Notice: The information contained in this document is intended to provide an overview of the current situation of regulatory developments and recycling flows of end-of-life vehicles. This paper is provided for reference purposes only. References to sites, companies, and agencies are for information purposes only.

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1. Introduction

Copper and copper alloys are widely used in automotive applications. It has been estimated that this sector accounts for as much as 5% of the world copper and copper alloy semis production.

Main uses include:

- Electrical system: Wire harness, starter, generator/alternator, small motors and battery cables
- Motor windings, interconnectors, connectors for wires and in circuit boards
- Heat transfer systems and mechanical components: Automotive radiators and heaters, ventilators, bearings and bushes, alloying element for aluminium cast parts (engine blocks, radiators, wheels) and high-strength low-alloy steel, brake lining.

Once reaching the end of their service life, vehicles represent a major source of scrap material for recycling. This Info Circular aims at providing background information on some of the key issues and challenges facing copper recycling from end-of-life vehicles. It is intended to address the identified issues in an ICSG case study on regulatory impacts in the field of end-of-life vehicles.

2. Key Facts, Figures and Challenges Concerning ELV

2.1. Current and future scrap availability

In Table 1 selected data concerning end-of-life vehicles recycling in the European Union, Japan and the USA are compiled.

Table 1: Selected country statistics on end-of-life vehicles (Sources: see References)

<table>
<thead>
<tr>
<th>Country statistics (Annual basis)</th>
<th>European Union</th>
<th>Japan</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car production (Automobiles &amp; Trucks)</td>
<td>16 – 18 Million vehicles</td>
<td>9 – 10 Million vehicles</td>
<td>15 – 17 Million vehicles</td>
</tr>
<tr>
<td>Cars in use</td>
<td>200 Millions</td>
<td>~ 50 Millions</td>
<td>200 – 210 Millions</td>
</tr>
<tr>
<td>New cars registered</td>
<td>14.0 – 14.5 Millions</td>
<td>5.0 – 5.5 Millions</td>
<td>15.0 – 15.5 Millions</td>
</tr>
<tr>
<td>Deregistered cars</td>
<td>11 - 12 Millions</td>
<td>~5 Millions</td>
<td>13.5 – 14.5 Millions</td>
</tr>
<tr>
<td>Shredded/recycled cars</td>
<td>7.0 – 8.0 Millions</td>
<td>4.0 – 4.5 Millions</td>
<td>12.5 – 13.5 Millions</td>
</tr>
<tr>
<td>Abandoned/stored cars</td>
<td>~ 5-7%</td>
<td>~ 1%</td>
<td>~6%</td>
</tr>
<tr>
<td>Exported used cars</td>
<td>3.0 – 3.5 Millions</td>
<td>0.5 – 1 Millions</td>
<td>n.a.</td>
</tr>
<tr>
<td>Average weight of car</td>
<td>1000 – 1200 kg</td>
<td>1000 – 1200 kg</td>
<td>1200 – 1400 kg</td>
</tr>
<tr>
<td>Copper &amp; alloy content</td>
<td>1.0 – 2.2%</td>
<td>n.a.</td>
<td>1.4 – 1.5%</td>
</tr>
</tbody>
</table>
2.2. Changes in the material composition of cars

In Figure 1, the historical development of the average material composition of cars is illustrated. In the last decades, a significant decrease of the iron and steel share occurred, while the share of aluminium and other materials (mainly plastics) increased. In the case of copper, an increase of copper use for electrical wiring and in powder applications lead to a slight increase of the overall copper usage in the car over time. The current average of copper and copper alloy content in ELV is estimated to be in the range of 1.0 – 2.2%.

Figure 1: Exemplary average composition of current end-of-life vehicles

The AMM compiles data on material use for typical North-American-built family vehicles. While the copper and brass use per car has been constant over the last decade, the material share of copper and brass has been decreasing over the last years due to the increase of the average weight of these cars (AMM 2001).
2.3. Selected Legislation addressing End-of-Life Vehicles

European Union

In 1997, the European Commission adopted a Proposal for a Directive on End-of-Life Vehicles which aims at making vehicle dismantling and recycling more environmentally friendly, sets quantified targets for reuse, recycling and recovery of vehicles and their components and pushes producers to manufacture new vehicles also with a view to their recyclability.

This legislation was officially adopted by the European Parliament and Council in September 2000 and was published in Official Journal L269 on 21st October. (Directive 2000/53/EC). It was supposed to be implemented by 2002 in all member states.

The Directive requires to set targets for material recovery of 85% and of recycling of 80% until January 2006 and a material recovery of 95%, and recycling of 85% until January 2015. The Commission will also establish European standards on material coding and identification and detailed rules on compliance control with the reuse, recycling and recovery targets set by the Directive. To date, Austria, Denmark, Germany, The Netherlands, Spain, Sweden, and Portugal and the United Kingdom have introduced the requirements laid out in the EU directive (see ICSG Regulatory Survey).

In many member countries voluntary industry initiatives for car recycling are well established. Examples are the French Accord Cadre, the Dutch ARN system, the Spanish AGBAR scheme, the Italian Fiat Fare System and the Swiss Stiftung Autorecycling. Similar schemes exist also in Belgium, Germany, and Portugal.

Japan

The Law on Recycling of End-of-life Vehicles was passed in 2003 and requires manufacturers and importers of motor vehicles to recycle the following items before disposal (in addition to established scrap metal recycling): Air bags, fluorocarbons used in air
conditioners and automobile shredder residue. The latter is of importance to copper, as residual copper mainly from copper wiring is contained in the ASR. This copper could be recovered in the future. The recycling law is expected to be fully implemented by the end of 2004. Regarding the financing of the recycling scheme, recycling fees will be collected from buyers when new vehicles are sold. In addition, for vehicles purchased before the law is implemented, fees will be charged when car owners bring in their vehicles for their mandatory maintenance inspection.

In addition to the recycling law, a voluntary industry initiative for car recycling had already been launched in 1997. The initiative was initiated by METI, JAMA (Japanese Automobile Manufacture Association) and other industry associations. The initiative sets a recovery rate of 85% for end-of-life vehicles until 2002 with ASR landfilled at 60% of 1996 level. This rate is to be increased to 95% recovery by 2015 with ASR landfilled at 20% of 1996 level. The recyclability rate for new vehicles should reach 90% by 2002. Regarding toxic substances, it is pursued to reduce the lead content in new vehicles by 50% by 2002 and 33% by 2005 compared to the level in 1996.

USA

To date there is no national legislation specifically addressing the collection and recycling of end-of-life vehicles. However, a series of voluntary industry recycling initiatives are established and the existing collection and recycling system is regarded to be well operating. The most prominent initiative is the Certified Automotive Recycler (C.A.R.) Program of the Automotive Recyclers Association (ARA) that was launched in 1994. The guideline establishes a set of standards for general business practices as well as environmental and safety issues and aims to provide guidance for member facilities.

2.4. Current Status of Recycling of End-of-Life Vehicles

End-of-life vehicles are a major source of scrap metal. The usual treatment route of the obsolete car includes depollutioning, selective dismantling, and size-reduction via a shredder. The shredder operation leads to a separation of the mass flow in three fractions: the Steel fraction (via magnetic separation), the Non-Ferrous Metal fraction, and the Automobile Shredder Residue (ASR). Copper is recovered from the non-metallic fraction in media/metal separation plants (using eddy-current, screening, sink-float techniques, etc.). According to the European Ferrous Recovery & Recycling Federation (EFR), the current EU infrastructure for end-of-life vehicles recycling comprises over 10,000 recognised dismantlers/scrap yards, more than 200 recognised shredders and around 40 media & metal separation plants (Isager 2001).

Around 7 - 8 Million cars are currently being recycled annually in the European Union. Assuming an average copper and copper alloy content of 1.7% in the end-of-life vehicles (CRU estimate) and an average weight of 1.1 tonne of obsolete cars the theoretical copper scrap availability in end-of-life vehicles amounts to around 150,000 tonnes of copper and alloys. Additionally, up to 50,000 tonnes of copper and alloys may be contained in deregistered used vehicles abandoned, stored or leaving the EU while being exported for re-use and/or recycling to mainly Africa and Eastern Europe.

The situation is quite similar in Japan and the USA as illustrated in Table 2.
2.5. Copper Recycling from End-of-Life Vehicles

Copper recycling rates in the shredder process are usually significantly lower than for steel and aluminium. While the former are usually in the range between 85 – 95% the corresponding copper recovery rates are believed to be somewhere between 40 – 60%. The copper recycling efficiency heavily depends on the efforts for selective manual dismantling prior to the shredder process (e.g. removing brass radiator, motor, electrical wiring, etc.).

Table 2: Copper content in current vehicle reservoir in use and associated flows

<table>
<thead>
<tr>
<th>Flow/Stock</th>
<th>European Union</th>
<th>Japan</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper stock in cars in use</td>
<td>~3.0 Million tonnes</td>
<td>~0.8 Million tonnes</td>
<td>~3.0 Million tonnes</td>
</tr>
<tr>
<td>Copper available for recycling in one year</td>
<td>200,000 tonnes</td>
<td>75,000 tonnes</td>
<td>200,000 tonnes</td>
</tr>
<tr>
<td>Copper collected for domestic recovery</td>
<td>150,000 tonnes</td>
<td>65,000 tonnes</td>
<td>190,000 tonnes</td>
</tr>
<tr>
<td>Copper export in used/end-of-life cars</td>
<td>50,000 tonnes</td>
<td>10,000 tonnes</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

A significant amount of copper is entering other metal recycling loops (such as steel, aluminium, and zinc recycling loop) as alloying element or undesired impurity. In the case of steel recycling, the presence of copper may be of particular concern. Manufactured steel products have to comply with a series of physical and chemical characteristics including specifications regarding the relative contents of alloying metals. In this context, copper is mostly regarded as undesired impurity remaining in the secondary steel products. It is usually not removed in the secondary steel making process and, consequently, contributes to the overall weight of the steel product. For quality reasons (e.g. surface defects) it is usually required to maintain a copper content of less than 0.2% in high quality steels. As the copper contamination may increase for each lifecycle, the copper content in recycled steel scrap should be reduced as much as possible. The copper outflow into the steel fraction obtained in the ELV shredder process has to be reduced to < 0.25% according to the European steel scrap classification (maximum allowed impurity of “E40” shredder scrap).

In Figure 2, typical flows of copper in the car recycling process are illustrated.

In light of the upcoming requirements regarding material recovery, further measures for improving the ELV recycling performance are already under development. This could include increased manual dismantling of electrical wiring prior to the shredder operation (mainly to reduce outflows to other metal loops), and the recovery of residual metals from the automotive shredder residue fractions.
Data sources: ICSG estimates based on various technical studies on end-of-life vehicles recycling (see references).
2.6. Product Design for Reuse and/or Recycling

Considerations regarding product design for reuse and recycling as well as product stewardship in general will become increasingly important for both automobile manufacturers and scrap recyclers. For instance, the European Commission has proposed a technical directive that would impose standards on EU automotive manufacturers to achieve that new vehicles can be more easily recycled after fulfilling their service life. The proposed technical rules include provisions regarding salvaging components and the creation of material checklists to support re-use of components and recycling of materials. It is also foreseen that manufacturers must present a strategy for the dismantling of end-of-life vehicles and their subsequent recycling and reuse of its parts.

2.7. Recycling of Automotive Shredder Residue

To date, Automotive Shredder Residue (ASR) has been mainly landfilled (~80% in Western Europe) or it has been partly co-incinerated in municipal solid waste incineration plants or otherwise treated for energy recovery (e.g. in cement kilns) (~20% in Western Europe). In the near future, an increase of ASR recycling can be expected due to the envisaged overall material recycling rates that have been established in European and Japanese regulations addressing end-of-life vehicles. As previously laid out, the bulk of non-recovered copper would be included as impurity and/or alloying element in the other metal loops or included in the automotive shredder residue light and heavy fractions (mainly copper wire/harness).

The corresponding processing technologies are currently under development or in pilot plant stage. Reuse and/or material recycling technologies in pilot projects and/or under development include treatments such as pyrolysis, melting cyclones, cokeless cupolas, etc. In these processes, it is often foreseen to separate metal fractions for recovery including copper. In one proposed process, copper can be recycled from ASR using a pre-treatment with a dry mechanical separation and comminution technique (recovery efficiency ~30%). The remaining fraction can be injected into a smelting cyclone for recovery of a copper/iron melt suitable for recycling in the copper industry. An overall material recovery of copper of up to 90% may be achieved with these techniques in the future (Selinger 2003).

2.8. Restrictions and Bans of Hazardous Substances

The End-of-Life Vehicles Directive of the European Union establishes use restrictions and bans for selected hazardous substances. For copper, the restriction of lead use is of particular importance. An average passenger car roughly contains about 8 – 12 kg copper alloys containing lead with an estimated individual lead content of materials and components between 0.2% to 10% by weight.

Copper-lead alloys applied in cars include:

- Bearing shells and bushes: Copper alloys containing up to 4% lead are used in bearing shells and bushes. These are used in cars in a wide range of applications, such as in crank spins in combustion engines, hinges and shock absorbers (hydraulics and pneumatic uses). The main reason for adding lead is for emergency lubrication purposes especially in the starter phase.
- Other parts containing copper-lead alloys include applications such as brake lining, nozzles, connection parts, fixtures and locks.
Regarding copper-lead alloys, certain material and components should be exempted or continue to be exempted from prohibition, since the use of lead in those specific materials and components is still regarded to be unavoidable (but might be restricted in the future):

- Copper alloys containing up to 4% of lead by weight
- Lead-Bronze bearing shells and bushes
- Copper in brake linings containing more than 0.5% of lead for vehicles type-approved before 1 July 2003 and servicing on these vehicles before 1 July 2004. A maximum concentration value of up to 0.4% by weight of lead in copper intended for friction material in brake linings shall be tolerated until 1 July 2007 provided it is not intentionally introduced.
3. References and Further Reading


