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End of Waste – Scrap Metal Case Study

Working document

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Introduction IPTS End of waste project

In the preliminary communication regarding the Thematic Strategy on Waste, among others, the issue of when a waste ceases to be waste is highlighted as being ambiguous and the clarification of this could be important and beneficial. It is proposed that in order to improve this situation, the revised Waste Framework Directive shall contain a provision that is designed to clarify "end of waste" status for those waste streams where the use of "end of waste" would be appropriate, on a stream-by-stream basis. The aim of the IPTS project is to support the development of such end of waste criteria under the revised Directive, through a scientific, thorough and transparent analysis.

On the request of the DG ENV, the IPTS project is to achieve the following three objectives:

- To propose candidate waste streams for the definition of 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 proposed revision of the Waste Framework Directive (WFD)

- To develop a methodology (including the frameworks for the technical analysis and impact assessment) for proposing end of waste criteria under the WFD

- To apply the methodology to propose and assess end of waste criteria (possibly alternative sets of such criteria) for a number of pilot cases.

To achieve these objectives, a number of research activities have been initiated. A literature review and assessment has been carried out in identifying current practices within the EU and also the general views of the various stakeholders regarding the end of waste concept. As a result, some candidate waste streams / secondary material categories have been identified together with early indications of possible end of waste criteria.

An analysis of waste streams in the EU both in quantitative terms and in respect of the associated environmental issues (i.e. the upstream examination) is being launched. This work will basically result in a list of waste streams, categories for the recovered material, and the general steps involved from which specific ones can be selected for more detailed examination.

To develop a framework methodology as a guidance to define end of waste criteria, three pilot cases, i.e. aggregates, compost and metal scrap, are being carried out to provide feedback and to refine the general framework methodology so that it can be applied consistently for detailed assessment of other waste stream categories. These parts of the project are closely linked and interactive. With applying the framework methodology, the pilot cases are expected to assess the feasibility of end of waste criteria on each of the studied waste streams and to propose the suitability of a general framework methodology for the development of the end of waste criteria. The case studies may also conclude that end of waste criteria are not appropriate for the studied waste stream.

Case study of metal scrap

As one of the three pilot cases, metal scrap focuses on two types of metal scrap, i.e. iron and steel scrap and aluminium scrap, and both scraps originate from and are widely used across various industrial sectors to household appliances.

Scrap is generated when a metal containing product reaches its end of life or during product fabrication, however the amount of scrap collected and finally recovered depends on various factors, such as the distribution of the product, the possibility and techniques for separation, etc. as well as a variety of legislation. Logically the main scrap sources are those products for which metal is the main input material, namely, vehicles and mass transportation facilities (including ship and aeroplanes), metal products for construction, machinery, electrical and electronic equipment, cables, and beverage cans and foil. It is not possible, from the point of view of data and information as well as practical resources for this case study, to cover all the sources of metal scrap, and therefore, only the above mentioned main sources of scrap are discussed here after.

The objective of this background paper is to provide an introduction to the metal case study and, as a starting point in the first expert workshop, to discuss with the experts from different parts of the metal scrap recycling industry on the current issues related to scrap generation and management, processing technology and standards, market, environmental impact, etc. In this paper, the approach of the case study presents the key steps and important elements. The quantitative and qualitative analysis of these elements is discussed in more detail in the study methodology.

Objective and approach

The specific objective of this case study is to provide scientific arguments on:
1. if there is a need for end of waste criteria for metal scrap, and if yes,
2. the type of criteria that is most suitable, and
3. the possible consequences of the implementation of such criteria on the economic and environmental performance of the industry as well as on legislation issues.

Three phases are foreseen in carrying out the case study. The first phase is to understand the current structure of the scrap sector in the metal industry. The collection and processing of both steel and aluminium scrap, though operated separately and much less centralised than the primary metal production, has long been established and the flow from waste to secondary material and their markets are relatively well organised. Thus, it is essential to carry out an overview of the industry as a whole and to evaluate the detailed set-up of the scrap sector in particular, so that the possibility of end of waste criteria and their impact can be anticipated. It is expected that, besides desk research, interviews and site visits will be carried out as a means of information and data collection.

The second phase focuses on all the technical issues related to end of waste criteria. The process from scrap to secondary raw material, and the specification and standard as well as any other regulations that are applied at each step of the process are the bases on which determine the feasibility, the style and the technical elements of the end of waste criteria.

Two principles are laid out for defining the end of waste criteria in the proposed Waste Framework Directive and they are the non-existence of negative environmental impact and the existence of a market for recycled substances. This implies that the alternatives of scrap management should be examined in terms of environmental impact from a life cycle point of view. The environmental benefit of recycling scrap metal is fairly well assessed in many earlier studies, and is considered to be sufficient for safeguarding the first principle. However, during the case study, data and information will be gathered on the environmental impact of scrap management as a baseline for the comparison of the alternatives of the end of waste criteria. Due to the high value of metal, the existence of a market for various scrap derived secondary raw material is evident, nevertheless, the case study will provide several facts and data on the current secondary market and trade as well as its trend in the medium term.

In addition, evaluation of the end of waste criteria will also be carried out in the second phase. First, an analysis on the possible impact of the criteria on the industry will be carried out, along with the potential effects on the environmental performance of the sector and legislation/regulation related issues. Secondly, the conclusion on the EoW criteria and the results of theses assessments will be communicated through a second expert workshop in order to finalise the entire case study.

The last phase of the case study concerns its contribution to the methodological development of the end of waste criteria. The experiences and results of the metal scrap case will be compared to, and analysed together with, the other two cases in order to propose if and how a general framework can be derived for the end of waste criteria.

Methodology to define end of waste criteria

As already mentioned, the following elaborates further the key elements of the study and they are considered to be the focuses of the discussion at the first expert workshop. However, it should be noted that since the project is at its early stages, not all information and data are yet available.

1. Understanding the scrap sector of the metal industry

Due to the high value of metal, both iron and steel and aluminium scrap have been recycled whenever possible since the existence of the metal production itself. Given the chemical and physical properties of metal, the metal scrap can be recovered becoming secondary raw material which can, in almost all applications, compete with virgin material. Although scrap can be processed with high efficiency and little loss, this highly depends on the cleanness of the scrap, which is determined by separate collection and scrap treatment. Different scrap types (defined by scrap source) are the bases for the collection system and technologies employed in scrap processing, as well as being the starting point of the scrap sector.

I. Scrap source

Scrap is first being distinguished as new scrap or old scrap depending on whether it reaches its end of life before or after the consumer.

New scrap:

New scrap generated during the production process is completely recycled either circulated onsite or sent directly to a remelter/refiner or a steelwork. Since the composition of the scrap is known, in principle it does not need any treatment process, although sometime cutting and shredding might be necessary.

The total quantity of the new scrap can be estimated by input to output ratio at the plants for different products. Data yet to be gathered.

In a recent Communication from the Commission "Interpretative Communication on waste and by-product", an example is given as non-waste for off-cuts and other similar materials. It stated: "where material of this kind requires a full recycling or recovery operation or contains contaminant that need to be removed before it can be further used or processed, this would indicate that the material is a waste until the recycling or recovery operation is completed." Following this guidance, most of the clean off-cuts, from, for instance, extrusions, which can be directly fed into furnace, can be argued as non-waste. However, there is still room for interpretation for off-cuts such as painted or coated profile, sheets, etc. What are the common contaminants in new scraps, and when is the recovery operation considered as complete?

Old scrap:

Old scrap is collected after consumption, either separately or mixed, and it is often contaminated to a certain degree, depending highly on its origin and collection systems. Since the life time of many metal products is more than ten years and some can be as long as more than 50 years, for instance products for building and construction, there has been an accumulation of metal in use since the beginning of the industry.

<u>*Aluminium scrap*</u>
According to the industry association, currently around 540 million tonnes of aluminium products are in use and there was nearly 8 million tonnes of old aluminium scrap generated in the year 2004 worldwide. 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. In the EU (data for EU25 only), the total recycled old scrap was two million tonnes in 2004 and the total aluminium in use amounted to nearly 120 million tonnes. The key sources of aluminium scrap and its characteristics are summarised in the following paragraphs:

Vehicles and transportation:
The automobile industry is by far the largest market for aluminium application and the largest source of aluminium scrap. When a car has come to its end of life, it is collected and dismantled. The amount of 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 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% (~3Mt) of total recycled aluminium, 12% of which is estimated to originate from ELVs. With the sector's consumption of aluminium being around 10 Mt, it implies a rate of recycling at approximately 30% (taking into account the aluminium use in vehicle some ten year ago, this rate is most likely to be higher). 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 Mt of aluminium stored 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 two and nine million tonnes 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 Mt worldwide. However, as already mentioned, due the very long lifetime of buildings, its contribution to recycled scrap was only 7% in 2004, i.e. around 0,5 Mt 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 between 92 and 98% even though the aluminium content in building (mass-based) 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 for being directly sold for reuse or sent to 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 life time. The current consumption is close to five Mt per year. The sector contributes nearly 28% of the 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 first one 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 very little.

Cable and wire:
When buildings and old installations need to be demolished, renewed and/or upgraded, scrap is generated, however, no data available enable a total estimate. Since the current demand is mainly driven by new installations in developing countries, the available scrap from this sector may expect to rise in the future. According to BIR, in 1997 world-wide, cables generated over one million tonnes of scrap metal, the majority of which is copper, although power transmission cable use aluminium as the conducting metal.

Electrical and electronic equipment (EEE):
It is estimated that each EU citizen currently produces around 17-20 kg of waste from EEE (WEEE) per year and thus the waste stream adds up to 9-10 million tonnes at the Community level. Expected growth rates are between 3 and 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 found in electrical and electronic equipment and account for almost half of the total weight of WEEE (seems high). Aluminium as one of the non-ferrous metals represents approximately 4,7% of the total. Based on such an estimate, the yearly generated aluminium scrap from e-waste could be around 400.000 tonnes in the EU. However, the collection rate is unknown, and the actual amount of scrap recovered is expected to be less.

Iron and steel scrap

Since 2004, the EU25 has consumed in total around 100 million tonnes of iron and steel scrap each year, i.e. 54% of the steel produced, and considering a small amount of net export, the total domestic supply of scrap was slightly more than the consumption. The main sources of iron and steel scrap are expected to come from the construction and transportation sector, which together accounted for 42% of the total steel consumption in 2006. Mechanical engineering, tube and metal ware 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.

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[1], around 8 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 6Mt of steel scrap are generated from cars, i.e. 6% of the 2005 steel scrap consumption. From all the ELVs, Veolia reported that the total recovered ferrous was 11 Mt in Europe, representing 11% of the scrap source. (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 UK shows that some 90.000 tonnes of iron and steel were recovered from construction and demolition waste in 1998.

Equipment and appliances:

This category covers a wide range of products from home appliances, such as fridges, washing machines, ovens and microwaves, etc. to 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 available.

WEEE:

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[1] Stakeholder consultation on the review of the 2015-targets on reuse, recovery and recycling of end of life vehicles, final report, version of 4 November 2005.
End of life vehicle regulation in Germany and Europe – problems and perspectives, Wuppertal institute, 2001

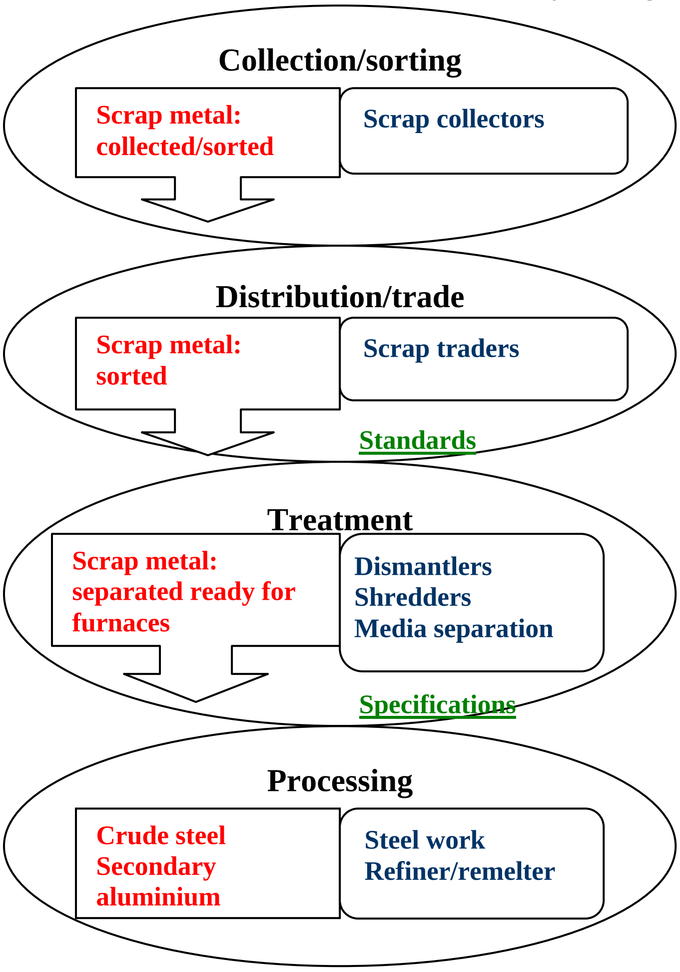
As discussed previously, on average steel accounts for half of the content on a weight basis in electronics, and this would potentially generate some 4Mt of steel scrap each year in Europe (seems high). However, without the information on collection rates, it is difficult to estimate the actual amount of steel scrap from WEEE.

Packaging material:
Steel packaging includes food cans, beverage cans, aerosols, etc. According to APEAL, over 2,3 Mt of steel packaging was recycled in 2005, which is about 2% of the total scrap recycled in the EU.

II. Industry structure

The scrap recycling industry consists of scrap collection and sorting, distribution, treatment and processing. Along this chain, as shown in the figure, scrap is cleaned to become secondary material for final products. In the steel industry, scrap processing is an integrated part of the primary steel production, while the secondary aluminium production distinguishes itself from the primary aluminium industry.

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 scrap yard 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 industry, though some industry initiatives are taken in the case of UBCs, e.g. can collection centre, scrap terminals, where steel and aluminium cans are separated and bailed 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 quantity of the scrap being shipped. The export and import of steel scrap totalled (export+import) 16-19 Mt in the last few years and the amount of aluminium scrap (new and old) shipped within Europe was estimated being five Mtonnes in 2004. Scrap trade may be done in any bilateral way between collector, broker, treatment plant or refiner/remelter.

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 shredder and 40 media separation plants in the EU25. 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.

III. Management alternatives

As already mentioned, due to the high value of metal, scrap is recycled becoming secondary metal or reused whenever it is possible. Although different types of scrap has its own requirement for treatment, in general, scrap recycling consists of collection, sorting, shredding and or sizing, and media separation. This process can be summarised as the following, and some details will be discussed later in this paper:

- Scrap is being collected either separately or mixed and then sorted in the scrap yard and then sold to scrap treatment plants or sent directly to a refiner/remelter.
- Arriving at the scrap treatment plant, different type metals are further separated and prepared for shredding/sizing. Shredding and sizing is needed for a later 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.
- When necessary, shredded scrap metal needs to be dried or to be further removed off possible contaminants such as oil, grease, lubricants, lacquers, rubber, and plastic laminates. This is usually not done at the scrap treatment plant, and instead, for energy efficiency reasons, is done at the refinery or remelter.
- At the refinery, scrap metal is first cleaned from contaminants at below melting temperature in kilns and then charged to the furnace going through melting, fluxing/refining, and tapping.

When metal containing products can not be easily collected separately, for instance flexible metal packaging, majority of them will be incinerated for energy recovery, and the incineration slag is usually treated with metal recovery.

According to EAA, some 1,7 Mt of old aluminium scrap is not recycled and some of this is expected to end up being landfilled. The figure for iron and steel scrap is reported to be 29Mt 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 Mt of scrap in 2000, 86,5 Mt was old scrap).

IV. Specifications and standards

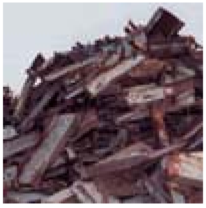
Currently, specifications and standard classifications for metal scrap exist at all levels, international, European, national, as well as between individual parties. It is not clear what the reasons for the existence of various standards/specifications are and how decisions are made as to which one is used. However, in many cases based on the production need, scrap is processed according to the specifications of the smelters and refiners. The standards are probably used as a reference for trade in the market to determine the quality as well as to set the price.

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
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.

Example I
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.

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 for steel scrap.

National standard classification
In the case of aluminium, various classifications are developed by the national industry associations of, for example, the UK, Spain, Belgium, France, and Germany.

European Steel Scrap Specification
In the case of steel, EFR and EUROFER developed the European Steel Scrap Specification in 1995 and an updated version is currently being proposed. 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.

V. Legislation and regulation

The management of scrap metal is currently under the waste regulations in the EU, e.g. the Waste Framework Directive and Regulation EEC Shipment of Waste. The scrap treatment plants (shredders, dismantlers, media separation plants) are operated under the permit for waste treatment (Check with industry!) The current discussion on the extension of the scope of the IPCC Directive in relation to waste treatment activities suggested the inclusion of separated installations for scrap metal treatment.

Most types of scrap metal belong to the "green list" where transportation and shipment (to non-OECD countries) is concerned. This means the shipment of metal needs to fulfil corresponding requirements based on the Regulation. The list makes a distinction of many different scrap metal origins or metal containing waste streams, though it is not clear how the treated scrap metal, for instance from WEEE, should be dealt with.

However, after the Mayer Parry case, for which a Guidance on application was published by the industry association together with the Environmental Agency of the UK, it is not clear in which member country and how the court decision has been interpreted and translated into national legislation.

The production of secondary metal at refineries and remelters and the treatment process of scrap metal on site are subject to the IPCC Directive. The related BREF document on non ferrous metal industry is to be reviewed in 2007. Scrap metal processed at the same site as secondary metal production usually need to be treated under high temperature to remove the coating, paint, etc. and thus at the same plant of secondary production would save energy.

REACH, the new EU chemical policy, requires manufacturers to generate the Safety Data Sheet (SDS) of the products. Should there be end of waste criteria for scrap metal, REACH may be applied. Subject to debate, this change could mean that the scrap treatment plants would need to provide a SDS to the refineries/remelters, as an intermediary product. Any impurities over a certain percentage would need to be examined and reported.

In the WEEE and ELV Directives, the following elements are described regarding the treatment and process of the two types of waste:

- separate collection
- permits for waste treatment operations
- compliance with minimum standards for recycling and treatment of WEEE, and the possibility of IPPC on WEEE treatment, recovery and recycling techniques
- minimum technical requirements for the treatment of ELVs

Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles - Commission Statements

ANNEX I

Minimum technical requirements for treatment in accordance with Article 6(1) and (3)
1. Sites for storage (including temporary storage) of end-of-life vehicles prior to their treatament:
- impermeable surfaces for appropriate areas with the provision of spillage collection facilities, decanters and cleanser-degeasers,
- equipment for the treatment of water, including rainwater, in compliance with health and environmental regulations.

2. Sites for treatment:
- impermeable surfaces for appropriate areas with the provision of spillage collection facilities, decanters and cleanser-degreasers,
- appropriate storage for dismantled spare parts, including impermeable storage for oil-contaminated spare parts,
- appropriate containers for storage of batteries (with electrolyte neutralisation on site or elsewhere), filters and PCB/PCT-containing condensers,

- appropriate storage tanks for the segregated storage of end-of-life vehicle fluids: fuel, motor oil, gearbox oil, transmission oil, hydraulic oil, cooling liquids, antifreeze, brake fluids, battery acids, air-conditioning system fluids and any other fluid contained in the end-of-life vehicle,
- equipment for the treatment of water, including rainwater, in compliance with health and environmental regulations,
- appropriate storage for used tyres, including the prevention of fire hazards and excessive stockpiling.

3. Treatment operations for depollution of end-of-life vehicles:
- removal of batteries and liquified gas tanks,
- removal or neutralisation of potential explosive components, (e.g. air bags),
- removal and separate collection and storage of fuel, motor oil, transmission oil, gearbox oil, hydraulic oil, cooling liquids, antifreeze, brake fluids, air-conditioning system fluids and any other fluid contained in the end-of-life vehicle, unless they are necessary for the re-use of the parts concerned,
- removal, as far as feasible, of all components identified as containing mercury.

4. Treatment operations in order to promote recycling:
- removal of catalysts,
- removal of metal components containing copper, aluminium and magnesium if these metals are not segregated in the shredding process,

Based on the understanding of the industry and it current situation, the first key questions of the case study arise. How will end of waste criteria affect and relate the existing standards/specifications as well as the legislations in place, should standards and specifications be the basis of, or be reflected/included in, the criteria, what could the benefits of end of waste criteria be, and how could the key players of the industry (and the structure) be affected?

2. *Defining end of waste criteria*

I. A life cycle approach to EoW

As already discussed, even though the principles being laid out in the WFD can be easily established in the case of scrap and its derived secondary metal, this case study will gather information and data in the following aspects in relation to the two principles and this information will be largely based on the existing studies.

Environmental and health aspects

As already mentioned, the environmental impact of waste management and the end of waste criteria should be evaluated from a life cycle point of view. Following the recycling chain (above), the key environmental impacts of scrap recycling occur at the steelworks and refineries/remelters. Scrap treatment, sorting, separating and bailing, are chiefly mechanical processes, and therefore emit dust and limited direct air emissions. While some individual scrap sources should be examined in detail due to their specific characteristics (discussed later in the paper), the potential environmental issues in scrap management are summarised here along the recycling chain.

<u>Risks related to scrap transportation and storage</u>

Although scrap metal in itself does not pose any risk to the environment, it may be contaminated with oil or mixed with other waste, which could cause problems during transportation or storage. For example, oil or paint attached to scrap metal, when exposed to rain, may cause contamination to its surrounding environment. If scrap metal is mixed with a certain amount of other waste, any shipment of such scrap metal can not guarantee to be free of risks.

<u>Energy use and GHG emissions</u>
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 demand 10 MJ/Mt, which is responsible for 1Mt CO2 emission per tonne of production. The production of crude steel from scrap is integrated in the steelworks, the use of energy and emissions are not reported separately. However, energy use in the processing of both scraps is much less in comparison to production of metal from ore or bauxite.

<u>Other air emissions in scrap treatment</u>
Several hazardous air pollutants are possibly associated with the secondary production, e.g. benzene, styrene, dioxins and furans, hydrogen chloride, hydrogen fluoride, and chlorine, HAP metals, arsenic, lead, and chromium. These substances are usually collected and controlled with standards.

<u>Chemicals and waste in secondary process</u>
For improving the product quality in secondary aluminium production, salt is added to the molten scrap, and result in slat slag and skimming, which consists of fluxing agents, impurities, and/or oxidized 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 for the same purpose, and meanwhile, aluminium metal is also recovered. The remaining residues are, whenever possible, used in cement production or land filled.

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/t (liquid steel) of slag and 10-20 kg/t (liquid steel) of dust is generated. The major components of EAF slag are lime, silica, and oxidised metal elements. Dust may contain a high level of zinc, lead and cadmium, and that from stainless steel processes has additional chromium, nickel and molybdenum elements. When economically viable, the metal content may be recovered, though current dust is mainly sent for landfill. Slag is recycled for reuse in steel making, or is analysed for its suitability for being applied as aggregates for building and road construction.

Economic aspects

In 2003, the total scrap metal trade (import + export) of the EU was 59 Mt, 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. The demand for scrap has evidently been rising in all countries, which has resulted in a high price for scrap metal in 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 the places where the largest recycling plants are built. As the recycling rate is increasing in all the sectors in the EU, it is expected that the amount of scrap will continuously increase, however this may not be sufficient for its current demand, and there is a risk that the secondary metal industry in the EU would experience a supply shortage.

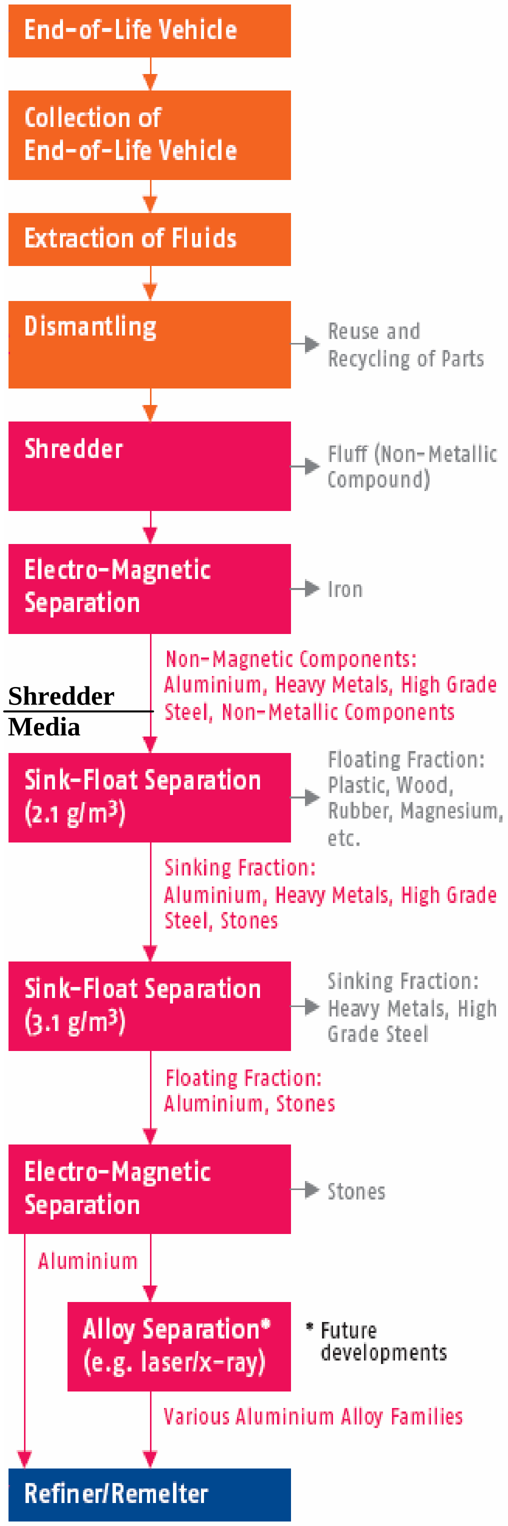
As already mentioned, from a life cycle point of view, it is fairly certain that the recycling of metal scrap is the most desirable management alternative both environmentally and economically. A further focus of the case is to explore if and what

could be the impact of end of waste criteria on the environmental and economic performance of the industry, i.e. does end of waste criteria bring additional environmental benefits and how would the criteria affect the trade and market position of the EU. These questions are part of the quantitative analysis regarding the overall impact of end of waste criteria, hence they will be further explored at a later stage of the case study.

II. Technical issues

The scrap metal flow (from end of life product to secondary material) and the steps in its management may vary depending on the origins. For example some scrap, e.g. new scrap, is very clean even without any treatment and can be directly used as input material for the furnace. This implies that the end of waste criteria for different scrap metal may occur at different stage of the flow.

Since the main sources of both steel and aluminium scrap are the same and they are treated in the same plants and separated at certain stages, it is proposed that the end of waste criteria in this study are examined first by the origins of scrap taking into account the difference between the two types of scrap metal and then the possibility for synchronising or harmonising. The following origins of scrap metal are to be studied in detail in the case study (BIR, EAA, ELDAN recycling, and Novelis are the main references):



<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 at the same time a scrap treatment plant. ELVs are treated 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 a 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 from the other materials, leaving non-ferrous metals to pass to further stages, i.e. dense media separator and eddy-current separator, for the segregation of one type from another. The separated ferrous part contains as much as 98% of the metal and more than 99% of the non-ferrous metal can be recovered. Further advanced technology for the separation of alloys is being developed for

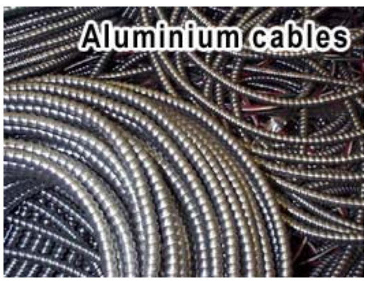
industrial application.
There are two main types of residue generated in these processes: the airborne dust (fluff), caught by the shredder dust collection system (consisting of upholstery fibres, dirt, rust, paint, etc.), and the non-metallic residues separated from the recovered material streams by the media separation plant (consisting of unusable rubbers, plastics, stones, etc.). The dust and the separated residues together represent about 17 to 25% of the average vehicle weight. This has been land filled, representing no more than 0.2% of total landfill waste in the EU.

Used beverage cans
In most countries, used beverage cans (UBCs) can be made from both 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 UK, 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 bailing and are then sent to refineries. The recycling process of aluminium cans is shown in the following diagram.

On arrival at the refinery, the bailed aluminium can is first shredded into small-size pieces, and then passed through a magnet field to remove any remaining steel contaminants. Next, the shreds need to be removed off paint, ink, coating etc. by blowing in hot air at a temperature of 500^0C. 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 cable and most of the other type of cables used in building, communication, electronics and automotive are normally from copper.

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. The following steps are common in cable scrap chopping process:

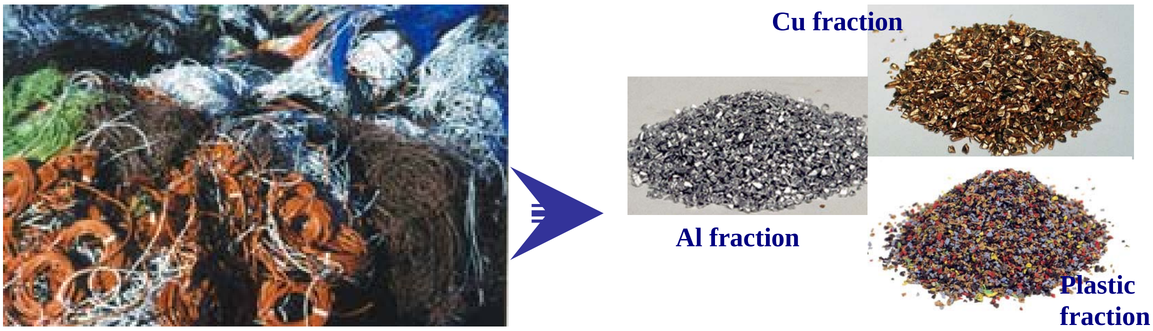


- Pre-sorting: is to separate cable scrap by type of insulation,

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 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 chop. 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, however, inevitably small amounts of metal remain embedded in the plastics.
- Screening: to enhance 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 being 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 reduce to less than 0,1%, which, as a result, will increase the value of the recovered plastic.

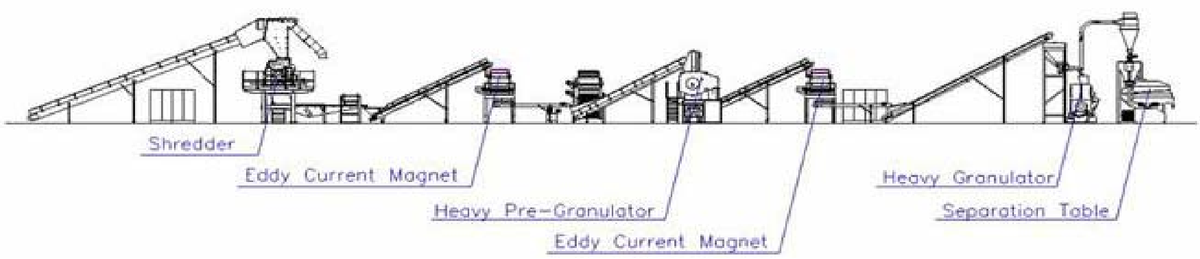
As an example, the picture shows the before and after treatment of ordinary dry cable scrap, which is usually a mixture of copper or aluminium conductors with rubber or paper insulation. They may also have steel or lead armouring. Pre-sorting in such a case is very difficult.



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. Apart from a metal content, EEE could also contain various chemicals, therefore it is necessary to check for hazardous components and dismantle and remove them before the automatic treatment process. This is done either by the WEEE supplier or at the treatment plants. After this de-pollution step, WEEE consists chiefly of a mixture of metal, plastics and glasses.

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, as shown in an example below.



Hand separation during the process makes it possible to pick out the stainless steel fraction. Al and Cu fractions can be basically separated from other non-ferrous metal after the process and can be sent directly to the refineries. Like in the case of cable, the metal content in the plastic could be high and it is possible to be further recovered during the plastic recycling process.

The preparation and treatment of different WEEE may have different requirements. For example fridge needs to be treated in an enclosed environment to avoid the emissions of CFC gases.

<u>Scrap metal from deconstruction</u>
Regulation 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 being 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 separated with magnets before being returned to metal industry.

<u>Stainless steel</u>
With the growing application of stainless steel in both industry and home appliances as well as in the transportation sector, the availability of stainless steel scrap is also increasing. In 2005, the available stainless scrap amounted to 2,1 Mt in the EU, accounting to nearly one third of the world total.

Stainless steel is usually collected separately due to the high value of the alloy elements. After stainless steel is separated from other scrap metal in treatment plants, it needs to be further separated using chemical analysis and stored by type. The stainless steel scrap traders and processors may also involve special experts for blending, blend the shredded scrap into chrome steel, nickel alloys and other types of stainless steel to meet the need of the customers.

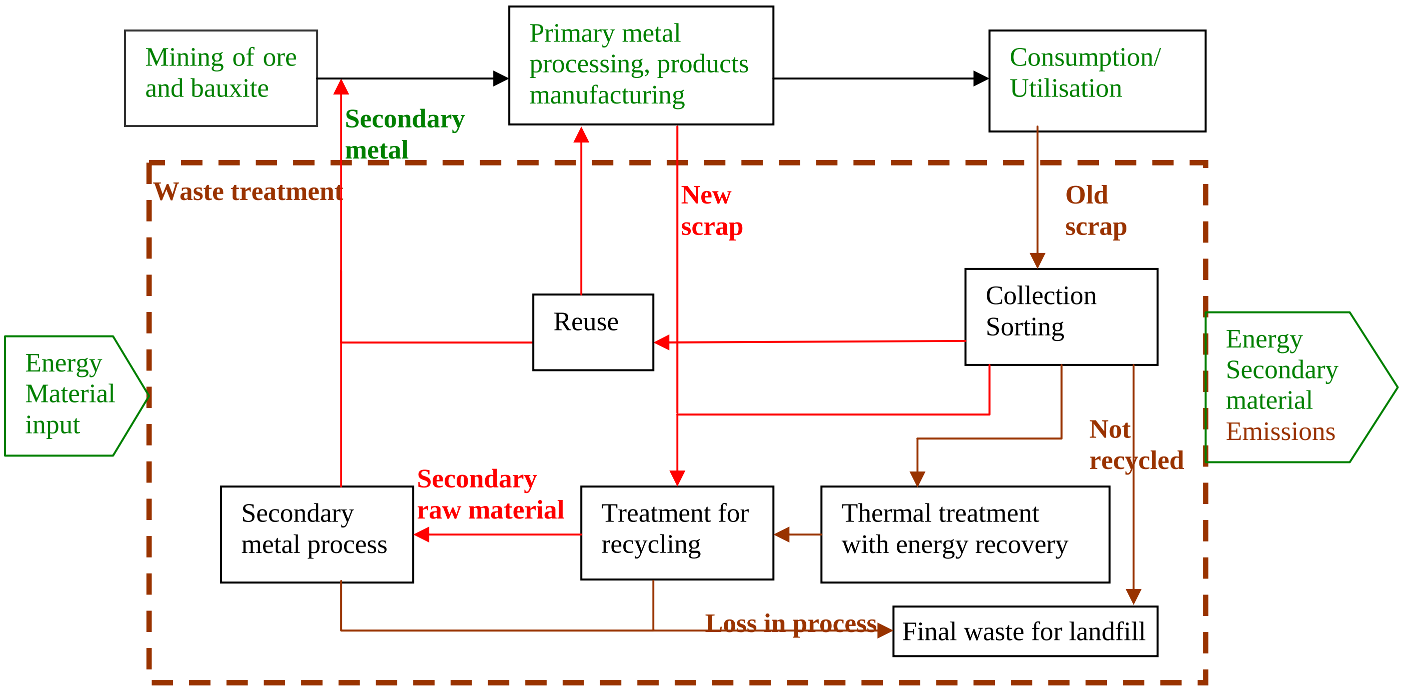
From the technical details discussed above, it is clear that proper separation and treatment of scrap metal disregarding their origins will result in suitable metal fractions as input to secondary metal production. Therefore, the crucial questions of the case study from the technical perspective are:
- can EoW criteria be defined at different stage depending on the scrap origin from both theoretical and a logistical point of view?
- is mixed non-ferrous metal acceptable as a product? is it necessary and technically feasible to always separate different kinds of non-ferrous?

- what could be the style of EoW, minimum requirements in the form of specification by the outputs, or minimum technical requirements for the treatment process by the origins, or a combination of the two?

Overall impact assessment

A full impact assessment is complex and time consuming. It is not foreseen that this study would carry out a complete assessment of the impact of the end of waste criteria on the environment, economy and society. However, subject to the availability of information and data, the following essential issues will be discussed in the case study to illustrate the possible impacts and their scale.

The impact assessment should also be analysed from a life cycle point of view, as discussed before. A general life cycle of scrap metal is illustrated as the following diagram:



Environmental impacts (using mid-point indicators):

1, does EoW affect GHG and other air pollutant emissions?
2. does EoW affect energy and resource consumption from both a waste management and a life cycle point of view?
3. does EoW affect any effluent emissions?
4. does EoW affect solid waste quantities for final landfill?
5. does EoW address the health risks related to recycling?

Economic impacts

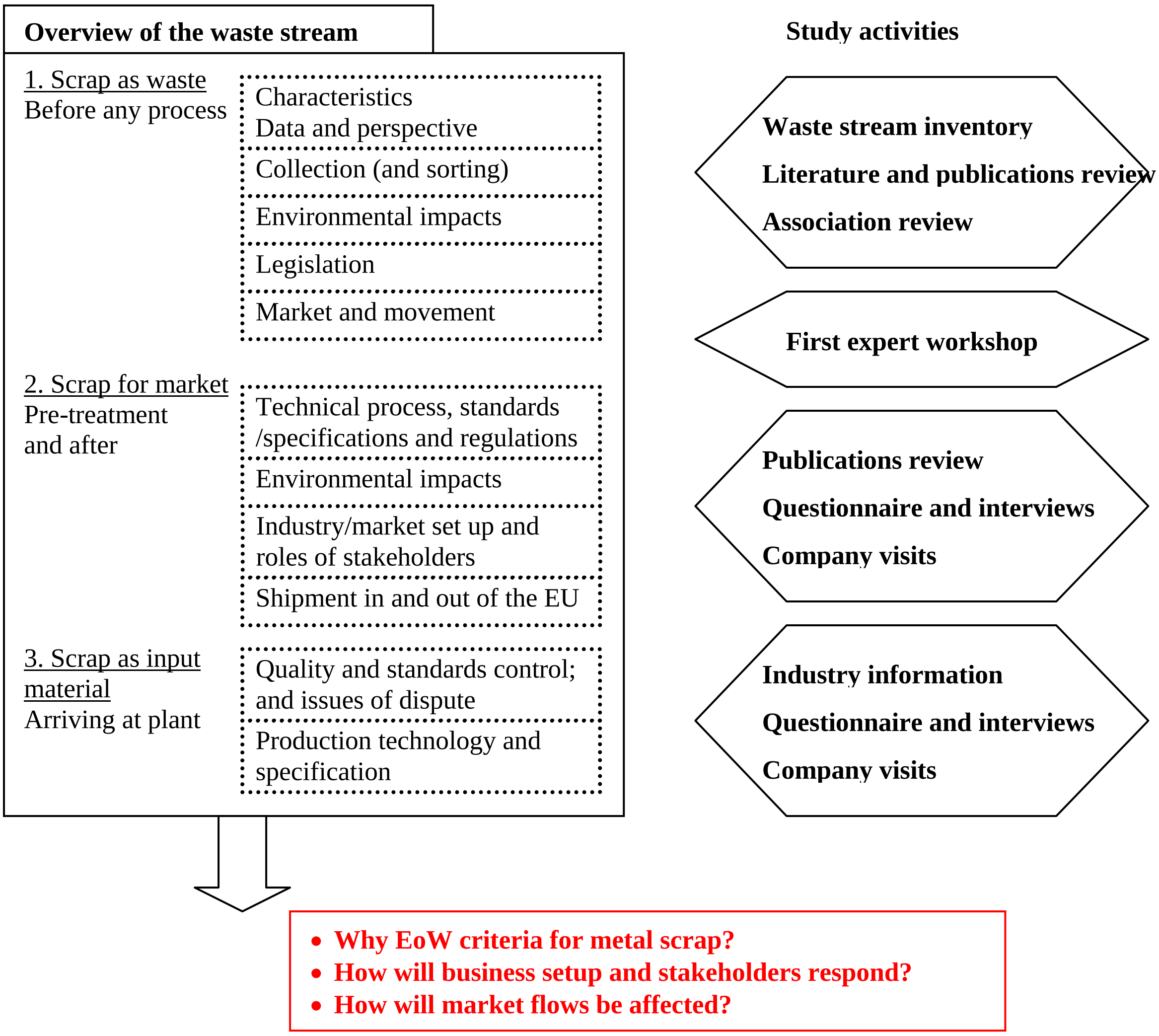
1. does EoW affect the market position of the industry?
2. is import and export affected?
3. does EoW affect the operational/production costs and the administrative cost of firms?
4. does EoW affect the application of technology and promote specific research?
5. does EoW particularly affect SMEs?
6. does EoW affect the quality assurance, thus increase or reduce business trust?

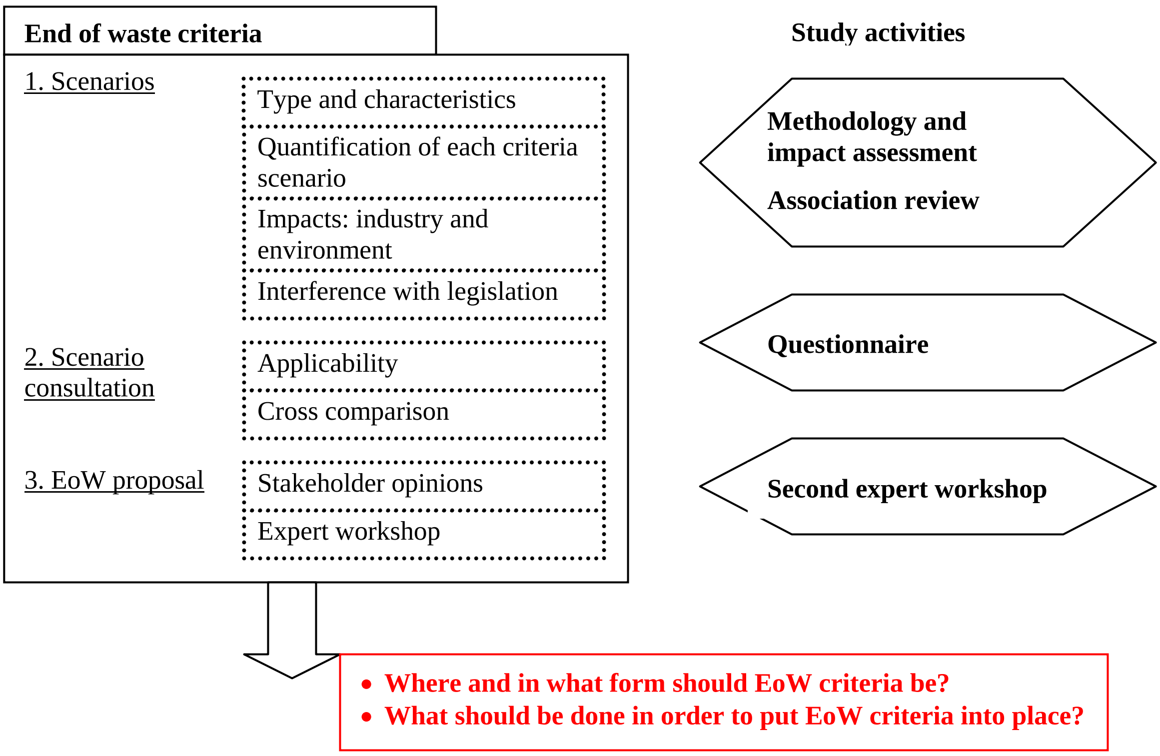
Social impacts

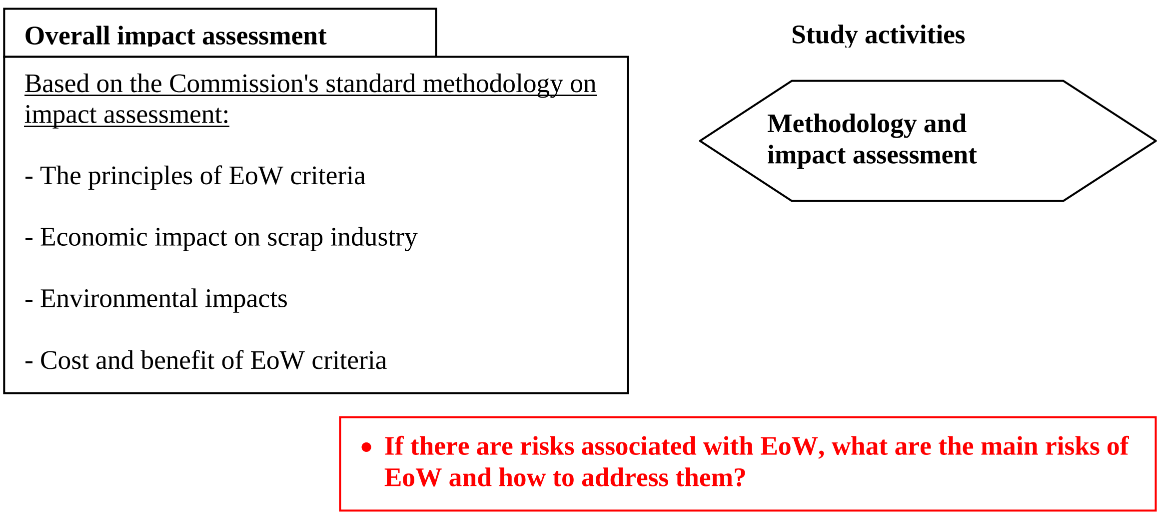
1. does EoW affect the number of firms in operation, thus to cause an increase or loss in jobs?
2. does EoW affect job quality and the working environment?
3. does EoW affect the equality between large cooperates and SMEs?
4. does EoW affect public administration?

Case study planning

Activities and time schedule




End of waste criteria
1. Scenarios
Type and characteristics
Quantification of each criteria scenario
Impacts: industry and environment
Interference with legislation
2. Scenario consultation
Applicability
Cross comparison
3. EoW proposal
Stakeholder opinions
Expert workshop
Study activities
Methodology and impact assessment
Association review
Questionnaire
Second expert workshop
• Where and in what form should EoW criteria be?
• What should be done in order to put EoW criteria into place?


Overall impact assessment
Based on the Commission's standard methodology on impact assessment:
- The principles of EoW criteria
- Economic impact on scrap industry
- Environmental impacts
- Cost and benefit of EoW criteria
Study activities
Methodology and impact assessment
• If there are risks associated with EoW, what are the main risks of EoW and how to address them?

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