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Extended producer responsibility for lamps in Nordic countries: best practices and challenges in closing material loops

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ABSTRACT

Extended Producer Responsibility (EPR) schemes are adopted not only to promote collection and recycling of waste products but also to close material loops and incentivise ecodesign. These outcomes are also part of creating a more circular economy. Evaluations of best practices can inform how to further optimise systems towards more ambitious collection, recycling and recovery of both hazardous and critical materials. Gas discharge lamps in particular are a key product category in this regard, considering both the presence of mercury and of rare earth materials in this waste stream. Nordic countries in particular are known for advanced collection and recycling systems and this article compares the EPR systems for gas discharge lamps. The EPR systems for lamps are evaluated using theory-based evaluation approaches to analyse both the performance of lamp EPR systems and challenges perceived by key stakeholders. The cases were constructed based on primary and secondary literature, statistical data, and interviews with stakeholders. The findings indicate that the collection and recycling performance is generally still high for gas discharge lamps in the Nordic countries, despite some differences in approach and structure of the EPR systems, but there remain opportunities for further improvement. In terms of EPR goals, there is evidence of improved waste management of these products as a result of the systems; however, there also remain significant challenges, particularly in terms of ecodesign incentives. The key factors for best practice are discussed, including aspects of the rule base, infrastructure, and operations. The particular characteristics of this waste category, including the rapidly changing technology, also pose challenges for EPR systems in the future.

1. Introduction

Energy efficient lighting is an important part of addressing climate change and transitioning towards a green economy with electricity for lighting accounting for approximately 15% of global power consumption and 5% of worldwide greenhouse gas (GHG) emissions (UNEP, 2012). Energy efficient gas discharge lamps (also known as fluorescent or mercury lamps), and now increasingly LEDs, have been gradually replacing traditional incandescent lamps for the last few decades and this trend has accelerated recently due to the tightening of energy efficiency regulations in most regions of the world (see e.g. UNEP, 2014). In Europe for example, EU Commission Regulation EC No 244/, 2009 and EU Commission Regulation EC No 245/, 2009 introduced stricter energy efficiency requirements for lighting products and a similar approach has been adopted through energy efficiency regulations in the U.S. (UNEP, 2014). Lighting represents a key area for achieving the European Union (EU) goal to increase energy efficiency by 20% by 2020 and replacement of inefficient lighting by 2020 is expected to enable energy savings to power 11 million households a year (EU Commission, 2013). The 2009 regulations initiated a phase-out of incandescent lamps (EU Commission, 2014a) and resulted in an increase in gas discharge lamps in the EU general lighting market (accounting for an estimated 43% of units sold in 2011 and 2012 (McKinsey and Company, 2012)). A further increase of both gas discharge lamps and LEDs is expected with the phase out of halogen lamps (originally scheduled for 2016, but now delayed to 2018).

However, in transitioning to energy efficient lighting, an integrated policy approach must also consider end-of-life management of energy efficient lamps (UNEP, 2012). The WEEE Directive (EU 2002/96/EC and recast 2012/19/EU) has implemented Extended

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Producer Responsibility (EPR) for such waste in EU member states and banned landfilling of WEEE covered by the legislation. Gas discharge lamps are covered under category 5 of the WEEE Directive. As a product group, they have special characteristics that make them particularly challenging for collection and recycling. They contain mercury that can be detrimental when released into the environment in large enough quantities (Wagner, 2011) or result in high mercury emissions when incinerated without adequate filter technology (Silveira and Chang, 2011). The fragility of lamps makes safe collection and transportation more complex to ensure the health of handlers (Kasser and Savi, 2013; Sander et al., 2013). Avoiding this environmental harm from waste gas discharge lamps is a compelling reason for "collecting as much as possible and in a safe way (avoidance of breaking) and to treat them properly" (Huisman et al., 2008, p. 281). However, collection and recycling of gas discharge lamps represents relatively high cost compared to the value of the product (Philips Lighting, 2012) and the low or negative value of the recovered material from lamp waste (G. Lundholm, personal communication, 13 August 2014). While clearly it is of societal value to avoid mercury contamination, this is a positive externality and moreover, it is a benefit difficult to quantify in economic terms.[1] As such, legislation, targets and other drivers are integral to incentivising end-of-life management (Huisman et al., 2008; G. Lundholm, personal communication, 13 August 2014). The high cost for lamps is tied to necessary recovery of hazardous materials increasing recycling costs, but also to challenges in collecting lamps. Lamps are lightweight, which means they are a small part of total WEEE and that filling trucks for optimal transportation can be an issue. Lamps are also dispersed in high quantities, geographically and between consumers and businesses. This necessitates the need for an extensive capillary network for collection.

The collection and recycling of gas discharge lamps can also create opportunities to recycle valuable materials. Waste gas discharge lamps contain rare earth elements (REE) in the phosphor layer, which is necessary for producing white light. Nearly all global supply of europium, 85.2% of terbium and 76.7% of yttrium is used for phosphors, and the majority of these are used for lighting applications (Moss et al., 2013; Tan et al., 2014). Despite only using 7% of global REE by volume, due to the high level of purity needed for lighting applications, phosphors represent 32% of the value for rare earth applications (Binnemans et al., 2013; Schüler et al., 2011; U.S. Department of Energy, 2011). The EU Commission's report on Critical Raw Materials for the European Union (EU Commission, 2014b), considers the REE group as having the highest supply risk and REE have received increasing attention in the last few years with rising prices and concern about supply restrictions from China, where over 90% of production takes place (Binnemans et al., 2013; Bloomberg News, 2015). The presence of REE in only small amounts in waste products represents a challenge for recycling, but increased recycling has the potential to address supply risks (Binnemans et al., 2013; Rademaker et al., 2013; Sprecher et al., 2014). However, currently less than 1% of REE is recycled and examples of closing this material loop are rare (Binnemans et al., 2013) but the experience in recycling REE from gas discharge lamps is promising (Dupont and Binnemans, 2015).

EPR systems for lamps have been in place in the EU under the WEEE Directive, but legislation has been present even longer in some countries, like Norway, Sweden, and Austria. Academic literature has evaluated various aspects of WEEE systems in the EU, including the challenges for collecting small WEEE (Huisman et al., 2008; Khetriwal et al., 2011; Melissen, 2006) However, there has been not been a comprehensive evaluation of the best practices and challenges for end-of-life management of gas discharge lamps specifically, despite this product stream having been acknowledged to be of particular relevance both for recovery of critical materials and for avoidance of mercury contamination. The literature that has addressed this waste stream has tended to focus on the set up of EPR systems for lamps in the EU in general (Wagner, 2011, 2013; Wagner et al., 2013) or has emphasised recycling over collection aspects (Silveira and Chang, 2011). Very little is known about how EPR systems for lamps compare or differ from the structure and performance of the overall WEEE systems.

The research presented in this paper evaluates EPR systems for lamps in the Nordic countries of Denmark, Finland, Norway and Sweden.[2] The Nordic countries have been recognised for best practices in the area of end-of-life management of WEEE (Román, 2012; Ylä-Mella et al., 2014a,b) and as such also provide good cases for a deeper analysis of EPR for lamps in particular. Such analysis can provide further insight into how to address the unique challenges for this waste stream and the factors that potentially contribute to better attainment of EPR goals and a more circular economy for this key product category. EPR includes goals to conserve source materials by promoting better waste management, ecodesign, and closing material loops and such goals are also an integral part of a circular economy (EU Commission, 2014c). This article presents analyses of EPR systems for lamps in Nordic countries in relation to EPR goals and discusses the factors that contribute to well-functioning systems as well as challenges still to be addressed in further optimising such systems.

Section 2 describes the methodology used in this policy evaluation and comparative case study methodology. Section 3 presents the findings of the comparative case study and evaluation of the performance of the Nordic EPR systems in relation to the EPR outcomes. Section 4 discusses these findings and presents factors identified as influential to the success of the systems as well as remaining challenges.

2. Methodology

The research approach used embedded multiple cases in which multi-level perspectives were explored simultaneously (e.g. gas discharge lamps, country perspectives, key stakeholder groups, etc.) (Yin, 2003). Comparative analysis of multiple cases particularly suits research evaluating multiple holistic systems and allows comparison of factors influencing performance (Druckman, 2005). The framework for the initial comparison of the EPR systems for lamps was based on important elements of such systems identified by Murphy et al. (2012). Nordic countries are the focus cases in evaluating EPR systems for lamps because they have been described for their best practices in performance for WEEE in general, but they have not been examined in regard to gas discharge lamps. High performing systems can be studied to identify the common elements that could be the key to their effectiveness. It can also reveal context-specific or organisational differences that have or have not influenced effectiveness, as well as challenges perceived about the different systems from corresponding stakeholder groups in each system.

[1] Some studies, for example, Hylander and Goodsite (2006) have tried and estimated a cost of USD 2500 to 1.1 million per kg Hg isolated from the biosphere depending on local factors quantity, nature of pollution, media, geography, technology used etc.

[2] Iceland has been excluded in this research as its context as well as the implementation and experience thus far with WEEE systems has been quite different than other Nordic countries so far. It is expected to further develop and resemble other Nordic country systems in the future (Baxter et al., 2014).