Waste Management 53 (2016) 204–217

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Potential reuse of small household waste electrical and electronic equipment: Methodology and case study

María D. Bovea *, Valeria Ibáñez-Forés, Victoria Pérez-Belis, Pilar Quemades-Beltrán

Departamento de Ingeniería Mecánica y Construcción, Universitat Jaume I, Av Sos Baynat s/n, 12071 Castellón, Spain

ARTICLE INFO

Article history:
Received 22 October 2015
Revised 31 January 2016
Accepted 18 March 2016
Available online 28 March 2016

Keywords:
Waste electrical and electronic equipment
WEEE
Small WEEE
Reuse

ABSTRACT

This study proposes a general methodology for assessing and estimating the potential reuse of small waste electrical and electronic equipment (sWEEE), focusing on devices classified as domestic appliances. Specific tests for visual inspection, function and safety have been defined for ten different types of household appliances (vacuum cleaner, iron, microwave, toaster, sandwich maker, hand blender, juicer, boiler, heater and hair dryer). After applying the tests, reuse protocols have been defined in the form of easy-to-apply checklists for each of the ten types of appliance evaluated. This methodology could be useful for reuse enterprises, since there is a lack of specific protocols, adapted to each type of appliance, to test its potential of reuse.

After applying the methodology, electrical and electronic appliances (used or waste) can be segregated into three categories: the appliance works properly and can be classified as direct reuse (items can be used by a second consumer without prior repair operations), the appliance requires a later evaluation of its potential refurbishment and repair (restoration of products to working order, although with possible loss of quality) or the appliance needs to be finally discarded from the reuse process and goes directly to a recycling process.

Results after applying the methodology to a sample of 87.7 kg (96 units) show that 30.2% of the appliances have no potential for reuse and should be diverted for recycling, while 67.7% require a subsequent evaluation of their potential refurbishment and repair, and only 2.1% of them could be directly reused with minor cleaning operations.

This study represents a first approach to the “preparation for reuse” strategy that the European Directive related to Waste Electrical and Electronic Equipment encourages to be applied. However, more research needs to be done as an extension of this study, mainly related to the identification of the feasibility of repair or refurbishment operations.

1. Introduction

Waste electrical and electronic equipment (WEEE) is a term used to cover all items of electrical and electronic equipment (EEE) or their parts that have been discarded by their owner as waste without the intention of being reused (Step Initiative, 2014). This waste stream is characterized by its resource recovery potential and its reuse potential, being “preparation for reuse” one of the end-of-life (EoL) strategies considered as a primary option after “prevention” by WEEE Directive (Directive 2012/19/EU).

According to the definitions by Waste Framework Directive (Directive 2008/98/EC), reuse strategy contributes to reduce the quantity of waste as well as the need of raw material used in production. Reuse could be defined as using a product again for the same purpose for which it was conceived, being this achievable through a range of product life extension strategies, as repair, refurbishment and/or remanufacturing (Ijomah et al., 2004; Den Hollander and Bakker, 2012).

Many items of EEE are discarded in different conditions: with minimal use, without considering their repair or at their proper end of life (EoL). Studies in several European countries conclude that about 20–30% of discarded EEE is fit for further extended use (Agamuthu et al., 2012). So, in this context, this study is focused on proposing a first approach to the “preparation for reuse” strategy encouraged by WEEE Directive.

The WEEE Directive regulatory framework establishes minimum targets for different WEEE categories. For example, for the sWEEE category, minimum targets for recovery should be 75% and for preparation for reuse and recycling should be 55%.

* Corresponding author.
E-mail address: bovea@uji.es (M.D. Bovea).

http://dx.doi.org/10.1016/j.wasman.2016.03.038
0956-053X/

Although the management of WEEE is widely analysed in the literature from different points of views (Lee et al., 2010, 2011; Lee and Sundin, 2012; Pérez-Belis et al., 2014), greater attention is given to recycling (Cucchiella et al., 2015; Silvas et al., 2015; Tanskanen, 2013; Zhang et al., 2015; as examples) versus reuse, whose potential is discussed in works such as Cooper (2004), European Commission (2015a), O'Connell and Fitzpatrick (2008), Watson (2008) or WRAP (2011).

Few specific studies applying the reuse strategy to WEEE can be found in the literature, as Table 1 reports.

Truttmann and Rechberger (2006) was one the first study focused on analysing the resource and energy consumption involved in the reuse of WEEE (ICT and large household equipment) by comparing scenarios with and without reuse of WEEE. The conclusions of that study were that, apart from environmental aspects, other considerations such as consumer behaviour or socio-economic reasons should be incorporated into the decision-making process. Ongondo et al. (2013) analysed the operations of socio-economic enterprises involved in the reuse of ICT equipment in the UK. Kissling et al. (2013) identified specific and generic success factors and barriers in the reuse of WEEE (ICT and large household equipment) in different profit/non-profit enterprises in America, Africa and Europe. Reuse operating models were identified for these enterprises in Kissling et al. (2012).

The economic performance of reuse processes is an aspect that normally appears compared with those from recycling processes (Babbitt et al., 2011; Geyer and Blass, 2010). The environmental performance of reusing WEEE compared to other EoL strategies is an emerging aspect in the literature. Lu et al. (2014) evaluated the environmental cost and social implications of reusing mobile phones by comparing formal and informal collection and treatment sectors in China using the Life Cycle Sustainability Assessment (LCSA) methodology (UNEP, 2011). Zanghelini et al. (2014) compared the environmental performance of three alternatives for managing a discarded compressor: landfill, recycling and reuse, by applying the Life Cycle Assessment (LCA) methodology (ISO 14040-44, 2006), obtaining better results for the reuse alternative for all the impact assessment categories analysed.

However, besides the environmental and economic aspects, reuse activities also have significant social implications. Although a market for reused EEE could not be fully feasible from an economic perspective, it could be justifiable in term of its societal benefits, since the reuse activities create employment, provide a living for local communities and training for low skilled and unskilled labour (Williams et al., 2008; Streicher-Porte et al., 2009; Ijomah and Danis, 2012).

The consumers' awareness and perception of reuse of WEEE is another aspect analysed in the literature. Cruz-Sotelo et al. (2013) and Ylä-Mella et al. (2015) examined the potential reuse of mobile phones in Mexico and Spain and in Finland, respectively, by surveys. Both pointed out that current storing habits of consumers make the potential reuse of WEEE difficult. A similar conclusion was obtained by Dindarian and Gibson (2011) and Dindarian et al. (2012), who used semi-structured interviews to evaluate the consumer behaviour of consumers discarding microwave ovens. In general, the barriers for consumers to buy used products are related to consider them unattractive/old-fashioned or even "contaminated" by previous owners (Fisher et al., 2008), and to unreliable due to the lack of standards for their inspection (Wei et al., 2015).

Related to the design process of EEE, the way in which EEE is designed is crucial to assure the feasibility of its potential reuse at its EoL, being especially remarkable in the case of sWEEE (Darby and Obara, 2005). Several studies have been focused on how the design process of EEE could be addressed to facilitate the reuse activities (Rios et al., 2003; Sundin and Bras, 2005; Rifer et al., 2009; Sundin et al., 2009). A complete review of the state of the art in this field can be found in Hatcher et al. (2011) and of specific operations/times for optimizing disassembly sequences for WEEE in Goodall et al. (2014). Others studies are focused on exploring automatic end-of-life processes for disassembly specific EEE (Sundin et al., 2012).

In line with this design perspective, many products have not been designed to be durable, observing a trend of decreasing products lifespans. Nowadays, some measures are being adopted facing this situation. For example, implications of the Ecodesign Directive (Directive 2009/125/EC) for lighting and vacuum cleaners are incorporating minimum durability criteria as mandatory requirements while some labels promoting reuse and repair of products are appearing, as Miljönar label (European Commission, 2015b).

Apart from the previous mentioned aspects, the availability of a reverse logistic system for discarding EEE at its EoL, is another key aspects affecting the success of the reuse process, as Knoth et al. (2002) and Walther et al. (2010) state. A good example of the reverse logistic activities of reprocessing and repairing electrical and electronic goods by non-profit-organization could be found in Lechner and Reimann (2015), determining that in these specific cases, the reduced economic efficiency is due to the preference of ecological or social benefits rather than economical ones. Qualitative aspects of EEE reuse, such as the job creation potential and the impact on prosperity for low-income families, are also considered by O'Connell et al. (2013), supporting that if reuse of white goods were conducted by social enterprises, it would create more employment than an equivalent amount of recycling for those most vulnerable to unemployment. With this approach, they determined that a special role for the social economy in reuse policies should be considered at national levels.

On analysing the WEEE categories, from Table 1 it can be concluded that information and communication technology (ICT) and large household appliances are the WEEE categories that have been studied the most, while small WEEE (sWEEE) is one of the less studied WEEE categories (except for mobile phones (Cruz-Sotelo et al., 2013; Geyer and Blass, 2010; Lu et al., 2014; Ylä-Mella et al., 2015)). According to Annex III of WEEE Directive, sWEEE fraction includes equipment with no external dimension more than 50 cm, including household appliances, consumer equipment, luminaires, equipment reproducing sound or images, musical equipment, electrical and electronic tools, toys, leisure and sports equipment, medical devices, monitoring and control instruments, automatic dispensers, etc. Some other definition could be found at Dimitrakakis et al. (2009a, 2009b) who refer to sWEEE as the electrical and electronic equipment (EEE) that due to their small size and weight are able to be disposed of in the general household refuse. Furthermore, their different functions and variety of materials makes that most of sWEEE have several inconvenient for reuse and recycling.

Regarding the disposal habits, these have not been assimilated by consumers as in the other categories. This fact is mainly due to the lack of specific selective collection programmes for sWEEE (Dimitrakakis et al., 2009a, 2009b). However, WEEE Directive introduces a growing interest on this fraction and presents a novelty in this respect by forcing distributors, at retail shops with sales areas related to EEE of at least 400 m^2 or in their immediate proximity, to provide for the collection of sWEEE free of charge to end-users and with no obligation to buy EEE of an equivalent type. The relevance of the sWEEE fraction is due to the fact that represents one of the largest WEEE fraction by number of units (although not by weight), and is constituted by a wide variety of material among which are hazardous and valuable substances (Rotter and Janz, 2006).

Regarding international standards, only PAS 141 (2011) is specifically developed for proposing techniques for the inspection