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Sustainability assessment and prioritisation of e-waste management options in Brazil

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ABSTRACT

Brazil has an increasing rate of e-waste generation, but there are currently few adequate management systems in operation, with the largest share of Waste Electrical and Electronic Equipment (WEEE) going to landfill sites or entering informal chains. The National Solid Waste Policy (2010) enforces the implementation of reverse logistics systems under the shared responsibility of consumers, companies and governments. The objective of this paper is to assess sustainability and prioritise system alternatives for potential implementation in the metropolitan region of Rio de Janeiro. Sustainability criteria and decision alternatives were defined by elicitation of stakeholders. The adopted multicriteria approach combines Life Cycle Assessment with qualitative evaluations by a small sample of regional experts with knowledge of the problem. The recommended system consists of a hybrid WEEE collection scheme with delivery points at shops, metro stations and neighbourhood centres; a pre-treatment phase with the involvement of private companies, cooperatives and social enterprises; and full recycling of all components in the country.

1. Introduction

Adequate e-waste management is still a challenge in most parts of the world, especially in developing countries. It is estimated that Brazil generated 3.8 kg of Waste Electrical and Electronic Equipment (WEEE) per capita in 2008 (Araújo et al., 2012), and 7 kg/capita in 2014 (StEP, 2015). This may be less than Mexico's 2014 generation rate (8.2), but it is more than the other BRICS countries, with the exception of Russia (China 4.4 kg/capita, India 1.3, South Africa 6.6, Russia 8.7) (StEP, 2015). Despite such a rapidly increasing generation rate, only a few adequate WEEE management systems are currently operating in the country. A large share of the e-waste produced is still disposed mixed with household waste and is destined for landfill sites, or informal chains operated by waste pickers, cooperatives and scrap dealers. The estimated recycling rate for the country is 2% (Bandini, 2009 *apud* Araujo, 2012).

In Rio de Janeiro city, the composition of collected household waste in 2012 indicated that 3.7 k tonnes of WEEE were sent to landfill sites (COMLURB, 2013), wasting valuable and non-renewable resources with considerable environmental risks. It is known that rough recycling techniques like burning cables and acid leaching are commonly applied by the informal sector in the country (Souza, 2014; Lundgren, 2012). This is an insalubrious and inefficient practice to recover materials. In addition, the country seems to be an illegal receiver of e-waste from developed countries in North America (Lundgren, 2012). Illegal and informal activities are also responsible for a large amount of Electrical and Electronic Equipment (EEE) consumed in the country; in 2014 non-official markets accounted for 1.5 million purchased computers, corresponding to 15% of the total for the year, and 35% of desktops (ABINEE, 2015).

In order to tackle those issues and to implement adequate e-waste management, the Brazilian Solid Waste National Policy – PNRS (Brazil, 2010) enforced the implementation of WEEE reverse logistics under the shared responsibility of EEE producers, importers, distributors and retailers (direct chain), with broader responsibilities of governments and other actors. In order to implement reverse logistics, those EEE direct chain actors must analyse

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different WEEE reverse logistics options, assess technical and economic feasibility, and propose a model satisfying the objectives and principles defined in the Policy as far as possible, which include the protection of public health and environmental quality; incentivising the recycling industry and resource recovery; integrating waste management; making the articulation of the different sectors; promoting operational and financial sustainability; giving stimulus to Life Cycle Assessment, and to the integration of waste pickers' cooperatives (Brazil, 2010). Proposals of WEEE reverse logistics systems have been submitted by those actors to a council of related Federal Ministries, headed by the Ministry of the Environment (MMA), which is entrusted with analysing, suggesting alterations and selecting the model to be implemented in the country. By August 2013 four proposals had been received, but due to the complexity of these multiple interests as well as the complexity of the decision problem, namely the tasks of building a coherent set of criteria and to evaluate and compare system alternatives, two years later there was still no approved final model. Proponents pointed out some issues that still needed to be addressed, such as: the implementation of a clearly communicated recycling fee; the control of imported electronic products and the simplification of WEEE transportation and WEEE ownership (Brazil, 2015).

PNRS stimulates this decision process to be reproduced at lower government levels. For instance, a São Paulo state resolution calls for industry to introduce WEEE reverse logistics proposals. Commitments must be signed by the end of 2015 (Sao Paulo, 2015). Local government resolutions are essential because municipalities are legally responsible for Municipal Solid Waste Management (MSWM) and because reverse logistics systems must be aligned with the mandatory Municipal Waste Management Plans. The Brazilian National Solid Waste Plan (PLANARES) targets indicate that the implementation of PNRS waste management strategies must start first with the largest cities, with progressive expansion to the smallest ones.

Adequate WEEE management implementation should consider a set of sustainability criteria, aligned with both the PNRS objectives and context-specific stakeholder values. Souza et al. (2015) elicited the perspectives of stakeholders involved in the Brazilian WEEE context and specifically in Rio de Janeiro, and using decision science techniques derived a set of relevant social and economic criteria to support this particular decision. These criteria were: social inclusion; employment and generation of income; professional development; health risks and working conditions; workers access to education and healthcare; system feasibility and efficiency; population awareness and adhesion to reverse logistics; innovation and stimulus of new economic activities; and competitiveness of formal EEE products in regard to the informal ones.

Assessment of environmental performances needs a systematic approach which calculates impacts based on system modelling and resources flows along the different EEE/WEEE life cycle stages. Because of its capacity to analyse complex systems and a large amount of data, Life Cycle Assessment (LCA) has been widely applied in the context of waste management and particularly WEEE management. Besides this fact, there are still few LCA applications in Brazilian waste management.

Despite the need for relevant information to assess potential impacts of system alternatives and to make decisions on Brazilian e-waste management, there is a lack of an adequate database. Collection of primary data is often obstructive, especially in regional, local and organisational scales. A practical solution to facilitate such decision could be to promote the integration of Multicriteria Decision Analysis (MCDA) with LCA, qualitative evaluations of social and economic indicators. A robust approach to sustainability assessment and prioritisation of alternatives should be a multicriteria method that, among other features, allows for the adoption of a life cycle perspective and for a non-compensatory integration of both quantitative and qualitative indicators (Cinelli et al., 2014).

Regarding qualitative assessment of waste management sustainability indicators. In some contexts the available sample of evaluators with proper knowledge of the problem may not be sufficient to enable statistical analyses of the qualitative and quantitative measures, but the intervention of human expertise must still be considered in the decision. This can be the case, for example, of technical councils that may be organised to evaluate local WEEE management systems in Brazilian cities.

The objective of this paper is to assess sustainability and prioritise system alternatives for e-waste management in the city of Rio de Janeiro, Brazil. Specific objectives are:

- to develop an approach and consult experts for qualitative evaluation of social and economic relative performances of the system alternatives;
- to build a multicriteria analysis model, adequate for cases with small samples of evaluators; and
- to integrate MCDA with Life Cycle Assessment and with qualitative social and economic assessment.

This paper builds upon previous studies of some of the authors, namely Souza et al. (2013), where e-waste management system alternatives for Brazil/Rio de Janeiro were identified based on stakeholder elicitation; and Souza et al. (2015), where a set of sustainability criteria for Brazilian/Rio de Janeiro e-waste management was derived from stakeholder perspectives. The present study targets e-waste management specialists and decision-makers in Brazil, and seeks to recommend a solution to the decision problem, leading to the implementation of an e-waste management system in Rio de Janeiro.

2. Background knowledge

2.1. E-waste management in the Brazilian National Solid Waste Policy

According to the National Solid Waste Policy (PNRS), consumers (both population and institutions) are responsible for disposing of their e-waste separately at adequate delivery points defined in Municipal Solid Waste Plans. Retailers and distributors are responsible for returning the products to producers and importers, who in turn have to provide adequate treatment and final disposal of refuse. PNRS (Brazil, 2010) permits that these actors formalise one or more management entities, which can outsource reverse logistics operations to private waste management companies, MSWM schemes, skilled cooperatives or social enterprises. PNRS stimulates involvement of cooperatives if they have adequate training, working conditions and environmental licences to perform the required activities.

Proposals of a WEEE reverse logistics system for the country should be presented to the Ministry of the Environment by producers, importers, distributors and retailers. The selected model must be formalised into a Sectorial Agreement (SA), a contract signed by all aforementioned parties. It can also be specific to State SA and to Municipal SA. The SAs have to detail, among other information:

- descriptions of the set of integrated activities by each participant in the reverse logistics system, in the processes of collection, storage, transport, recycling and final disposal, indicating:
  - technical recommendations at each stage;
  - criteria to install and operate delivery points;
  - adopted collection schemes;
  - procedures and responsibilities for sorting, reuse, recycling, treatment, and final disposal activities;

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