New and Reconditioned Electrical and Electronic Equipment. How does change the environmental performance?

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1. Introduction

The European Waste Electrical and Electronic Equipment (WEEE) system has introduced measures to encourage first the reduction of the number of WEEE and then their separation in order to prepare for reuse. The scope of this study, carried out within the LIFE12 ENV/IT001058 - "WEEENmodels" project, was to compare the environmental performance of the life cycle of new electrical and electronic equipment (EEE) and the reused one through the Life Cycle Assessment (LCA) methodology. Different set of replaced components have been evaluated in order to understand which determines the best solution. Finally, both *attributional* and *consequential* LCI (Life Cycle Inventory) modelling framework have been implemented.

2. Materials and methods

Given the widespread typologies of WEEE, for each WEEE group, a representative product has been considered, assuming that it generates the same environmental damage of the other products belonging to the same category (see Table 1). In addition, lower performance has been taken into account for the use phase of reconditioned EEE, namely higher energy and water (only for reused R2) consumptions have been assessed. The lifespan of the reused product is supposed to be equal to half-life time of an equivalent new product. This study evaluated different set of replaced components for each WEEE category in order to examine how the environmental performance can vary adopting different maintenance choices in the reconditioning step. Table 1 reports the representative selected product of each WEEE category and the two different set of replaced components taken into account. Scenario A has been defined by interviewing several technicians. The main question asked was "*what are the first components that normally damage?".* The interview outcomes are reported in Table 1. Scenario B represents an alternative set of components, but it does not represent the most common replaced set.

Product	Replaced components-Scenario A	Replaced components-Scenario B
R1- Refrigerator	Compressor; Refrigerator liquid; Gaskets	1 PWB[§]; Resistor; Thermostat
R2- Washing machine	1 PWB[§]; Engine; Belt	1 PWB[§]; Water pump; Filter
R3- CRT	3 PWB[§]; Electron gun	Funnel glass; Panel glass
R4- Laptop	Li-ion battery; NiMH battery; 4 PWB[§]	Power pack; Hard disk
R5- Fluorescent lamp	2 Capacitors	2 Resistors

[§]PWB: Printed wiring board

Table 1: Representative product per each WEEE category and set of replaced components

The functional unit is 1 p (one product) for each WEEE category. The system boundaries cover the entire life cycle of EEE ranging from the collection of the decommissioned product to selection, maintenance of the product to be reused and final treatment of the product. The application of *attributional* or *consequential* LCI modelling framework is still a very debated and pending scientific subject. Various opinions/interpretations there are in the LCA scientific community on the proper application of attributional or consequential LCI modelling [3,4 and so on]. For this reason, both *attributional* and *consequential* LCI modelling framework have been applied. In *attributional* LCI modelling, the multifunctionality has been addressed by “partitioning” adopting the economic value based allocation. *Consequential* modelling has been here performed through the system model *Substitution, consequential, long-term* of Ecoinvent v3 database. The environmental analysis have been conducted adopting SimaPro 8.2 software. Primary and secondary data have been aquired from Ecoinvent v3 database and the internal database of LCA Working Group - University of Modena and Reggio Emilia. The environmental comparison has been carried out adopting Impact 2002+ modified method [1], which is an impact assessment method that covers more impact categories than other methods, includes more substances, and being a midpoint and endpoint oriented. However, some modifications have been implemented in order to describe the system considered in a more representative manner [2].

3. Results and discussion

The environmental results of the present study performed by *attributional* and *consequential* LCI modelling vary greatly leading to different result interpretations. Figure 1 reports for each WEEE category the environmental comparison between the entire life cycle of the new EEE and the reused one (scenario A and B) adopting *attributional* and *consequential* LCI modelling respectively.

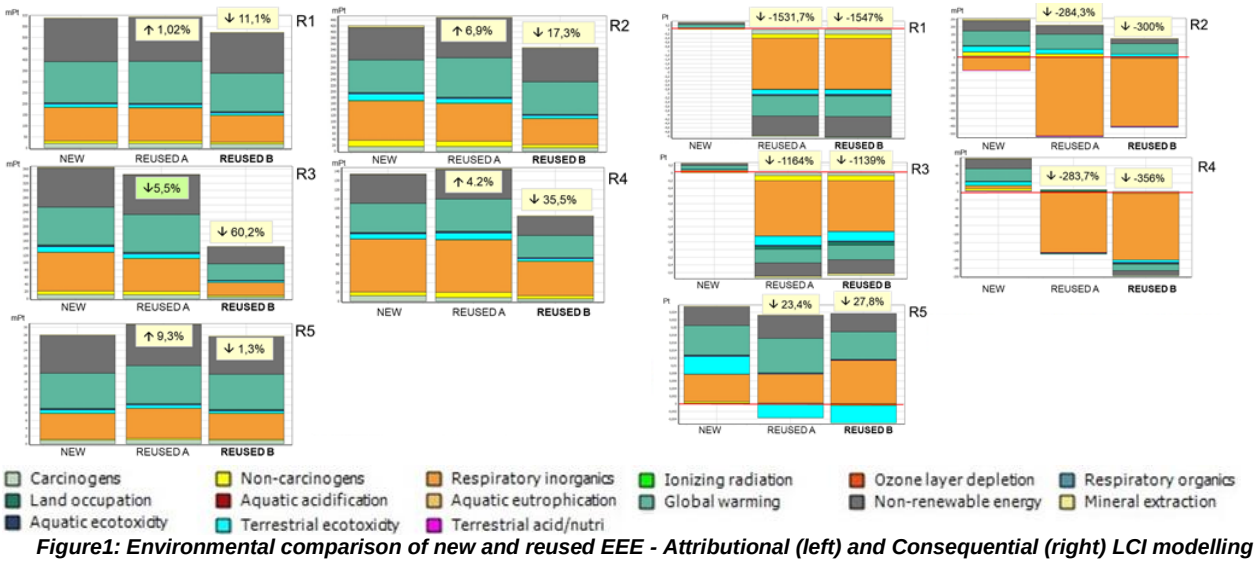

Figure1: Environmental comparison of new and reused EEE - Attributional (left) and Consequential (right) LCI modelling

Attributional LCI modelling. The environmental comparison between new and reused WEEE showed that *i*) Scenario A determines a damage increase for all WEEE categories except for R3. Indeed, the associated environmental damage decrease of 5.5%; *ii*) Scenario B produces a damage decrease for all WEEE categories, the main impacts reduction occurs for the reused R3 and R4. *Consequential LCI modelling.* The environmental comparison highlighted for both scenarios a considerable damage reduction for the reused EEE respect the new one. The main impacts reduction involves R1 and R3 WEEE categories. In addition, Scenario B determined the best environmental performance. Furthermore, for the reused R1, R2, R3 the analysis of results carried out environmental credits. This is due to the avoided burdens associated to the manufacturing of the new EEE, since the system boundaries have been enlarged until to considering the avoided production of the new product.

4. Conclusions

Attributional and *consequential* LCI modelling performed different LCIA results. Following the methodological guidance for the identification of the most adequate LCI-modelling framework presented by [3] would recommend adopting *consequential* LCI modelling, but we suggest to LCA practitioner to focus also the attention on the request of who commissioned the project, which often in the waste field are local administrations. Generally, this type of stakeholder wants a snapshot of the real effects that waste management policies provoke on human health and environment. For this reason, *attributional* LCI modelling would be the proper LCI modelling to achieve this scope. Considering this LCI modelling the Scenario B determines the best environmental performance. Finally, future research step will be the conduction of multicriterial decision-making analysis, which will be carried out through a Fuzzy Promethee model group, able to integrate objective (e.g. environmental) criteria with subjective (e.g. social).

5. References

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