Utilizing Economic Value, Resource Availability, and Environmental Impact Metrics to Improve the WEEE and Battery Directives and Promote Alignment with the European Commission Circular Economy Strategy

Citation: Ford, Patrick et al. "Utilizing Economic Value, Resource Availability, and Environmental Impact Metrics to Improve the WEEE and Battery Directives and Promote Alignment with the European Commission Circular Economy Strategy." REWAS 2016, edited by Kirchain, R. E. et al., Springer, 2016, 289-295. © 2016 The Minerals, Metals & Materials Society

As Published: http://dx.doi.org/10.1007/978-3-319-48768-7_45

Publisher: Springer International Publishing

Persistent URL: https://hdl.handle.net/1721.1/127263

Version: Author's final manuscript: final author's manuscript post peer review, without publisher's formatting or copy editing

UTILIZING ECONOMIC VALUE, RESOURCE AVAILABILITY, AND ENVIRONMENTAL IMPACT METRICS TO IMPROVE THE WEEE AND BATTERY DIRECTIVES AND PROMOTE ALIGNMENT WITH THE EUROPEAN COMMISSION CIRCULAR ECONOMY STRATEGY

Keywords: Waste Electrical and Electronic Equipment, WEEE Directive, Battery Directive, Recycling Economics, Circular Economy

Abstract

Waste electrical and electronic equipment (WEEE) provides complex challenges and unique opportunities for maximizing resource efficiency in the European Union (EU). This is due in part to the increasing volume, complexity, and value, and decreasing life cycles of such items. Current EU regulations, specifically the WEEE Directive and Battery Directive, focus on the end-of-life management of electronics and the impact of device design and material composition on environmental and human health. While these Directives are robust, the mass-based metrics on which they are focused can lead to a loss of materials that are impactful from an economic, resource availability, and environmental perspective. There is a need for increased research on the impact of these Directives on the availability of secondary raw materials and for an alignment of the WEEE Directive with the European Commission's Circular Economy Strategy. This can facilitate the development of more holistic policies based on the complete life cycle of devices and all stakeholders involved in its design, manufacturing, use, reuse, repair, and recycling.

Introduction

End-of-life waste electrical and electronic equipment (WEEE) represents one of the fastest growing waste streams in the EU, projected to increase by 3% to 5% each year [1, 2]. WEEE consists of a variety of devices, including mobile phones, computers, printers, white goods, and televisions, all of which must be responsibly managed at their end-of-life. The ten categories of WEEE are: large household appliances; small household appliances; IT and telecommunications equipment; consumer equipment and photovoltaic panels; lighting equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments; and automatic dispensers [3].

The materials contained within these devices include conflict minerals (gold, tantalum, tungsten, and tin), precious metals (gold, platinum, palladium, silver, and others), plastics, and glass [4]. These present a unique set of challenges and opportunities due to the potentially high value and demand of the materials, and the environmental dangers posed if managed incorrectly on a large scale [5].

All WEEE in the European Union (EU) must be handled according to two main regulations, the WEEE Directive and the Battery Directive. Each of these documents provide detailed guidelines and benchmarks geared towards increasing the mass of WEEE that is collected and recycled, while also decreasing the negative impact of potential toxins contained within the devices [3, 6]. However, the economic value, resource scarcity, and environmental impact of the materials within end-of-life electronics are not described explicitly in the directives. As a result, materials such as gold, silver, and platinum, which are more difficult to recover, but also more valuable than other metals on a per mass basis, may be lost to an outgoing waste stream [7]. Below we detail the policy objectives of the WEEE Directive and the Battery Directive, the opportunities for improving the directives through the inclusion of more robust metrics, and the research needed in order to address this gap.

EU Policies

The WEEE Directive was first established in 2003 (2002/96/EC), but was recast in 2012 as 2012/19/EU. This most recent version went into full effect in 2014. The overall goals of this directive are to minimize the mass of WEEE entering landfills each year, to protect environmental and human health, to increase the mass of commodity materials reused each year, and to hold producers responsible for the devices that they put on the market [3, 8]. More specifically, the target collection rate of end-of-life WEEE is 45% from 2016 – 2019 and 65% from 2019 going forward. The collection rates are measured by mass, and not by numbers of devices or the economic value of a given device [3]. Downstream of collection, targets are also established for the recovery and recycling of the waste materials. Recovery is defined as any operation in which waste serves "a useful purpose by replacing other materials which would otherwise have been used to fulfill a particular function." Recycling is defined as "any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes [9]." Starting in August 2015, recovery targets range from 75% to 85% and recycling targets range from 55% to 80% depending on the category of waste in question [3]. The recycling process can vary by device and facility, but the directive mandates that printed circuit boards with surface areas greater than 10 square centimeters must be removed. However, this is only the case for "separately collected WEEE," which is defined as "collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment [9]." Although it was reported in 2008 that 65% of WEEE put on the market was collected separately, it is widely believed that much of this is still improperly handled downstream of the collection process [3]. This can lead to large losses of the valuable materials detailed above, attributing to losses of capital and secondary resources, and negative environmental impacts.

The Battery Directive (2006/66/EC) went into effect in 2008, and mandates that all batteries be removed from devices prior to being recycled. It also requires that all member states achieve a collection rate of at least 45% by 26 September 2016. Further downstream of collection, this directive requires that recycling processes for lead-acid, nickel-cadmium, and other batteries and accumulators recover 65%, 75%, and 50% by weight, respectively [6]. These requirements have been put in place to reduce the negative environmental impacts of materials within batteries, both in use and at end-of-life [6].

Discussion

WEEE Directive Improvements. The regulations detailed above focus on two major objectives: to collect and recycle the highest percentage of end-of-life WEEE possible by mass; and to reduce the impact of the waste on environmental and human health. These goals have helped to shape electronic waste management policies for over a decade, but often lead to a loss of valuable and potentially scarce materials that would otherwise re-enter the market as secondary raw materials. This is due in large part to the processing steps, which often target the easier to access materials such as copper due to the high associated processing costs of other materials. As a result, more complex pieces such as the printed circuit boards may be lost to the waste stream [7]. Previous authors have noted the discrepancies between mass-based and value-based metrics and the impacts on the types of materials that are recovered [5]. From an economic standpoint, gold has been found to be the most important element contained in consumer electronics [5]. Therefore, even if a large percentage of the total mass of a device is recovered, the fraction that is lost can contain a high percentage of the value if gold remains in the unrecovered fraction [10].

Researchers have also studied the environmental and resource availability impacts of electronic devices and the materials of which they are comprised. Several of these studies have included an analysis of effective metrics for measuring impact on a large scale [2, 5, 11-15]. These studies are not confined to the economics of recycling, and therefore also identify and discuss critical materials such as certain rare earth elements (REE) that are oftentimes not recovered under present day policies and recovery infrastructures.

The WEEE and Battery Directives do point to the need for reducing toxins and protecting environmental health, but a more robust set of metrics that incorporate overall environmental impact in conjunction with the economic value and availability of those materials could help to strengthen the underlying goals of the directives. This could also help to lead to a cascading effect, where the directives help to inform future decision making around device design, collection, and recycling. There are two key factors that will help to drive the success of any metric aimed at improving the WEEE or Battery Directives. The first is to utilize industry best practices to form robust and innovative metrics that not only aim at increasing recycling rates, but also evaluate and help to improve the overall system, from device design and manufacturing to its end-of-life. Secondly, the actual implementation of these potential changes would require buy in both from policymakers and the public, meaning that the inclusion of these stakeholders throughout the process would be vital to its ultimate success. Overall, there is a need for additional research on the value of the materials lost during the processing of WEEE due to the regulations as written, and the potential for reinvestment of this value back into the recovery process. In addition, it will be necessary to consider more holistic metrics, beyond only mass or value-based components, in local and national policies.

Circular Economy Strategy. An example of research that is currently underway in the EU, and is seeking to identify connections between more holistic WEEE end-of-life policies and material impacts, is the European Commission Circular Economy Strategy. In order to do this, the European Commission has carried out a series of proposals and reports aimed at analyzing the impact of the WEEE and Battery Directives, as well as other regulations on resource recovery and the European economy [16-24]. Much of this work has centered on the group's Circular Economy Strategy, which is projected to be fully laid out by the end of 2015 [24]. Among the findings listed, several relate to the connection between EU policies and the recovery of materials that can re-enter the market as secondary raw materials [22]. These reports stress the importance of considering the entire life cycle of the device when analyzing its environmental and economic impacts, and the role that metrics can play in the outcomes of implemented legislation [18, 19]. A specific example is discussed in relation to the Battery Directive, where mass-based targets that do not differentiate between chemical compositions can lead to the loss of lighter batteries that may contain more valuable, but difficult to recover materials [18]. In addition, a separate analysis of mobile phones stressed the importance of connecting market forces with appropriate policies in order to ensure that devices can be repaired, reused, and recycled as effectively as possible [23]. Lastly, progress towards the implementation of the Circular Economy in the EU has been aided by the WEEE and Battery Directives, but a focus on resource efficiency is needed in order to catalyze system-wide improvements in device design, manufacturing, use, and recycling [20, 21].

Conclusions

The current framing and implementation of the WEEE and Battery Directives guide EU WEEE policies, but the present focus on mass-based metrics do not sufficiently target specific materials of importance. There are several steps that could be taken to increase the recovery of targeted materials, while continuing to carry out the present day objectives of lawmakers in the EU and the Circular Economy Strategy. Therefore, we offer the following two recommendations: (1) to better align the WEEE Directive and Battery Directive with the European Commission Strategy on the Circular Economy; and (2) to increase research on the impacts of the WEEE Directive on the availability of secondary materials resources, the profits generated from recycled goods, and the environmental impact of key materials. Aligning the WEEE and Battery Directives with the Circular Economy Strategy could allow for newly designed targets that focus on specific materials that can be cycled from end-of-life devices back to the secondary raw materials market. Lastly, increased research on materials availability, and economic and environmental impacts would aid more informed policy decisions about the metrics used in the directives, and the devices that should be analyzed in most detail.

References

1. Cucchiella, F., et al., *Recycling of WEEEs: An economic assessment of present and future e-waste streams.* Renewable and Sustainable Energy Reviews, 2015. **51**: p. 263-272.

2. Georgiadis, P. and M. Besiou, *Environmental and economical sustainability of WEEE closed-loop supply chains with recycling: a system dynamics analysis.* International Journal of Advanced Manufacturing Technology, 2010. **47**(5): p. 475-493.

3. *Directive 2012/19/EU Of The European Parliament And Of The Council of 4 July 2012 on waste electrical and electronic equipment (WEEE)*. 2012, European Union: European Union. p. 1-34.

4. Fitzpatrick, C., et al., *Conflict Minerals in the Compute Sector: Estimating Extent of Tin, Tantalum, Tungsten, and Gold Use in ICT Products.* Environmental Science & Technology, 2015. **49**(2): p. 974-981.

5. Chancerel, P., et al., *Estimating the quantities of critical metals embedded in ICT and consumer equipment.* Resources, Conservation & Recycling, 2015. **98**: p. 9-18.

6. *Directive 2006/66/EC Of The European Parliament And Of The Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC*, E. Council, Editor. 2006, European Union. p. 14.

7. Chancerel, P., et al., *Assessment of Precious Metal Flows During Preprocessing of Waste Electrical and Electronic Equipment.* Journal of Industrial Ecology, 2009. **13**(5): p. 791-810.

8. *Impact Assessment of the Recast Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE)*. 2013, Department for Business, Innovation and Skills (BIS): United Kingdom.

9. *Directive 2008/98/EC Of The European Parliament And Of The Council of 19 November 2008 on waste and repealing certain Directives*. 2008, European Commission: European Union. p. 1-28.

10. Hageluken, C. *Improving metal returns and eco-efficiency in electronics recycling - a holistic approach for interface optimisation between pre-processing and integrated metals smelting and refining*. in *Proceedings of the 2006 IEEE International Symposium on Electronics and the Environment (IEEE Cat. No. 06CH37796)*. 2006. Place of Publication: Piscataway, NJ, USA; Scottsdale, AZ, USA. Country of Publication: USA.: IEEE.

11. Nicolli, F., N. Johnstone, and P. Söderholm, *Resolving failures in recycling markets: the role of technological innovation.* Environmental Economics & Policy Studies, 2012. **14**(3): p. 261-288.

12. Geyer, R. and V.D. Blass, *The economics of cell phone reuse and recycling.* International Journal of Advanced Manufacturing Technology, 2010. **47**(5-8): p. 515-525.

13. Olivetti, E., F. Field, and R. Kirchain, *Understanding dynamic availability risk of critical materials: The role and evolution of market analysis and modeling.* MRS Energy & Sustainability - A Review Journal, 2015. **2**: p. 1-16.

14. Alonso, E., *Material scarcity from the perspective of manufacturing firms : case studies of platinum and cobalt*. 2010: c2010.

15. Bauer, D., et al., *U.S. Department of Energy Critical Materials Strategy*, D.o. Energy, Editor. 2011, U.S. Department of Energy Office of Policy and International Affairs (PI). p. 196.

16. *Commission Staff Working Document Impact Assessment Accompanying the document Proposal for reviewing the European waste management targets*. 2014, European Commission: Brussels, Belgium. p. 1-128.

17. *Proposal for a Directive Of The European Parliament And Of The Council amending Directives 2008/98/EC on waste, 94/62/EC on packaging and packaging waste, 1999/31/EC on the landfill of waste, 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment*. 2014, European Commission: Brussels, Belgium. p. 1-32.

18. *Ex-Post Evaluation of Five Waste Stream Directives*. 2014, European Commission: Brussels, Belgium. p. 1-89.

19. *Progress Report on the Roadmap to a Resource Efficient Europe*. 2014, European Commission: Brussels, Belgium. p. 1-19.

20. *Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The RegionS Towards a circular economy: A zero waste programme for Europe*. 2014, European Commission: Brussels, Belgium. p. 1-14.

21. *ANNEX to the Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions Towards a circular economy: A zero waste programme for Europe*. 2014, European Commission: Brussels, Belgium. p. 1-3.

22. *Analysis of an EU target for Resource Productivity*. 2014, European Commission: Brussels, Belgium. p. 1-30.

23. Vanner, R., et al., *Scoping study to identify potential circular economy actions, priority sectors, material flows and value chains*. 2014, European Union: Luxembourg. p. 1-321.

24. *Roadmap - Circular Economy Strategy*. 2015, European Commission: European Union. p. 1-9.