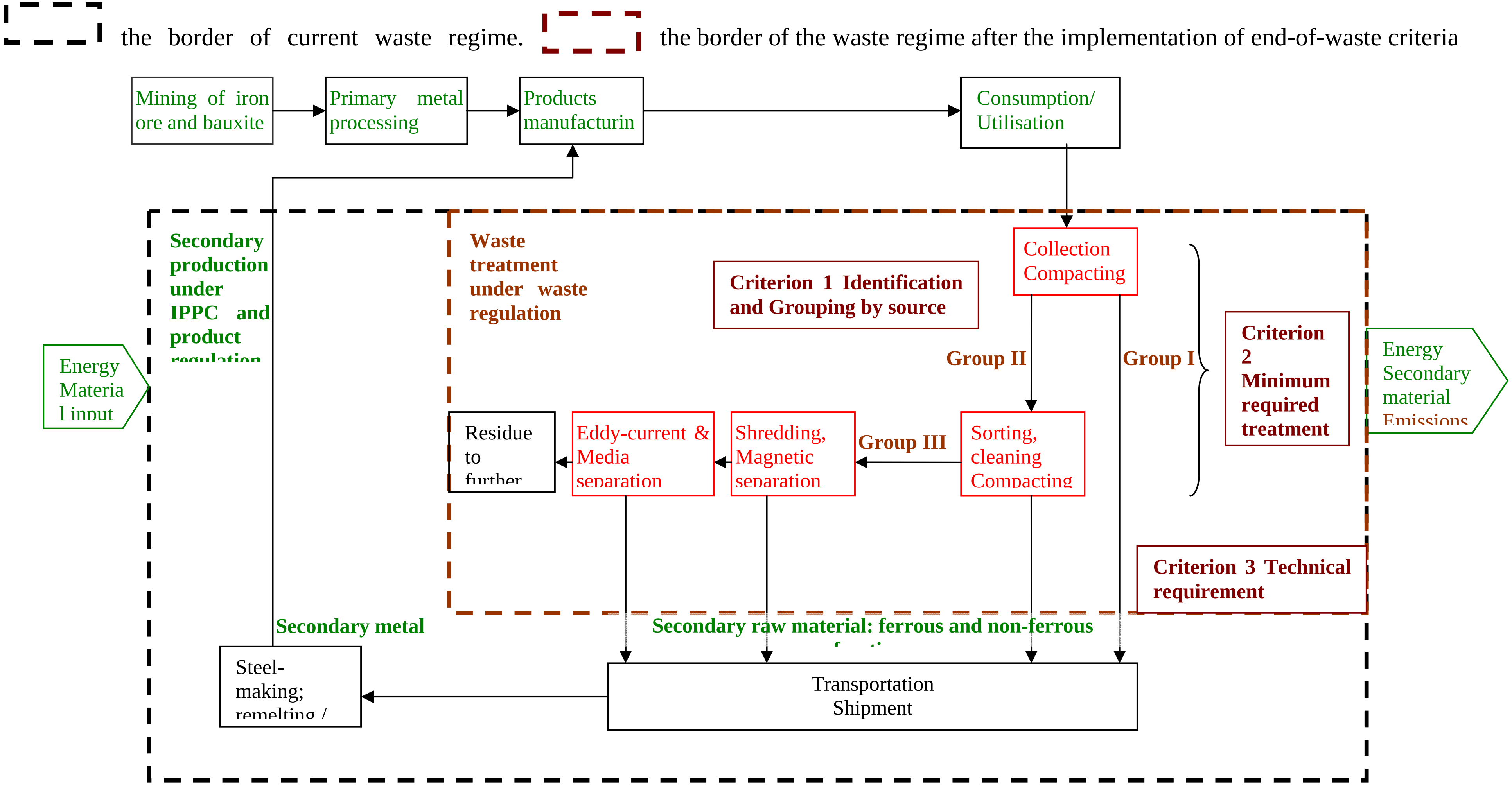
	The criteria	Explanations	Reasons
Product requirements	**Ferrous metal scrap shall meet all of the following product quality requirements (a)–(d):** **(a) meet European steel scrap specification or other specification accepted by the steel industry;** **(b) metal content ≥ 95 % (mass weight); (the exact metal content to be elaborated; 95 % is an example);** **(c) free of visible oil;** **(d) not have any of the properties included in Annex III of Directive 2008/98/EC on waste (properties of waste which render it hazardous).** **Aluminium metal scrap shall meet all of the following product quality requirements (e)–(g):** **(e) compliance with standard EN 13920-1:2002, including regarding metal content, or the specifications for scrap by the secondary aluminium industry. The type of alloy and the mixture of non-ferrous metal shall be described,** **(f) free of visible oil;** **(g) not have any of the properties included in Annex III of Directive 2008/98/EC on waste (properties of waste which render it hazardous).**	In case of ferrous metal scrap, the metal content of ≥ 95 % is an example. The metal content limit value needs to be elaborated. As a principle, recovered scrap should have a metal content, in the form of free metal element or alloy, which should be no less than the attainable scrap purity by the correct application of the minimum requirement treatment described above (processing). In case of aluminium scrap, the specifications including minimal metal content are given by standard EN 13920-1:2000 and its parts. Each part of the standard deals with a different kind of aluminium scrap.	Condition (c) in Article 6(1) of the WFD implies that scrap must fulfil the technical requirements of the using industries and meet the applicable standards. Condition (d) implies that end-of-waste criteria need to ensure that the use (understood as including also transport, handling, trade) of scrap shall not lead to overall adverse environmental or human health impact. Therefore, scrap shall cease to be waste only if it does not have any hazardous properties and the content of other components than metals is limited to the extent that can be achieved by effective processing. Metal content is a general measure for the effectiveness of the required processing (sorting, separation, enhanced treatment) of the waste. A minimum metal content should therefore be required in order to ensure that the material has been treated sufficiently so that transporting, handling, trading and using the scrap will not increase the environmental and health impact (or risks) compared to a situation where the waste status is maintained.

	The criteria	Explanations	Reasons
Quality control procedures	**The acceptance of input materials, the required processing and the assessment of compliance with product requirements shall have been carried out according to good industrial practice regarding quality control procedures.**	In remains to be considered what the minimum requirements regarding quality assurance should be.	
Product application	**Aluminium scrap as well as iron or steel scrap shall cease to be waste when it is placed on the market or when it is used as an input to metallurgic production processes, provided that all of the end-of-waste criteria (input materials, processing, product requirements, quality control) have been met.**	Usually, placing on the market after completing all required treatment processes will the point in the recycling chain when the scrap ceases to be waste. However, there may be cases where there is no market transaction between completion of the required waste treatment processes and the start of the metal production.	

The end-of-waste criteria state the minimum requirements that a certain type of metal scrap should complete in its current recycling practice in order to be classified as non-waste. Therefore, end-of-waste criteria do not replace any current legislation that waste and metal scrap is subjected to in its recycling processes and application; however, it will change at the point of fulfilling the criteria the legal status of metal scrap from waste to secondary material.

Furthermore, the end-of-waste criteria do not replace standards or specifications. It should also not be seen as an assurance of quality for any specific production or application, but as an assurance of the minimum quality of metal scrap as a secondary raw material.

Figure 33: Criteria of metal scrap



4.4 Impact assessment

The impacts of end-of-waste discussed in this section focus on the changes end-of-waste criteria might cause compared to the current situation, i.e. metal scrap being waste until fully recycled. As a standard approach, the impacts of the end-of-waste criteria will be discussed from the environment, economic and social perspectives. Furthermore, the impacts will also be discussed from the point of view of changes in relation to other legislation as well as the potential practical implications of the end-of-waste criteria on the scrap metal sector.

4.4.1 Environmental and health impact

As discussed before, metal scrap is recycled whenever possible irrespective of its status as waste. Therefore, the introduction of end-of-waste criteria is not expected to affect the recycling rate. Moreover, since the end-of-waste will affect very little the current recycling process, if at all, the overall environmental impact of the end-of-waste is considered to be limited.

In the cases where different practices exist in the recycling process, the end-of-waste could result in favouring one practice over another. For example, for light metal scrap, compacting, e.g. baling, is one of the minimum required treatment processes in order to change the waste status; therefore from the end-of-waste point of view compacted light metal scrap is the preferred practice. Transportation of compacted light material is more cost and fuel-efficient, and reduces the risk of loss during handling. However, since baling prevails in the current recycling practice, the impact is expected to be negligible.

The group criteria proposed in the outline could encourage high-quality scrap metal being separated at source or sorted out as early as possible to be able to take advantage of end-of-waste status. In this way, the recycling industry could avoid any unnecessary movement of scrap and improve the overall efficiency. In Germany, there is the evidence that some thermal treatment does take place before metal scrap arrives at the refineries. This may not be efficient from the energy saving point of view, thus the introduction of the end-of-waste criteria, which does not require pre-thermal treatment of the certain waste streams, e.g. beverage cans, may further encourage the thermal treatment to be done at the refineries, where emissions and other environmental issues are addressed by the IPPC Directive.

The technologies to separate mixed metal containing wastes have become more efficient and more capable of handling specific types of waste. This has made it possible to recycle the separated plastic and other non-metal section of the mixed waste, which brings not only direct economic value to the recycling plant, but also results in reduced amount of waste for landfill or incineration. These developments at the recycling plant are already important in enabling Member States to reach targets for recycling set under the End-of-Life Vehicle, WEEE and Packaging Directives and will become more so as those targets increase. The end-of-waste status should encourage the further development of such technologies.

4.4.2 Economic and market impact

The proposed end-of-waste is expected to have limited impact on the overall economic performance of the industry, e.g. total revenue, profitability, production costs, etc. It will have little impact on the structure of the sector and relationship between different actors in the recycling chain. Some refineries or remelting plants may decide to only purchase scrap that has met the end-of-waste criteria and, therefore, are products, due to certain advantages, for example, avoiding some permitting requirements related to waste management. However, given the high value of scrap and its ever increasing demand, this would not be likely to decrease demand for low quality scrap, rather that the scrap processors will improve the treatment process and ensure better recycling quality.

Metal scrap is traded worldwide. One of the important implications of the end-of-waste is that once its legal status changes from waste to non-waste (secondary material), the movement of scrap metal will not be subjected to waste transport and shipment regulation. This will result in, to a different extent in different Member States, less administrative work related to preparing the necessary documents for shipment. Furthermore, in terms of external trade, the status change brought by end-of-waste will alleviate the general barriers which recent changes to EU waste shipment regulations have imposed on movement to non-OECD countries. This will in turn reduce the trend for overseas buyers, seeking to avoid these controls, to turn to non-EU suppliers. As a consequence, this may result in an increase in trade of metal scrap with non-EU countries. Such increase could put pressure on the availability of metal scrap for the refineries and remelting plants in the EU. However, since metal scrap has always been widely traded across all the regions of the world, it is not clear how end-of-waste could actually affect the volume of trade.

4.4.3 Social impact

Similarly, it is not expected that the end-of-waste criteria will significantly affect the number of persons employed, or the current structure of industry. Although difficult to estimate, statistics show that there are a substantial number of small plants. It is not clear if and how end-of-waste may affect the competitiveness of SMEs. By reducing the administrative procedures, SMEs may benefit more than large corporations.

For the metal industry, metal scrap being waste is also a social image issue, since waste normally presents a rather negative image to the society. The change of the status of metal scrap at certain stage of the recycling chain could bring the industry the positive social recognition and credibility. This could have a positive effect on situations related to staff recruitment, which will become more and more important as technologies and markets grow. It could also help local communities understand the environmental importance of the metal recycling process. In turn, this may make it easier for negotiating the location of recycling sites close to collection points. In the long term it may also encourage governments and investors to favour metal processes which use scrap metal rather than virgin raw materials.

4.4.4 Legislative impact

4.4.4.1 REACH

Under REACH, pure metal is considered as a substance and is required to be registered. Metallic alloys are considered as special preparations and the Commission is developing guidance on the registration of substances in preparations. It is clearly stated in the REACH legislation that safety data sheets (SDS) are required for certain special substances and preparations (e.g. metals in massive form, alloys, compressed gases, etc.) listed in Chapters 8 and 9 of Annex VI to Directive 67/548/EEC.

When metal scrap ceases to be waste, it will be subject to REACH. However, recycling of metal scrap is considered as a form of recovery, thus under the three conditions stated here below, it is exempted from registration, according to Guidance on registration, June 2007, published by European Chemicals Agency (pp. 33–34):

'*(1) The recovered substance must have been registered. This means that if, for some reason, the substance has not been registered at manufacturing or import stage the recovered substance has to be registered following the recovery operation before being put to a new use. On the other hand, the person who performs the recovery should check whether an exemption applies to the recovered substance. If an exemption applies which frees the recovered substance from the registration obligation, then that exemption can of course be invoked.*

(2) The substance already registered must be the same, i.e. have the same chemical identity and properties, as the substance being recovered. For example, if the substance itself was modified in the recovery then the recovered substance has to be registered.

(3) The legal entity who did the recovery must ensure that information on the registered substance is available to it, and that information must comply with the rules on information provision in the supply chain. This means that the person who did the recovery must have obtained one of the following: (i) a safety data sheet, as required by Article 31(1) or (3), on the registered substance, (ii) other information sufficient to enable users to take protection measures, as required by Article 31(4), for the registered substance, or (iii) an information package comprising the status of the registered substance under the authorisation part of REACH, any applicable restrictions under REACH, other information necessary to allow appropriate risk management measures and the registration number, as required by Article 32(1).'

It is clear that the chemical and physical characteristics of the metal components (pure or alloyed) do not change during the phases of use and recycle. It is also clear that all the individual metals are registered when manufactured. However, during the recycling process the following changes occur that are considered relevant to REACH.

First, collection and sorting of metal scrap may separate different metals but could result in mixture of different alloys. Based on the understanding of REACH, mixed metal alloys could be seen as preparations consisting of several different metals, which should be already registered by the primary producers.

Second, mechanical separation of metal-containing products results in ferrous and different non-ferrous fractions with high purity, but it is impossible to reach 100 % purity free of alien elements. These alien elements often are stone, plastics, pieces of rubber, sand, etc., of which the composition and total amount are difficult to be precise. In this case, it is likely that they are considered as impurity under REACH. REACH requires the register to characterise the impurity in term of composition and estimated quantity.

There is still the need for legal clarification of the issues regarding metal scrap under REACH, and only then is it possible to estimate the cost of REACH for the scrap processors. However, considering that the metal elements will likely have been registered by 2010 by manufacturers and or importers and so recyclers may gain some relief from REACH Article 2(7)(d), and the examination and report of impurities demanded by end-of-waste criteria, the work that needs to be done under REACH and the cost should be minimal.

Implementation of end-of-waste in principle does not result in additional process or requirement comparing to the current recycling chain. However, since REACH will apply to scrap that ceases to be waste, scrap processors have to fulfil REACH related obligations.

4.4.4.2 Waste shipment regulations

On 12 July 2007, the new Waste Shipment Regulation (EC) No 1013/2006 came into force. Accordingly, most metal scrap is under the list B of the Part 1 of the Annex V, 'which are not covered by Article 1(1)(a) of the Basel Convention, and therefore not covered by the export prohibition', and is also referred to as the 'green list' (it should be noted here that many countries have not confirmed the 'green list').

Export of waste under the 'green list' within the OECD countries is not subject to notification and consent procedure and is done under normal commercial transactions; however, the new Waste Regulation does require the completion of an Annex VII form.

For 'green list' exports to non-OECD countries, the regulations require the Commission to obtain a new declaration from the receiving country as to whether it will accept each kind of waste; it may also require pre-notification.

'*According to the basic provisions of the EU waste shipment regulation exports of "green-listed waste to non-OECD countries for recovery have to be controlled according to choices made by the importing countries themselves. A number of options are laid down in the regulation and communicated to the non-OECD countries by the Commission. Countries were asked whether they agreed to accept "green-listed" waste and, if so, whether the notification and consent procedure set out in the EU waste shipment regulation should apply or not. Regulation 801/2007 takes into account all the replies received. If countries do not reply the default position is for prior written notification and consent procedures to apply.'* Based on the reply from the receiving country, '*Article 36 of the shipment of waste regulation prohibits any export of green-listed wastes that an importing country has prohibited. It also prohibits the export of any green-listed waste which the competent authority of dispatch has reason to believe will not be managed in an environmentally sound manner in the country of destination.*' (Reference to NOTICE about Regulation (EC) No 801/2007).

The end-of-waste will affect metal scrap that has fulfilled the criteria and become product/secondary material. In the list B, the possibly affected ones are some metal scrap under B1010 (ferrous and aluminium) GC010 (electronic assemblies consisting of only metals or alloys) and GC020 (electronic scrap e.g. printed circuit boards, electronic components, wire, etc.) and reclaimed electronic components suitable for base and precious metal recovery). The other wastes listed in list B will not become non-waste under the end-of-waste criteria. Most of the countries who have replied have accepted B1010 as green list without the need of control. However, so far a large number of non-OECD countries have failed to respond, and where no reply is received, the red list is assumed. This has resulted in high numbers under the red list in the case of ferrous scrap (Table 50).

Table 50: Summary of country's responses

Number of countries responded	B1010 iron or steel scrap (*)	B1010 aluminium scrap
Green list	18	46
Ban	1	56
Red list (including no reply)	42	61
Total	60	163

(*) Only including countries with iron and steelworks.

When scrap is traded under the 'red list', exporters of scrap metals to non-OECD countries are required to pre-notify, which requires administration and payment of a fee; shipments are delayed whilst this is completed. The cost of pre-notification differs country to country. The end-of-waste status will thus save such costs, delay, and the workload related to these documents when exporting scrap that is classified as non-waste, i.e. secondary raw material/product.

4.5 Conclusions

As stated before, the purpose of the case studies under the end-of-waste project is to assist the development of a general methodology to defining end-of-waste criteria meanwhile they also illustrate how to do it and what are the important issues. From the research and the discussion of the scrap metal case, the following conclusions can be made.

- In the case of scrap metal, compliance with the market and environmental principles is fairly evident. For this type of waste with high economic value, the recycling industry and the market are well established in an efficient way. The end-of-waste status is more relevant in terms of relief of administrative work and removing barriers to existing trade than the further promotion of recycling.
- Given the fact that the secondary materials are often generated from different waste streams and fractions with different degrees of purity, it is necessary to examine the sources of waste and distinguish them according. This is important not only because the recycling path and technical process are determined by the purity of the waste but also such distinction favours early sorting and separation of waste fractions. Furthermore, the identification of sources also is necessary to single out some of the waste fractions of a waste stream that cannot become non-waste until they complete the entire recycling process, thus are excluded from the end-of-waste discussion.
- After examining the origin of the scrap, the end-of-waste criteria should look at the treatment processes, and define the proper sorting and treatment steps that are considered necessary to ensure the quality of the secondary material and address any risks. If necessary, the end-of-waste criteria should be flexible to accommodate different fractions and bring the end-of-waste status as early as possible to maximise the benefits of end-of-waste.
- Furthermore, end-of-waste criteria should provide a set of technical requirements on the secondary material/product to warranty that they are consistent, of certain quality and safe without hazardous component. Such technical requirements should be in harmony with industrial standards or specifications, which must be fulfilled when scrap metal becomes non-waste.
- End-of-waste criteria should also consider the use of secondary materials/products if they are to be directly released to the environment. However, this is unnecessary in the scrap metal case since they are input materials to the metal industry.

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Abstract

The report includes a methodology for the development of end-of-waste criteria for specific types of waste according to Article 6 of the Waste Framework Directive as well as three pilot case studies (on compost, aggregates and metal scrap) in which the methodology was tested.

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