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What are the environmental benefits of increasing the WEEE treatment in France?

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Abstract

In France is estimated a generation of about 17 and 23 kg per year of Waste Electrical and Electronic Equipment (WEEE) per inhabitant, however, in 2014, the return rate for household WEEE hardly reaches 38% of the total market input. The French regulation targets a higher collection rate for the next years: 45% between 2016 and 2019, and 65% after 2019. Besides complying with the regulations, improving WEEE treatment represents an environmental and economic opportunity. The aim of this work was to quantify the benefits of improving the treatment of WEEE in France by the life cycle assessment methodology. A mobile phone charger was selected as a case study, and three scenarios were assessed based on the actual collection rate and the future recycling targets. The optimization of the reverse logistic and the transition to renewable energies are crucial points to reduce the environmental impacts of the recycling channel.

1 Introduction

Waste Electrical and Electronic Equipment (WEEE) is one of the fastest growing waste streams in the world. In 2014, 42 million tons of WEEE were globally discarded [1]. In France is estimated a generation of about 17 and 23 kg per year of WEEE per inhabitant [2].

To address the e-waste problem, the European Union published in 2002 the WEEE directive. As a first priority, the Directive aims to prevent the generation of WEEE. Additionally, it aims to promote reuse, recycling and other forms of recovery of WEEE so as to reduce the disposal of waste [3]. Considering the continuous increase of e-waste flow, the directive was revised (Directive 2012/19/EU) and new targets and strategies were defined.

The French implementation of the WEEE directive was combined with the process of the RoHS directive (Directive 2002/95/EC), after an extensive process of consultation with all stakeholders involved. The collection system in France was set up around several types of actors. Producers, distributors, and local authorities had their roles included in the French legislation.

The e-waste system management in France is organized in two flows: household and professional. For the household WEEE, the producers are responsible for the removal and treatment of the e-waste. The producers must fulfil these obligations either by joining one of the producer compliance schemes (also known as producer responsibility organizations or take back schemes) already approved by the authorities, or by putting in place an individual system that must be approved by the authorities (no individual scheme has been approved to date).

Even though France has a recycling channel implemented since 2005, the return rate of household hardly reaches 38% of the total market input [2]. Factors such as sorting errors, plundering, alternative systems of collection and treatment are some of the reasons for household WEEE to be diverted from WEEE Compliance Schemes.

The French regulation (decree 2014-928) presents challenging collection rate for the next years: 45% between 2016 and 2019, and 65% after 2019.

Besides complying with the regulations, improving WEEE treatment represents an environmental and economic opportunity. WEEE encompasses a particularly complex waste flow that can cause environmental and health problems. Moreover, the production of electrical and electronic equipment (EEE) requires the use of materials with limited availability and high value added. Recycling can therefore avoid the extraction of new resources.

2 Life cycle assessment of WEEE

Aiming to assess the environmental impacts related to the life cycle of electrical and electronic equipment, in the past ten years, some life cycle assessment were published mainly in Europe, North America and Asia (e.g. [7];[8];[9];[10];[11]).

In some studies, the disposal of electronic waste is presented in terms of recycling, rather than disposal through other methods such as reuse, energy recovery or landfill. However, once the recycling processes have inherent losses, even a recycling scenario is associated with a landfill or incineration scenario. The transport during the end of life stage is many times not considered or the distances are estimated and not necessarily in accordance with the reality [12].

It was noticed that few studies have discussed the environmental gains of recycling channels based in their real performance and targets. In this context the aim of this work is to quantify the benefits of improving the treatment of WEEE in France applying the life cycle assessment methodology.

3 Methods

A mobile phone charger treated in France was selected as a case study considering that it is a numerous product that contains different materials that are also part of other electronic equipment. The functional unit considered was: treat 1 kg of mobile phone charger. A mobile phone charger was dismantled and weighted by the authors and its composition is presented in Table 1:

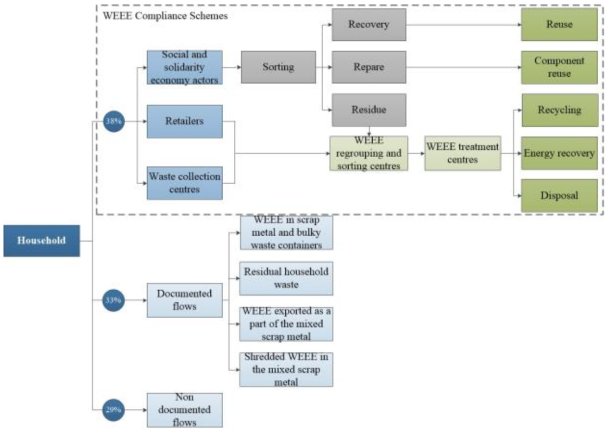
Table 1: Composition of the mobile phone charger

Components	Materials	Mass
Plug	Plastic (100% polycarbonate)	42.3
	Printed wiring board	25.8
Cable	Copper	21.1
	Plastic (50% polyethylene and 50% PVC)	10.8

After an analysis of the e-waste management in France four current practices were identified: (1) maximum recycling of materials (including plastics); (2) recycling of materials with the best referenced recycling channels (e.g. printed wiring board); (3) recycling of materials that don't need high technology development; (4) disposal in landfills.

In this context and considering the current recycling rate and the future recycling targets, three scenarios were assessed. The current scenario was developed considering data published by the French environment and energy management agency (ADEME), as presented in Figure 1. As previously mentioned, the return rate for household WEEE is 38% of the total market input. Of the remaining residues, about 33% are treated in documented flows (14.8% are shredded with mixed scrap metal; 8.6% are exported as a part of the mixed scrap metal; 4.8% are treated with residual household waste and 4.8% are mixed with scrap metal and bulky waste containers) and 29% in flows not yet documented [2].

Figure 1: Distribution of households WEEE flows in France



The future scenarios are projections of this baseline scenario seeing the growth of plastic and precious metal recycling.

Life cycle inventory for each scenario was developed based in the inventories available in Ecoinvent database (version 3.1, recycled content dataset) and adapted with literature and primary data obtained in discussions with specialists and recyclers. The mainly adaptations were:

- Efficiency rate of separation and recycling of WEEE ([13];[14];[15]);
- Energy consumption for sorting the plastics considering the near infrared and optical sorting techniques [16];
- Localization of treatment sites considering secondary data [17] and primary calculation of transport distances (road and maritime);
- Landfill scenarios assessed according to the methodology developed by Doka [18].

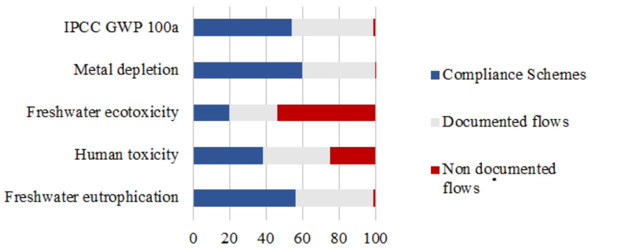
Life cycle impact assessment results were calculated at midpoint level by using the Recipe method (version 1.12 - Hierarchist) adapted with the IPCC method (version 1.01). The ReCiPe was selected considering that it is often used in LCA of EEE (e.g. [11];[19];[20]) and that the method allows fulfillment of the requirement of ISO standards which prescribes a selection of impact categories that reflects a comprehensive set of environmental issues related to the product system [21].

The life cycle impact assessment (LCIA) was performed in two steps: firstly, the impacts of the end of life scenarios were assessed; than the impacts of the end of life scenarios were compared to the virgin materials production in order to evaluate the benefits of recycling as a potential reducer of new resources extraction. This approach was selected once the recycled materials have the same or closely resembles the inherent properties of the primary materials (closed loop recycling) [22]. In the following section the results are reported and discussed.

4 Results and discussion

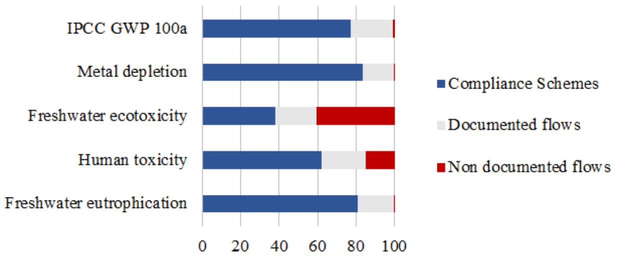
Figures 2 and 3 presents the results of the LCA of the current and future scenario with 65% of collection rate. The impact related to global warming potential, are mostly related to incineration and transport. In the other impact categories, excluding metal depletion, the impacts are mostly related to incineration and landfill processes. For the metal depletion impact category, the impacts are mainly due to the increase in energy consumption for recycling the plastics (the French energy mix considered in Ecoinvent database is 77% nuclear power).

Figure 2: LCIA of the current scenario



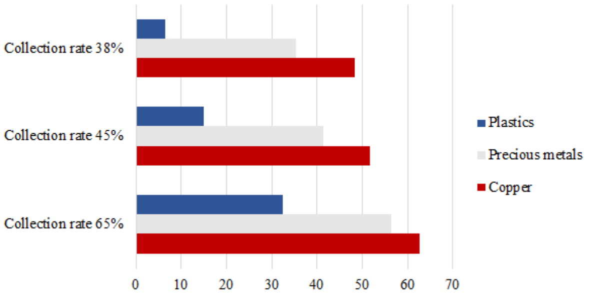
As it can be noticed, with the increase of the collection rate, the impact related to the compliance schemes increases. The growth of the collection rate entails the intensification of some impact categories (global warming potential, metal depletion and freshwater eutrophication) mainly due to energy consumption and transport necessary to recycling. Otherwise, the impacts related to human toxicity and ecotoxicity reduces, once a smaller quantity of e-waste will be incinerated and landfilled.

Figure 3: LCIA of the future scenario with 65% of collection rate



The growth of the collection rate consequently results on the increase of recycled materials. Figure 4 presents the quantity of recycled material recovered in each scenario considering the processes losses.

Figure 4: Material recovery considering the increase of the recycling rates



5 Conclusion

The optimization of the reverse logistic and the transition to renewable energies are also crucial points to reduce the environmental impacts of the recycling channel.

All the efforts to improve the environmental performance of waste management of WEEE are not enough if no ecodesign practices are applied in the development of new EEE. A design that facilitates the dismantling and that prioritize recyclables materials and/or materials that can be recycled, together with the appropriate disposal of e-waste by the consumers are essential to decrease the impact of this channel.

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