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Waste Electrical and Electronic Equipments versus End of Life Vehicles: a state of the art analysis and quantification of potential profits

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Abstract

Waste Electrical and Electronic Equipments (WEEEs) and End of Life Vehicles (ELVs) are two of the main waste streams, after municipal solid wastes, both in volumes and growth rates terms. Even if their management begins to be adequately regulated almost worldwide, there are still clear lacks to be solved in many aspects. The aim of this paper is the comparison, through a structured literature analysis, of these waste streams under several perspectives, by evidencing current differences and potential commonalities. In addition, a quantification of potential profits rising from a joined management of different sources of PCBs is described in the last part of the paper.

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Keywords: Waste Electrical and Electronic Equipments; End of Life Vehicles; Printed Circuit Boards; Literature Review, Potential profits.

1. Introduction

End of Life Vehicles (ELVs), together with Waste Electrical and Electronic Equipments (WEEEs), are two of the main sources of secondary raw materials. Yearly, impressive amounts of wastes, quantified in several million tons by different experts and organizations (e.g. [1, 2]), are generated worldwide. Given the continuous increase of these volumes, during the last decades many international directives were introduced, trying to regulate flows of materials both landfilled and illegally shipped abroad. However, the adopted approaches favoured the only recovery of basic materials.

Nomenclature

ASR	Automotive Shredder Residue
ELV	End of Life Vehicle
EoL	End of Life
PCB	Printed Circuit Board
WEEE	Waste Electrical and Electronic Equipment

This way, many critical issues (a short list of them is reported here) raised during the years:

- A continuous landfilling of valuable resources;
- A common use of non-sustainable design procedures during the product development process;
- An absence of political support on investments in new recovery plants;
- A low performance level reached by current recycling technologies;
- A strong disaggregation of reverse logistic chains;
- A current focus on basic materials recovery;
- An absence of best practices and innovative business models.

The aim of this paper is the comparison, through a structured literature analysis, of WEEE and ELV waste streams under several perspectives, by evidencing current differences and potential commonalities. In addition, a quantification of potential profits rising from a joined management of PCBs from different waste streams is described in the last part of the paper.

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The paper is organized as follows: Section 2 presents a series of distinguishing points about the current management of WEEEs and ELVs. Section 3 assesses existing commonalities of these two waste streams. A quantification of potential profits and a discussion of results is conducted in Section 4. Section 5 presents some concluding remarks and future perspectives.

2. WEEEs versus ELVs - distinguishing points

WEEEs and ELVs are the two main sources of waste. However, their evolution followed different paths. The recycling of ELVs is a process existing since the '60s, and the reuse of scrap metals is not a new idea. Instead, the recycling of WEEEs is a modern process, developed since the '90s. Even if technologies applied in these two processes are similar (at least at macro level) their evolution brought to different focuses and performances. The management of waste PCBs is an important example going into this direction.

From the WEEE side [3, 4], consumer and industrial wastes are collected by formal actors (public or private collection points) and directly transferred to authorized treatment facilities. Here, depending on the type of WEEE, these are disassembled up to divide valuable components and hazardous elements. Both valuable and hazardous components are stored and, then, transferred to dedicated recycling plants. The remaining WEEE mass is directly shredded and separated onsite up to recover basic materials (e.g. construction metals, plastics, wood, glass, concrete, etc.) – see Figure 1. Being PCBs one of the most valuable components, they are separated from the wasted product during disassembly, classified, stored and transferred to dedicated plants for the final recovery of precious metals.

Figure 1. A typical WEEE recycling process – Adapted from [3]

From the ELVs side, cars can be distinguished into two main groups, premature and natural ELVs. Premature ELVs are cars that reached their End of Life phase because of a big accident. Instead, natural ELVs are cars reaching the End of their Life because of obsolescence. Whatever the ELV type, they are collected in many different ways (e.g. official dealers, body shops, auto wreckers, etc.). Then, they are deleted from the public register and depolluted from the main pollutant and hazardous components (e.g. batteries, fuel, oils, filters, etc.). Subsequently, most valuable parts (e.g. engines, catalysts, radiators, gearboxes, etc.) - if functioning - are disassembled and reused as spare parts in the secondary market. The car hulk is, then, crushed and fragmented into little scraps. At the end, these scraps are separated by exploiting their physical characteristics (e.g. density, weight, magnetism, etc.) up to obtain a uniform amount of materials. In general, the metal part is directly reintroduced in the automotive supply chain (as input material for foundries). Instead, the non-metal part (generally named Auto Shredder Residue - ASR) is currently landfilled or used as fuel for energy generation purposes [5] – see Figure 2. Information about non-reusable automotive PCBs are rare to find in literature. However (with a good approximation), it is possible to say that, if not disassembled from the car, automotive PCBs are crushed together with car hulks [6]. An important distinction between WEEEs and ELVs is present also in terms of strategies followed during the end of their life. In fact, recycling is the preferred strategy for the management of WEEE components [1] and remanufacturing the most common one for ELV components [7]. Undoubtedly, this distinction relates to the intrinsic value of cores. In fact, components embedded into WEEEs are, generally, low / medium value elements and their remanufacturing would not allow to re-enter from sustained costs. As opposite, automotive components (especially the mechatronic ones) have a very high value (because of their complexity) and the demand coming from the secondary market is well-developed. This way, remanufacturing costs are completely covered by revenues, so guaranteeing good profits to the actors involved in these activities. A reference market for remanufactured parts is in the USA.

Figure 2. A typical ELV recycling process – Adapted from [5]

Figure 3. A typical PCB recycling process – Adapted from [13]