

LIFE CYCLE ASSESSMENT OF WASTE FROM ELECTRIC AND ELECTRONIC EQUIPMENT: A REVIEW

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Introduction

Waste of electric and electronic equipment (WEEE) has become a pollution problem worldwide. Life Cycle Assessment (LCA) is a methodology for evaluating potential environmental impacts of products, processes, or services. Over the years, LCA has been applied in a wide variety of industries. Here we present a summary of what we think it is the first review on LCA of WEEE management (Rodriguez Garcia and Weil, 2016).

Methods

Our target were LCA publications on the end-of-life (EOL) of e-waste: collection, sorting, recycling, etc., as well as waste management. We only included studies addressing the full life cycle of appliances if they particularly focus on EOL. We identified publications following a three-step procedure: 1) screening of 17 peer-reviewed journals, 2) checking the literature cited and citing the already identified articles, and 3) final screening with alternative search engines. As of June 2015, we had identified 48 studies.

Results

The studies covering the whole life cycle did not consider EOL as the most impactful stage. Nevertheless, EOL was viewed as an important stage on environmental terms because of its potential benefits. Recycling can be an attractive alternative, as it might cause lower impacts than raw material acquisition. However, a high recycling rate is required for those benefits to occur. Still, other alternatives like remanufacturing might be even less environmentally harmful.

The latter conclusion is also supported by waste management studies including both waste prevention and waste treatment scenarios. Reuse might present two important exceptions to this trend: 1) It has a limited time-frame: after a certain point a new device would be less environmentally harmful than reusing an old one and 2) If the reuse is associated with resale. Resale favors the access to appliances to more people and thus increases the impact of WEEE for the whole population.

The importance of transport oscillates between studies that do not mention it at all to those considering it the main source of postconsumer impact. This disparity suggests the relevance of transport is location-

specific due to the collection methods and to distance. For a given appliance, the distance its waste needs to be transported might be decisive in determining which treatment alternative is preferable.

All waste treatment studies evaluated included recycling plus incineration and/or landfilling, showing the preponderance recycling has in current waste management strategies. Landfilling (a low-tech process) can be sometimes the least environmentally harmful, but in most cases recycling is the best alternative of the three. This is particularly true if it avoids the extraction of raw materials, namely but not exclusively metals. This thesis is also supported by studies focusing only on recycling, which also stressed that high recycling rates are necessary for those benefits to be substantial.

Conclusion

From reviewing 48 publications on LCA of WEEE, we found the following four trends on the environmental impact of the different stages of EOL:

- Waste management is usually not the most impactful life cycle stage, most environmental impacts of appliances are generated in the use phase or before.
- Once equipment turns into waste, the final treatment is responsible for most of the impact.
- Waste prevention might be more beneficial than waste treatment.
- As far as treatments goes, recycling tends to be less burdensome than incineration or landfilling, particularly if the recycling is closed-loop or recovers valuable materials.

These trends are not absolute: Transportation can be as important as disposal if the distance is large enough and landfilling can sometimes be the least harmful alternative. Thus, we recommend a case-by-case approach to find the most environmentally acceptable alternative for WEEE management. For that purpose, we suggest conducting an LCA adapted to the situation: type of waste, geographic location, etc. If possible, a number of EOL scenarios should be considered, including waste prevention, incineration, and landfill. Focusing on recycling processes might not find the overall best alternative.

WEEE management cannot only generate or prevent environmental problems, it has also important economic and social impacts. Thus, we recommend a Life Cycle Thinking approach considering the management of electronic waste as a complex system where technology, people, and the environment interact.

References

Rodriguez Garcia, G., Weil, M. (2016). Life Cycle Assessment in WEEE recycling. In A. Chagnes, T. Retegan, M. Nilsson, G. Cote (Eds.), *Research, Development and Challenges in WEEE Recycling* (1st ed.). Elsevier, Amsterdam, The Netherlands. *In press*.