Electrical waste management effects on environment using life cycle assessment methodology: the fridge case study

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Introduction

The quantity of “waste electronic and electrical equipment” (WEEE), comprising computers, hi-fi systems, freezers, fridges, etc., sold and thrown away by an average European inhabitant has been continuously increasing over the years. Recovery, treatment and valorization of these waste is only put in practice for few years in most of European countries. These operations permit the reuse of materials and the decrease of environmental impacts essentially for climate change, ozone layer and fossil fuel depletion categories.

Materials and methods

This study is based on WEEE life cycle assessment and more particularly on treatment and valorization of fridges and freezers. Two scenarios were envisaged: situation before fridge collection and the Belgian current situation for which all national fridges are treated in Liège. Before WEEE treatment, fridges were collected by scrap dealers to recover metals. Other parts were sent to landfill and refrigerant was released to the atmosphere. The current scenario includes fridges dismantling, grinding, primary materials sorting, glass, plastic and metals recycling, and refrigerant incineration.

Table 1 indicates the average fridge composition [1] taken into account for environmental impacts estimation. The study is based on the global mass of recovered fridges in 2009 in Belgium, i.e. about 7000 tons.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Al</th>
<th>Cu</th>
<th>Fe</th>
<th>Plastic</th>
<th>PUR</th>
<th>R11-R12</th>
<th>Oil</th>
<th>Compressor</th>
<th>Cable</th>
<th>Glass</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>2.42%</td>
<td>0.13%</td>
<td>42.35%</td>
<td>16.84%</td>
<td>11.15%</td>
<td>0.39%</td>
<td>0.30%</td>
<td>21.70%</td>
<td>0.10%</td>
<td>0.50%</td>
<td>0.90%</td>
</tr>
</tbody>
</table>

Table 1: Fridge average composition

Steps for the first scenario without any treatment are i) metals recycling (aluminum, copper and iron); ii) emissions of refrigerants into the atmosphere and of oil into the soils; iii) landfilling of the remaining parts. Considered steps for the current scenario are i) recycling of plastics, glass and metals; ii) energy and material consumptions of the treatment facilities; iii) R11 (CCl₃F)-R12 (CCl₂F₂) refrigerants incineration, responsible for the ozone layer depletion and the greenhouse gas effect.

The study was made in accordance with ISO standards 14040 [2] and 14044 [3] using the ReCiPe [4] methodology to evaluate environmental impacts. Technical data were provided by Van Gansewinkel [5]; ecoinvent databases [6] and scientific literature were also used to get all the necessary data.

Results and discussion

Main results

Figure 1 shows standardization results of both scenarios for 10 out of the 18 impact categories considered by the ReCiPe methodology, with the hierarchist endpoint perspective. The other categories were not used due to data deficiency such as for land occupation or ionizing radiation. This graph permits to highlight the importance of each category compared with the standard reference. Climate change, ozone depletion and fossil depletion are the three categories showing the most important environmental impact for the scenario without any treatment. With treatment and valorization of fridges these impacts are clearly reduced especially due to the capture and incineration of refrigerants which used to be released to the atmosphere.
Refrigerant (R11 – R12) emissions into the atmosphere led to high impacts in climate change and ozone depletion categories in the old method. Controlled incineration and limited landfill can significantly reduce carcinogenic emissions and emissions responsible for the ozone layer depletion and climate change.

![Graph showing the comparison of standardized environmental impacts with or without treatment of fridges](image)

**FIG. 1: Comparison of standardized environmental impacts with or without treatment of fridges**

**Important steps**

For the old scenario without any treatment, step ii) concerning release of refrigerants and oil participates the most to the environmental impact followed by the landfilling. Metals recovery permits an environmental gain and reduces the global score for both scenarios. About the treatment and valorization scenario, the recycling of different materials such as plastics, glass or metals leads to a negative, i.e. beneficial, impact. Incineration of refrigerants avoids quite totally their emissions into the air, reducing their impact on the ozone layer. Energy and material consumptions exert a positive impact which is compensated by the other environmental benefits.

**Conclusions**

Results of this study prove the importance of collecting and valorizing fridges especially for old fridges containing refrigerants banned by the Montreal Protocol. Recovery and incineration of these pollutants permit to greatly reduce climate change and ozone depletion impacts.

**References**


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