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RECYCLING SCENARIOS FOR WASTE CATHODE RAY TUBES*

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Abstract

With the diffusion of the technological progress we have lost the habit of repair, re-use and recycle many goods. To contrast the production of waste and favor sustainable management actions, the European Parliament has promulgated the WEEE (waste electrical and electronic equipment) directive. In this context, the present study deals with management options for waste cathode ray tubes (CRTs). Different recycling scenarios were evaluated for the recovery of valuable secondary raw materials, such as the fluorescent powders containing yttrium, glass cullet and lead. Our results suggest that the recovery of secondary raw materials from CRTs creates benefits for the environment.

Keywords: life cycle assessment, recycling, waste CRT, yttrium

1. Introduction

Today the habit of repair, re-use and recycling of goods is not common as in the past, especially for electric and electronic equipment (EEE). This phenomenon is enhanced by the rapid evolution of new technologies, that favors the purchase new EEE and throw away the old one. In Europe the WEEE directive (EC Directive, 2012), aims at the prevention of WEEE, the re-use, recycling and recovery to reduce the disposal of waste and retrieval of secondary raw materials. For cathode ray tubes (CRTs), the WEEE directive establishes that

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from WEEE separately collected, at minimum CRTs and the fluorescent powders must be removed. Indeed, in the fluorescent powders are present metals of concern, such as yttrium that can be recycled as a secondary raw material for the production of the red phosphors of monitors (Beolchini et al., 2012).

At present the CRT technology for monitors has been gradually replaced by the flat display technology. In order to fulfill the WEEE directive for the end-of-life of these WEEE, glass-to-glass recycling is an option based on the use of parts (funnel and panel glass) of waste CRT for the production of new goods (Kang and Schoenung, 2005). This scenario represents the conventional recycling option that was applied when CRT monitors were produced at a large scale. Glass-to-lead recycling is an alternative strategy, where the major concern is represented by lead, which is separated from glass. Currently the fluorescent powders of CRT monitors are not treated by recycler companies, but disposed of in landfill (Lee and Hsi, 2002; Nnorom et al., 2011). In this regard our research group has developed a recycling process aimed at the recovery of rare earth elements, within the European research projects called HydroWEEE 231962 (Innovative Hydrometallurgical Process to recover Metals from WEEE including lamps and batteries), and its follow-up, HydroWEEE Demo 308549 (Rocchetti et al., 2013; Toro et al., 2010).

2. Objectives

In this context, the main objective of the present study was to evaluate the potential impact on the environment of different options for waste CRTs by means of simplified life cycle assessment (LCA). Three scenarios were considered for the management of waste CRTs: (i) conventional recycling addressed to the production of new CRT monitors; (ii) recycling of the CRT components for other purposes; iii) disposal in landfill for hazardous waste.

3. Materials and methods

In the present study we compared the environmental impacts of conventional recycling of steel, funnel and panel glass (when CRTs were produced at large scale, "CRT technology"; scenario 1) and up-to-date recycling of one CRT monitor (when CRT, are replaced by the flat screen technology, "flat display technology"). In the "flat display technology", steel and the panel glass are recycled in a case (scenario 2), and in the other also lead from the funnel glass (scenario 3).

These scenarios were also compared to the disposal in landfill (scenario 0). Moreover, special attention has been directed to the recycling of yttrium from fluorescent powders of a CRT applying a hydrometallurgical process developed by Rocchetti et al. (2013), and compared with disposal in landfill. Other details about the methods applied in the present study can be found elsewhere (Rocchetti and Beolchini, 2014).

4. Results and discussion

The potential CO_2 emissions in the considered scenarios within the two frameworks with a different technology of monitor production (CRT or flat screen displays) are reported in Fig. 1. In scenario 1 of "CRT technology" a net credit (1.0 kg CO_2-eq.) for the environment was observed for the management of a CRT. Most of the emissions of CO_2 were associated to the use of energy necessary for the separation of panel and funnel glass. Conversely, if a waste CRT was disposed of in landfill the impact was evaluated as 0.8 kg CO_2-eq. (scenario 0). In the framework "flat display technology", scenario 2 determined a credit equal to 0.7 kg CO_2-eq. towards the environment.

Thanks to the recycling of the steel and panel glass it was possible to compensate the CO_2 emissions due to the treatment. In the same framework, also in scenario 3 a credit (0.9 kg CO_2-eq.) for the environment was achieved, less waste was conferred in landfill and more secondary raw materials were recovered.

The recovery of yttrium from the fluorescent powders of one waste CRT resulted in a credit for the environment (0.76 Kg CO_2), while the disposal in landfill determined an impact of 0.01 kg CO_2-eq. (Fig. 2). These results are promising as an high impact is associated to the primary production of yttrium.

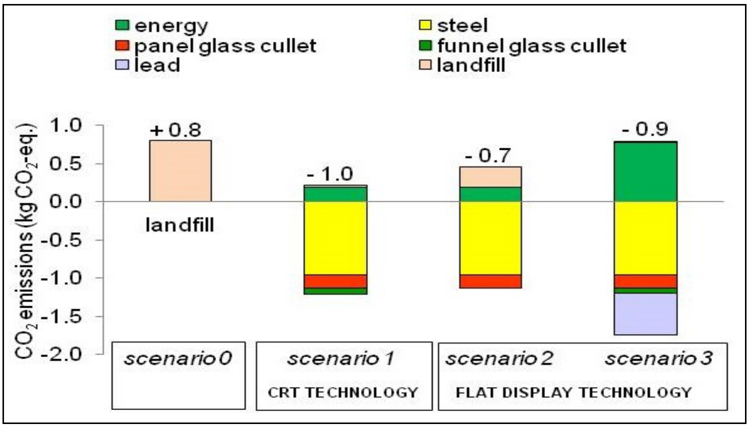

Fig. 1. Emissions of CO_2 for the management options of one waste CRT (Rocchetti and Beolchini, 2014).

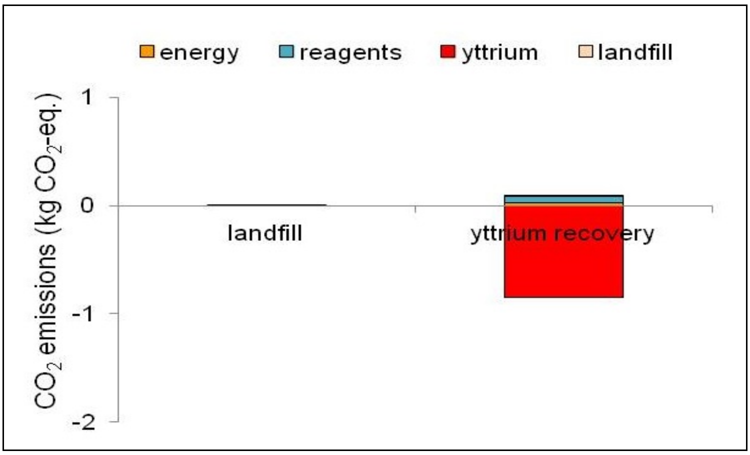

Fig. 2. Emissions of CO_2 for disposal in a landfill and treatment for yttrium recovery from one waste CRT (Rocchetti and Beolchini, 2014).

5. Conclusions

The present study has considered several options for the management of waste CRT, and through life cycle assessment has quantified the impacts and the credits for the environment. According to our results the way directed to the recycling of CRT and recovering secondary raw materials, as well as reducing the amount of CRTs conferred in landfill is the right one to cover.

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