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SCIENCE DIRECT

Science of the Total Environment 359 (2006) 38–56

Science of the Total Environment
An International Journal for Scientific Research into the Environment and its Relationship with Humankind

www.elsevier.com/locate/scitotenv

Producer responsibility, waste minimisation and the WEEE Directive: Case studies in eco-design from the European lighting sector

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Received 23 December 2004; received in revised form 28 June 2005; accepted 6 July 2005
Available online 19 September 2005

Abstract

The EU Directive on Waste Electrical and Electrical Equipment (WEEE) (2002/96/EC), to be implemented in stages from August 2004, attempts to tackle the growing quantity WEEE by making producers responsible for the costs of the collection and recycling of their products at the end of usable life. This is considered to give producers a financial incentive to reduce waste at source through eco-design. This link is, however, under-researched and little is known generally about the effectiveness of extended producer responsibility (EPR) and policies to promote it.

This paper presents the findings of an exploratory study to address these important gaps in knowledge. Literature review was used to develop an analytical framework to explain the relationships between the drivers for eco-design and the role of policies to promote EPR. This was applied to eight case studies of firms from the European lighting sector. While quantitative data to confirm the link between EPR and eco-design were difficult to obtain, the case studies showed that EPR has had little effect on product development so far. Within the sector studied, most producers have been able to pass on incremental costs associated with EPR to customers with negligible effects on sales. This reflects perceptions in the lighting sector that, because demand for products is relatively price inelastic and the regulation affects all producers equally, EPR is unlikely to drive eco-design at least in the short run. The cases also showed that choice between individual and centrally provided waste recovery schemes rested on perceptions of relative costs and practicability. It was evident that other drivers, such as bans on hazardous substances, product declarations and supply chain pressures, were often more effective promoters of eco-design. Thus it seems a mix of policy measures is required rather than reliance on economic instruments alone.

Keywords: Extended producer responsibility; Eco-design; Environmental policy; WEEE

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0048-9697/$ - see front matter
doi:10.1016/j.scitotenv.2005.07.001

1. Introduction for revision

Policy discourse concerned with sustainable development has called the environmental efficiency of modern production and consumption practices into question (Meadows et al., 1972; Weizacker et al., 1998; Perman et al., 1999; Hawken et al., 2000). Two aspects have been of particular concern, namely: excessive and inefficient use of natural resources and the generation of large quantities of emissions and noxious residuals, including solid waste, that have a deleterious effect on the earth's ecological systems. Actions to de-carbonise economies, improve the efficiency of resource use and minimise potential pollutants have become key elements of policy and law to promote sustainable development (Berkout, 2002; Tietenberg, 2003; Dti, 2003; Segger and Khalfan, 2004; Hawkins and Shaw, 2004). In this context, this paper considers actions to address the growing quantities of waste electronic and electrical equipment (WEEE) generated within the European Union by promoting extended producer responsibility (EPR).

Following an overview of policies to promote EPR in the electric and electronic goods sector, evidence is presented from literature of the links between eco-design and EPR and of factors which influence business decisions to undertake eco-design. The research methodology is then set out, describing an analytical framework developed from literature and used to analyse eight exploratory case studies in the European lighting sector. The paper ends with conclusions which point to the need for an improved understanding of company responses to drivers of eco-design, including those associated with environmental policies.

2. Policy context

2.1. Waste minimisation and extended producer responsibility

Within the European Union, policies to address waste issues are increasingly formulated by the European Commission and subsequently enacted by Member States. While traditionally these have sought to remediate the environmental impacts of landfill and incineration, preventative policy measures are now receiving greater attention (OECD, 2002; Connelly and Smith, 2003). Such policies have focused on achieving waste minimisation and generally prefer waste reduction, followed by product reuse and materials recovery in order to avoid disposal to landfill (Davoudi, 2000; McDougall et al., 2001; Wilson et al., 2001; Commission of the European Communities, 2003; Jönsson et al., 2003).

Recent policies to achieve waste minimisation have sought to attain this through extended producer responsibility (EPR). As the term implies, this makes producers responsible for managing the potential environmental effects of their products from the point of sale throughout a product's entire life cycle (OECD, 2001). Crucially, such legislation extends producer responsibility into the post-consumer stage and transfers responsibility for dealing with products at the end of their usable life from local authorities, taxpayers and consumers to the producer.

EPR may be implemented through a mixture of regulatory, economic and voluntary policy instruments (Lindhqvist, 2000). While economic instruments are receiving increasing interest in government policy-making circles (Dryzek, 1997; Tews et al., 2003), regulation remains the predominant environmental policy instrument (Gouldson and Murphy, 1998) and has been used at both national and supra-national levels within the EU to implement EPR.

2.2. EPR and waste electrical and electronic equipment

The quantity of waste electrical and electronic equipment (WEEE) disposed of within the European Union has been of particular concern, especially given the predicted increase in WEEE of 3% to 5% per year (Cooper, 2000; Dti, 2002a; Mayers and France, 1999). Such waste presents particular environmental challenges given the complexity of electrical and electronic components and their potentially hazardous nature.

Discussions in the EU about how generation of WEEE might be curbed by EPR began in the early 1990s (Mayers and France, 1999). These resulted in the EU Directive on Waste Electrical and Electrical Equipment (2002/96/EC), which was adopted in January 2003 and is to be implemented in stages from August 2004. It seeks to address WEEE arising from households and businesses and specifies quantitative targets for separation, collection and recycling of WEEE, which is free of charge to the households. The Directive assigns financial responsibility for such activities to producers (Official Journal of the European Union, 2003). It comprises some 18 articles, including Article 4 that requires a commitment to adopt product designs that facilitate waste minimisation. However, at the time of the study upon which this paper reports, the European Commission had not yet conveyed the measures deemed adequate for compliance with Article 4.

While the UK Government was required to transpose the WEEE Directive into national law by 13 August 2004, it will now undertake this during summer 2005 and implement the Directive's producer responsibility obligations for household and non-household WEEE along with associated take-back obligations on retailers/distributors from January 2006 (Dti, 2005). The UK government consulted on article 4 in 2004 and hoped to achieve compliance through voluntary agreements and new product standards. There appear to be no plans for quantitative targets.

The approach to compliance with the WEEE Directive varies amongst Member States of the European Union (Cooper, 2000). For example, Netherlands and Sweden have already legislated on EPR for WEEE. In the Netherlands all categories of WEEE except information and communications technology (ICT) are subject to a compulsory scheme managed by a producer responsibility organisation (PRO). Here, fees set to recover the annual costs of the scheme are added to the price of new products (Ministry of Housing, Spatial Planning and the Environment, the Netherlands, 1998, 2001). In Sweden, a not-for-profit organisation collects and recycles WEEE, with fees set to cover the costs of the operations. However, producers of electrical and electronic equipment (EEE) can choose to fulfil their obligations individually by undertaking the necessary activities themselves or by individually contracting them out (Naturvardsverket, 2002). For joint, collective schemes, fees are based on the sale value of new products, whereas the charges for individual solutions are set when products become waste.

3. Eco-design and EPR

Innovatory activities undertaken by firms to develop cleaner products may be conceptualised as eco-design. Eco-design is concerned with the development of products which are more durable, energy efficient, avoid the use of toxic materials and which can be easily disassembled for recycling (Roy, 2000; Sherwin, 2000; Lewis and Gertsakis, 2001; Bhamra, 2004). It emerged in the 1990s with the realisation that by changing product concepts and thus associated inputs and production processes it is possible, at least in principle, to avoid the generation of wastes and the costs of abatement.

Table 1 summarises how eco-design provides opportunities to minimise waste and improve the efficiency of resource use through modifications to product size, serviceable life, recyclability and in use characteristics. It is clear that eco-design must take a whole life perspective in that measures taken in one stage can lead to trade-offs in another. The take up of eco-design will reflect the extent to which firms think they will be better off as a result. Table 1 also shows some of the perceived potential disadvantages to firms of eco-designs which may act as barriers to adoption. From a policy perspective, it is important to understand why firms adopt eco-design, and the extent to which take up might be influenced by EPR.

Studies show that factors which influence a firm's decision to undertake eco-design are various and may be divided into drivers that are external and internal to the organisation. Legislation and customer demand have been cited as the most important external drivers of eco-design (Argument et al., 1998; McAloone, 1998; van Hemel, 1998). The importance of legislation as a stimulus for eco-design is supported by evidence that changes in product design have been induced by producer responsibility in the packaging, automobile and electrical and electronic equipments (EEE) sectors (Davies, 1996; Lindhqvist, 2000; Tojo, 2001; Zoboli, 2000). However, other studies show that many companies in the EEE sector are not aware of, and fail to anticipate, producer responsibility (Naturvardsverket, 2002; Trenchard and Gowland, 2003). With respect to customer demands, Dalhammar (2002) notes the increasing importance of market drivers, although this may not be entirely independent

Table 1
Eco design and waste minimisation: opportunities and limitations

Opportunity	Achieved by	Potential disadvantage/limitations
Reduced product size/mass	Using less bulky, less heavy materials Reduced product dimensions Making products foldable for storage and transport	Less bulky materials may be more complex and thus unfavourable for recycling Increased efficiency in material use may result in cost and price cuts that encourage increased production and consumption, with limited net gain
Extended product life	Using durable materials Facilitating repair through easy dismantling and replacement of components Avoiding highly fashion-sensitive styles	Products become outdated in design and performance New shorter life products may have lower environmental impacts in the use phase that off-set the environmental gains of a long life Obsolete products in fashion driven markets
Improved recycling potential	Facilitating disassembly Reducing number of components Reducing complexity of materials	Some complex materials have less mass, saving energy during the use phase, or are more durable than easy-to-recover materials Easily recyclable materials may have substantial environmental impacts during other life cycle stages, e.g., virgin aluminium
Improved performance in use	Reduced mass Use of energy saving devices Incorporating automatic controls Extended maintenance intervals	Increased complexity Increased risk of failure Compatibility with existing infrastructure and systems

Adapted from Lewis and Gertsakis (2001), van Hemel (1998) and Persson (2001).

of environmental legislation which places controls on the use of particular substances or components.

Internal stimuli may be more important than external drivers (van Hemel and Cramer, 2002) or may exceed external drivers after the initial triggering effect of the latter (McAloone, 1998). Research has identified a range of internal drivers, but the findings vary among different studies. Examples are opportunities to innovate (Sherwin, 2000; van Hemel and Cramer, 2002), potentials for cost savings and commercial advantages, and staff and management commitment (McAloone, 1998; van Hemel and Cramer, 2002).

In addition to external and internal drivers, characteristics such as company size may influence product development (Brown and Eisenhardt, 1995) and eco-design in particular (Argument et al., 1998; van Hemel and Cramer, 2002). Supply chain pressure appears to have been a greater motivating factor for eco-design in smaller companies than in larger ones (van Hemel and Cramer, 2002; McAloone, 1998). Furthermore, the degree to which a given manufacturer adopts the principles of eco-design may reflect its country of origin and prevailing environmental standards and expectations. For this reason, national origin is seen to affect corporate environmental engagement (Kolk et al., 2001). Germany, the Netherlands, the Nordic countries and Japan have been ranked among the most advanced nations in terms of environmental policy and achievements in, for instance, emission reduction and waste minimisation. Britain, on the other hand, has been viewed as an environmental laggard in recent years (Connelly and Smith, 2003; Drake et al., 2003; Dryzek, 1997). Companies that operate in different countries are of course subject to different national environmental laws such that the impact of the home country origin on exporting companies may be limited as Kolk et al. (2001) found when they observed national differences in environmental reporting behaviour among large multinational companies.

Research indicates that little is known about the link between EPR and eco-design to develop cleaner products. Two studies (Argument et al., 1998; Tojo, 2001) looked at producer responsibility in large companies exclusively but did not specifically examine the economic mechanisms of the policy. Both were conducted before producer responsibility for WEEE was in force, and only one of them explored electrical waste. However, while there are few specific insights from eco-design literature, economic principles may offer useful insights here. These suggest that the incentive to avoid costs associated with EPR is thought to give firms an economic inducement to undertake innovatory activities which may be conceptualised as eco-design. However, this depends on whether the marginal costs associated with EPR are sufficiently large to have a negative impact on the financial performance of the firm, and linked to this, what proportion of costs (see Table 2) are likely to be borne by producers and customers respectively (Turner et al., 1994; Tietenberg, 2003). This in turn depends on the price elasticity of the demand for goods. If producers can transfer costs to customers via product price without affecting demand substantially, there is little incentive to innovate in order to reduce costs. This is the case where, perhaps through market dominance, branding and product differentiation, there are perceived to be few close substitutes for particular products, or where expenditure on the products is a very small proportion of total spending. In the longer term, however, substitutes are likely to emerge, such that there will be a tendency towards more elastic, price sensitive demands for particular products (Lipsey and Chrystal, 1995). In practice, it is difficult to calculate price elasticities for individual, differentiated products which often target particular segmented markets. Furthermore, price elasticity of individual products is often greater than for product groups as whole, in spite of attempts by producers to achieve the converse. Of course large scale, monopolistic producers may be able to exploit potential price inelasticity to their advantage, passing on additional costs almost entirely to their customers.

The response of producers to environmental charges also depends on whether they can avoid them (Drury, 2001). The charges paid to joint schemes are usually fixed per unit of product according to product types regardless of brand and detailed product specification. They vary in total according to sales volume. The charges may also vary over time depending on the administrative efficiency of the collection organisation and the development of collection and recycling facilities. However, a company cannot influence these charges in the short term by conducting eco-design since the charges rarely distinguish between brands and specification. Reductions in recycling costs that may arise over time by improved recycling techniques or by changes in product design by one or a few large producers are likely to benefit all producers of the product category that are members of the joint scheme. This could encourage a 'free rider' attitude amongst some manufacturers, diluting the effect of a joint scheme. For some producers, the only way to avoid charges may be to reduce production and sales. Where unit charges are high, the result could be convergence of product design and concentration of production into fewer hands.

Conversely, with individual contracts between producers and waste management companies, it may be possible to negotiate unit charges that vary with the end-of-life properties of the particular products (Dti, 2002b; Spicer and Johnson, 2004). Therefore, the potential to achieve short term cost savings through product development may be greater with individual solutions than joint schemes.

Thus, although the link between EPR and eco-design is relatively unexplored in the eco-design literature, economic principles provide useful insights. These accord a key role to the costs of EPR borne by the producer, especially how ability to transfer these to consumers influences a firm's responses to EPR. The limited findings from the eco-design literature were combined with these insights to form an analytical framework, which is presented in the subsequent section.

Table 2
Business costs of Extended Producer Responsibility (EPR)

Cost categories	Key cost components
Transaction costs	Identifying appropriate solutions and contractual partners; negotiating and managing contracts, reporting (Lipsey and Chrystal, 1995)
Collection	Containers at collection points, other equipment, maintenance, labour, transport, depending on waste volumes and distances between collection points (Theisen, 2002). Storage in the case of retailer take-back; staff time for planning and administration of operations
Recycling	Labour, equipment and space for (manual or automated) sorting, disassembly and processing; depending on waste properties and volumes (Leverenz et al., 2002). Staff time for planning and administration of operations
Miscellaneous	Provisions for environmental, health and safety protection (Leverenz et al., 2002). Waste management licences; auditing, information between different stakeholders

4. Research method

Given limited evidence of the link between EPR and eco-design, the research conducted here was classified as exploratory. Findings from literature were used to construct an analytical framework. This does not offer comprehensive ontological equivalence but rather was used as a heuristic device for exploring and conceptualising the link between EPR and eco-design. A balance between parsimony and explanatory completeness was struck and resultant conceptual insights used to guide investigation and facilitate analysis.

Consistent with the requirements of exploratory research (Robson, 2002), the conceptual framework identifies the input/drivers, process/responses and output/impacts of eco-design in the context of waste minimisation from the producer's perspective and provides a general outline of the relationships between these (Fig. 1). Limitations should be noted here as although the framework suggests a linear progression, there are many feedback loops and potential links with other factors which were not explored in this enquiry.

A multiple-case study approach was deployed and deemed appropriate to provide a broad understanding of eco-design and the likely response to the WEEE directive across a range of organisations (Robson, 2002; Miles and Huberman, 1994). Individual firms from the European lighting sector formed the unit of analysis and were selected to cover the following features perceived to influence the response to the WEEE Directive:

- companies that develop and market products;
- companies both with and without a reputation in eco-design;
- both relatively large and small companies (the latter classed as SMEs);
- companies with joint and individual WEEE solutions, respectively;
- from both environmentally leading and lagging countries;
- from countries with and without national producer responsibility for WEEE.

4.1. Case study design

For the purpose of this exploratory study and to reduce the degree of variation amongst case studies, it was decided to focus on and draw detailed insights from one product category. Preliminary enquiry showed that a number, albeit small, of companies had adopted individual and others had adopted joint

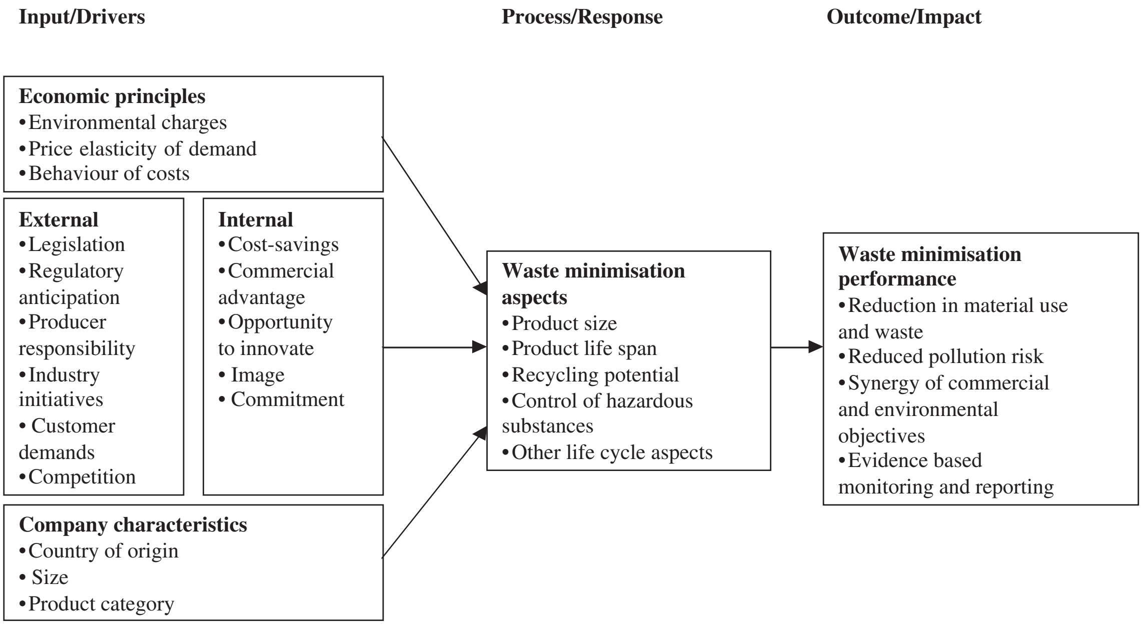

Fig. 1. Framework for the analysis of waste minimising aspects of eco-design.

WEEE solutions for lighting products. Furthermore, the environmental impacts of lighting products have recently received attention by UK organisations such as the Waste and Resources Action Programme (WRAP) and the Environment Agency of England and Wales (EA). In an attempt to promote eco-design, WRAP identified that the quality of recycled glass limits the potential market for recyclates as input material in lamp production and has attempted to overcome this barrier by providing technical and practical guidance to glass reprocessors (Hartley, 2003). As participants in a project to facilitate compliance with policies on product specification and producer obligations, the EA identified the lighting industry as one of seven prioritised sectors (Coleman and White, 2003). In particular, the EA is attempting to help small and medium size enterprises (SMEs) to interpret and meet new legislation on producer responsibility. Table 3 summarises the case companies with further details given in Appendix A.

Data from different sources such as company documents and semi-structured interviews were collected to enhance the richness of the data and reveal views of and performance in environmental management, eco-design and producer responsibility for WEEE (Yin, 1993). Quantitative data on performance was sought, but was found lacking because the case companies either did not undertake measurements, make data available, or the data did not exist in suitable form. Nevertheless, qualitative information derived from key informants on the above issues provided a picture of the influence of producer responsibility on eco-design.

Using the analytical framework detailed above, a semi-structured questionnaire was prepared to ensure that themes relevant to the aim of the study were explored in a consistent way (Appendix B). Two or more informants were interviewed in each case study organisation to reduce the possible bias of reliance on single informants. Most of the interviews were carried out by means of pre-arranged telephone conversations because this increased the accessibility of informants and provided a cost-effective medium compared to face-to-face interviews (Neumann, 2003). At one company, both face-to-face and telephone interviews were conducted and this confirmed that lack of visual information available in the latter did not appear to affect the quality of communication and outcomes. Notes were taken during interview, summarised and sent to the informants to allow for comments or clarification. Not all informants provided feedback on the summary. Of those that did, some informants made some amendments, whereas others agreed with the original text.

Table 3
Summary of case studies in lighting sector

Case	Nationality	Size	Products
A	Dutch	Large	Lamps and lighting products
B	German	Large	Lamps and lighting products
C	Swedish	Large	Luminaires
D	Swedish	Large	Luminaires
E	British	SME	Luminaires
F	German	SME	Luminaires
G	British	SME	Luminaires
H	Swedish	SME	Luminaires

Previously, similar qualitative methods have proved useful for understanding how industry responds to waste policy instruments (Kautto and Melanen, 2004). With more time and resources, a systems approach would allow further analysis of the interaction of the various factors influencing eco-design (Hemmelskamp et al., 2000), enabling elaboration of the framework contained in Fig. 1.

5. Results and discussion

The analysis of eight case study organisations in the lighting sector showed the extent to which waste minimisation was linked to product development, the role of economic mechanisms in the promotion of producer responsibility and major motives for eco-design at company level. These are discussed in turn, drawing on results from the cases summarised in the supporting appendices. With respect to product types, distinction is made between lamps (the component that generates light) and luminaires (combined lamps, fittings and controls).

5.1. Waste minimisation and product design

It proved difficult to derive objectively verifiable evidence in the case study organisations of the relationship between product development and waste minimisation and therefore of the possible influence of EPR on eco-design. Available information was largely anecdotal or confined to highly aggregated data published by the larger companies, with achievements commonly presented as examples of single products (Appendix C). Furthermore, in some cases, reported reductions in waste appeared to be independent of eco-design, being mainly due to improvements in recycling technologies and new uses for recyclates. There is a clear need to monitor, evaluate and report the achievements of interventions such as EPR in order to inform policy. This is a sensitive topic, however, given the need to respect commercial confidentiality.

5.2. Economic mechanisms of producer responsibility as a driver of eco-design

It is often argued that environmental regulation impacts negatively on the competitiveness of business. Few concerns, however, were expressed by respondents regarding the effects on competitiveness of producer responsibility for WEEE. Furthermore, all cases viewed their competitors as equally affected by the policy. Three of the cases in this study were subject to producer responsibility for WEEE in their home countries. All other cases generated some of their revenue from exports, some to countries with, and some to countries without national WEEE policies. Generally, products were not modified for different markets, except for country specific fire regulations and voltage.

How have companies responded to the economic mechanisms of WEEE? Two of the large Swedish companies (cases C and D) that are subject to a national WEEE policy earn at least 50% of their turnover in Sweden. Both companies joined the dominant collective scheme and paid a fixed entry fee, a fixed annual membership fee and a fee per product sold charged at two rates depending on the weight of the products (Appendix D). Both companies added these costs to the prices of the products. Neither perceived any negative impacts on sales and competitiveness. Consequently, customers carried the larger part, if not all, of the cost burden and there was little incentive for the companies to adopt eco-design to avoid the costs of producer responsibility the costs. Willingness for customers to absorb the additional costs, an indication of price inelasticity of demand, may be explained by the fact that additional costs only amount to one or two percent of the total product price. In such circumstances market mechanisms may not encourage companies to adopt eco-design as a means of reducing waste at source and whole life costs.

The limited incentive for eco-design was reinforced by the fact that fees are fixed for a particular type of product rather than varying with the end-of-life properties of a particular brand or detailed design. For this reason, companies could not avoid the costs in the short term through product development. In the longer term, a company joining a producer responsibility scheme may be able to reduce the costs for end-of-life management through eco-design if it has a large market share such that a large proportion of the total waste of a particular waste category derives from that company. Relatively large volumes of waste with consistent properties suited for recycling can reduce average costs. An informant in case D mentioned this possibility but remarked that this was not currently a consideration.

Neither case D nor H (a Swedish SME) had considered an individual solution to their producer responsibility due to the perceived high transaction and resource costs involved. They had, however, not attempted to calculate the potential costs and benefits of this option, nor of an eco-design option. In case D, a contributing factor may be that the decision about producer responsibility for WEEE was taken independently by the environmental manager and only later presented to the financial and accounting functions (Appendix D). The latter appeared to look at it as an environmental issue unrelated to product development and production with limited cost implications beyond the management of environmental effects. In the Swedish SME, however, the decision was made by the managing and marketing director who can be expected to have an integrated view of the cost implications of the decision. The choice in favour of the joint scheme relative to that for an individual solution appeared to be based on a broad assessment of the relative costs of options. This is an important point: unless environmental and financial decision making are integrated within businesses, the extent to which economic instruments can make a difference to business behaviour may be limited (Bennett and James, 1999). The cases show that this is particularly relevant for product development.

The other Swedish company (C) had chosen an individual solution (Appendix D). As with case D, the decision was taken by those responsible for environmental functions within the company. The main reason given by the informants was the existing collection and recycling infrastructure in the form of a network of retail outlets with bring-back schemes and contracts with a waste management company for recycling of waste from all business processes. This infrastructure reduced the transaction costs of the individual solution. Although the company claimed to engage in eco-design, the recycling charges did not vary with the end-of-life properties of the products. The company did not monitor the amount of returned WEEE relative the total waste and recycling, but the proportion was believed to be small and the waste contract had not been renegotiated after the implementation of the national WEEE policy. Other reasons for this may be that the company accepted WEEE from brands belonging to other organisations in their bring-back schemes and that EEE was only a small part of the total product range. Hence, the scope to avoid the costs of WEEE in the short term through eco-design was limited.

The increase in total product costs due to producer responsibility for WEEE was relatively small for most cases: between 0.5% and 3%. Furthermore, that part of the costs derived from other brands returned by customers or electrical and electronic waste arising from business processes rather than end-of-life products was not calculated (Appendix D). This may also explain why company C, allegedly, had not increased product prices following the implementation of the Swedish WEEE legislation. Consequently, the company rather than its customers carries the additional costs. It was reported that there had been little influence on product development due to the relatively low costs incurred hitherto. The situation may be different for companies marketing predominantly EEE and receiving large volumes of WEEE.

Are higher charges likely to provide an incentive for eco-design? Case A and B were not yet subject to producer responsibility for WEEE for lighting equipment but had assigned corporate task forces to deal with the forthcoming EU Directive. Their trade association reportedly had estimated the recycling costs at some 60% of the product price (Appendix D), but this seems high and probably reflects a strategic bias. However, the informants in the cases suggested that the effect on eco-design would be limited due to product characteristics of lamps, varying recycling techniques among recyclers and the fact that competitors were seen as equally affected by producer responsibility legislation. Due to the high level of standardisation, the ease with which products could be copied, the small unit size of each product and the difficulties of sorting large number of end-of-life lamps according to brand, companies advocated a joint responsibility. This reduces the extent to which costs could be avoided in the short term through eco-design. The informant in case A, which was the most advanced in eco-design of all cases, said that it was difficult to calculate the cost and benefits of eco-design. The company undertook eco-design of its different product categories because it believed it offered commercial advantage. However, in the case of lamps and producer responsibility for WEEE, case A and B's cost-reducing strategies focused more on influencing legislation and developing recycling techniques than on eco-design.

5.3. Motivations for eco-design

Are there conflicting or complementary drivers behind efforts in waste minimisation and eco-design? There were no indications that reduction in the unit size of products was motivated by producer responsibility (Appendix E). All cases except the Swedish SME claimed that they sought reduction in product size in dimension and/or mass in order to achieve potential cost savings in input materials, packaging and transport. In reality, however, technical and fashion requirements were perceived to overshadow such potential cost savings. Handling small components was also associated with relatively high average costs, outweighing the savings in input material. Policy interventions which influence the cost of materials could change this balance, however.

With regard to product life span, attitudes varied according to type of product involved. Longevity was a selling point for lamps, whereas luminaires were believed to be replaced before the end of their usable life because of changing fashions (Appendix E). Thus, there was a limited interest in extending product life span, although an informant in one case perceived that susceptibility to fashion trends varied amongst different types of customers. Thus, policy measures to encourage increased product life span are likely to be more effective if they address demand as well supply side issues.

Luminaires were usually designed to allow dismantling for the replacement of lamps and control and switch mechanisms. In effect, this practice leads to longer product service lives. British and German SMEs built in these replacement/servicing characteristics with little awareness of environmental issues and producer responsibility for WEEE. Article 4 in the WEEE Directive does not prescribe product longevity. Instead it states that product reuse should be encouraged. Neither lamp nor luminaire producers showed any interest in design for reuse. This seems to be because the promotion of second-hand product use has traditionally been outside the producer's remit. Furthermore, a combination of the fashion obsolescence of household luminaries and the longevity of industrial luminaires has reduced the importance of their reuse as an environmental or indeed financial target.

Awareness and concern about product recycling appeared to be related to general environmental awareness, which was greater in the large companies than in the SMEs. In environmentally active companies, recycling seemed to be a part of 'life cycle thinking' (Appendices 3 and 5). Policy debates about recycling and producer responsibility may have contributed to this. Cases A and B, Dutch and German respectively, monitored the recycling potentials of some of their products. The latter reported that improved recyclability occurred as early as the early 1980s, well before the discussions about producer responsibility for WEEE. The main reason was to save costs by reusing glass as a production input. The large Swedish companies reported an interest in the recyclability of their products, which could be a result of a relatively strong societal commitment to recycling and participation in segregating waste at source (Naturvårdsverket, 2002). However, recyclability was currently not prominent in product development. The eco-design guidelines in case C included end-of-life aspects which applied to all product categories and not only electrical and electronic equipment, confirming the limited effect of producer responsibility for WEEE on eco-design.

Public debates and government bans or restrictions of certain dangerous substances were strong incentives for eco-design in the four large companies and the Swedish SME (Appendix C). The Swedish lighting industry, through its trade association, has an environmental product declaration (EPD) of materials and substances used in its products and communicated by means of an eco-label. This EPD was referred to by all Swedish cases. It helped to promote environmental issues in case H, the only environmentally active SME in the study. Of course, the presence of dangerous substances affects the recyclability of products. It is not regulated in the WEEE Directive, but in a separate Regulation of Hazardous Substances (ROHS) Directive (2002/95/EC). Two cases specifically mentioned this as more important for eco-design than the WEEE Directive. Thus, regulation seems to have a greater and more immediate effect on eco-design than the type of economic policy incentive currently associated with WEEE.

Energy consumption during the use phase is a potentially significant environmental impact of lighting equipment. It is not included in the producer responsibility for WEEE but was frequently mentioned as an eco-design aspect (Appendix E). In particular the SMEs with no manifest environmental commitment were keen to emphasise the environmental friendliness of their efforts in this aspect. The fact that energy efficiency was an important sales argument appeared to be the main reason for making improvement. It should be noted that for other categories of EEE, such as vacuum cleaners, high energy consumption associated with a larger electric motor may be viewed as a sign of quality by customers. In the case of lighting products, product labelling can help overcome this by communicating light output rather than energy consumption. The way that product performance in use is communicated is a particularly important component of eco-design.

Evidence of environmental criteria in customer purchasing behaviour was reportedly relatively rare, but mainly experienced by the large companies and the Swedish SME. Some informants felt that much depended on the type of clients. Differences could also be noted within given customer categories between countries. A British SME perceived architects to be interested mainly in quality and style and not in environmental performance. The Swedish SME, however, found architects to be environmentally aware. Case D and H, both Swedish, had also experienced environmental demands from public procurers, albeit in terms of general evidence for environmental commitment rather than actual product contents and performance.

The three largest companies claimed to make environmental demands on their component suppliers. These demands were mostly generic, for instance, requiring compliance with legislation, restrictions of certain substances and some degree of environmental management. In case A and C, purchasing codes were applied to all product categories regardless of whether they were subject to producer responsibility for WEEE or not. There was no evidence that supply chain pressure was directly influenced by or furthering the objectives of producer responsibility for WEEE.

6. Conclusions and recommendations

This paper has explored evidence from literature and selected case companies of the link between EPR and eco-design in the context of WEEE and policy interventions to reduce it. Although the limitations of such exploratory research are widely accepted and understood (Robson, 2002), the results are considered to provide an indicative platform of knowledge to inform empirical testing of the relationships referred to above, allowing for variations in industrial and national circumstances and practices. The conclusions and recommendations here are made with these limitations and cautions in mind.

The research showed that placing financial responsibility on producers for collecting and recycling WEEE did not appear to have perceived negative effects on business sales and competitiveness. The latter suggests that demand for lighting products is price inelastic in the short term and/or that the charges were too small to have a significant negative impact on participating firm's customers. Consequently, charges for producer responsibility do not appear to be sufficient in themselves to stimulate eco-design. These findings appear to challenge the claims in the literature that internalising the costs of waste management necessarily leads to changes in product design (Cooper, 2000; OECD, 2001), especially when these can be passed on to users. In the longer term, however, there may be inducements towards eco-design in pursuit of cost minimisation and competitive advantage, but again this depends on industry and market circumstances.

With respect to the choice of collection scheme, whether individual or joint, much appears to rest on perceptions of relative costs of schemes, with limited consideration of the opportunity for eco-design under each solution. A tentative conclusion drawn here is that companies may prefer to adopt an individual solution for product responsibility if transaction costs are relatively low compared to joint schemes, each product unit has a high value, products are highly differentiated, can be sorted according to brand at a relatively low cost, and the number of returned products is relatively high. It was not evident, however, as suggested by some researchers, that individual solutions to WEEE designed to cater for the particular products of a company are likely to be more effective than joint schemes in stimulating eco-design.

Perceptions of relatively low costs for joint schemes have encouraged their choice, although there was a remarkable lack of calculations of actual costs and benefits. This partly reflected the fact that in some companies the choice was an environmental rather than a financial management decision, made difficult by the challenge of estimating the market costs and benefits of eco-design. The cost increase imposed by producer responsibility was often too small to outweigh other product requirements such as fashion trends. However, higher charges may not necessarily have a stronger effect on eco-design since competitors are felt to be equally affected and demand in this sector is believed to be relatively price inelastic. Rather than promoting eco-design per se, companies appear to seek cost reductions across all business activities, influence legislation and develop recycling techniques as the most effective cost-reducing strategies. Consequently, rather than rely on producer responsibility alone, complementary incentives are likely to be needed to progress eco-design. Although, some evidence was found of achievements in waste minimisation through product development, it was difficult to corroborate due to lack of objectively verifiable environmental monitoring and reporting, especially amongst SMEs.

Command and control in the form of substance bans were observed to be effective external drivers of eco-design. Substance bans will take effect through the ROHS Directive. Similarly, it is possible to prescribe product design standards that will facilitate recycling, although these would require updating as recycling technologies develop. Furthermore, there may be trade-offs amongst environmental properties whereby for example longevity requires the use of more complex materials.

Improved environmental performance during the use rather than end-of-life stage may be a stronger driver of eco-design than producer responsibility policies, with producers seeking to capture enhanced perceived user value as a source of competitive advantage. For example, energy efficiency of lighting products was particularly noticeable in SMEs who otherwise exhibited low environmental awareness. The only SME in the study undertaking environmentally conscious product development was encouraged by a combination of environmental demands from public sector procurers and an environmental product declaration. The fact that the product declaration was also the basis for an ecolabel strengthened the stimulus. This shows the benefit of a diverse, fit for purpose approach to promoting producer responsibility. In future, product declarations will include compatibility with the WEEE directive. It is important that the standards included in the latter reflect changing technology and are updated to encourage continuous improvement.

The limitations of this study provide opportunities for further research. The findings here reflect business responses to the WEEE legislation during the early stages of implementation. There should be continued monitoring to determine the achievements of the Directive against its stated aims and whether the responses by businesses are consistent with the principles of sustainable development. In this latter context, it is important to view the WEEE Regulations in a strategic context as they affect the design and development of products and processes, business competitiveness and over-all resource use efficiency. Indeed, there is a requirement on the environmental regulator to consider the impacts of its interventions on the viability of businesses. Policy makers need to know that the WEEE does more than provide another hurdle for business to jump over, that it will make a difference, and that the responses that emerge are fundamental to product and process design rather than short term coping strategies. In this respect continuous long term monitoring and evaluation of the policy is required to determine actual business achievements in waste minimisation through product development. This might be achieved by working closely with trade associations and business networks.

WEEE combines regulation with some limited use of economic instruments although these are mainly set at recovering the costs of the scheme rather than providing economic incentives as such. There is scope for the latter but this requires a better understanding of the underlying costs and benefits of alternative strategies for waste management in the EEE sector so that incentive charging scheme can be set accordingly. Indeed, the industry itself is best placed to determine appropriate charging regimes that will deliver policy targets in the most economically efficient way whilst retaining flexibility to accommodate different business circumstances at any point in time. As in other sectors, it should also be possible to design charging or permitting schemes in accordance with the degree of environmental risk.

In a wider sense these findings suggest that it is often difficult to determine the influence of any one policy instrument, in this case charges for WEEE recovery, on stimulating innovatory approaches in companies to improve resource use, waste management and sustainability. From this perspective, a better understanding of how environmental management decisions are made within organisations is essential, using the components and linkages presented in Fig. 1 as a starting point. It is apparent that responses to environmental policy are strongly influenced by many factors external and internal to the firm, including markets, competition, technology and institutions. This exploratory review of the WEEE Directive in the lighting sector confirms that understanding these wider factors is an essential prerequisite for effective policy-making and that in most cases a mix of policy interventions is likely to be appropriate.

Acknowledgements

This study was part funded by the Environment Agency of England and Wales. The views expressed are the authors' alone. The authors also wish to thank two referees for their extremely helpful comments.

Appendix A. Case characteristics

Case	Main product type[a]	Household/business markets	Home country	Export	Employees	Trade assoc. member	Informants
A	Lamps	Both households and businesses	The Netherlands	Global	47 000 (lighting division)	Yes	Eco-design manager
B	Lamps	Both households and businesses	Germany	Global, Europe 35%, Americas 50%, Asia Pacific 12%	35 000	Yes	Head of environmental affairs/technical director
C	Luminaires	Mostly households; special B2B department in the retail outlets	Sweden	Subsidiaries in 31 countries, in Europe 80%, North America 17%, Asia 3%	70 000 (entire company)	No	International environmental manager Environmental manager Sweden, retail outlets Environmental manager, product development Product engineer, lighting division
D	Luminaires	Mainly business; unusual that households are end-users	Sweden	Subsidiaries in north-western Europe; sales to Middle East and Australia, outside Sweden: ≈50%	1200	Yes	Environmental manager Development manager Accounting manager
E	Luminaires	Mainly business; households may be end-users of a small portion of sales	UK	Sales offices in the Netherlands, France and the Middle East	90	No	R and D/marketing manager Engineering manager (products)
F	Luminaires	Both households and businesses	Germany	Sales offices in 30 countries, global sales	150	Yes	Design engineer (Financial director)
G	Luminaires	Mainly business; household purchase through webpage	UK	Mostly domestic sales; some export to Russia	15	No	Product engineer Project engineer
H	Luminaires	Mainly business; households are end-users of a small portion of the sales	Sweden	Mostly domestic sales; some export to the Nordic countries and Germany	20	Yes	Managing/marketing director Product development and production manager

[a] Lamp: bulbs, tubes and similar. Luminaire: light fitting.

Appendix B. Survey questions

Informant
Role in the company; years in this position; background

Environmental criteria in product development and driving forces
Who determines product criteria?
Are there any environmental criteria in the product development process?
When and why were they introduced?
What environmental/waste minimisation aspects are emphasised? (particularly product size, product life span, reuse, repair, disassembly, recyclability)
Are the criteria binding or voluntary?
Are the achievements monitored; how?

Producer responsibility
Are you familiar with the term producer responsibility?
What actions did the company's awareness of producer responsibility for WEEE lead to, if any?
What options were considered for the responsibility and why?
What kind of solution did the company choose for fulfilling its producer responsibility for WEEE?
What were the reasons for the choice?
Who was involved in the decision?
What is the basis for the charges for producer responsibility? (fixed or variable)

Costs, prices, competitiveness
What costs are monitored and controlled in the product development process?
Does/will the costs of producer responsibility affect product prices?
How has/will this affect(ed) sales and competitiveness?
How has/will the company tried/try to influence its costs for producer responsibility?

Appendix C. Case study evidence of eco-design and waste minimisation-general; indicators and achievements

Case	General eco-design drivers and practices, including supply chain pressure	Waste minimisation indicators	Achievements
A, Neth lamps	Early 1990s management envisaged the business importance of eco-design; co-operation with academics. Computer-based tool to measure environmental impacts of products; Increasing customer demands from customers for environmental management and green products; environmental demands on suppliers through a staged model: from substances via environmental management to environmental best practice	% or times improvement; baseline: previous product % recyclability; total use hours (sample products)	25–60% weight reductions, 6 times longer life (individual products), near 100% recyclability (no baseline)
B, Ger lamps	Examples of material reuse, product size reduction and improved recyclability in the 1960s, 1970s and 1980s driven by cost saving potentials; now environmental considerations from product planning stage. ROHS Directive more important for eco-design than WEEE Directive. Environmental demands from European business customers; demands on suppliers re substances and environmental programmes	% or times improvement; baseline: previous product % recyclability; total use hours (sample products)	Example of reduced size, but no indicator or over-all figures; examples of increased product life but not no over-all figures; 100% recyclability (no baseline)
C, Swe lum	Product size reduction since the start due to cost saving potentials; eco-design tool/guidelines developed from experiments with LCA in mid-1990 — applied to all product categories where relevant; voluntary except for certain binding rules; few direct environmental demands from customers; Work with suppliers through staged model for action plans and EMSs	Sample products (of which one lighting) times or % improvement	Little on lighting products; claimed: energy consumption of lamp, size reduction, extended life
D, Swe lum	Late 1990s: eco-design opportunity to ensure continuous improvements required by EMS, although requirement not directed at products; environmental checklist applied in product development; Some environmental demands from public procurers	No	N/A (claimed: changes in substance contents, data not made available)
E UK, F Ger, G UK SME, lum	Product specs based on customer requests—no direct environmental customer demands. Waste minimisation and environmentally friendly aspects where they are driven by commercial advantages	No	N/A
H, Swe SME lum	Environmental aspects of products discussed in the company's product committee; except EPD, no formal environmental guidelines, recyclability said to be considered. Some environmental demands from architects and public procurers	No	Claimed: changes in substance contents; no absolute over-all achievements reported

Appendix D. Case study results on costs of producer responsibility

Case	Producer responsibility solution	Cost % product price	Costs transferred to product price (elasticity)	Cost avoidability, short term (ST), long term (LT)	Cost-reducing strategies	Solution decided by
A, Neth lamps	Advocate visible fees; (joint)	≈ 60%[a]	Yes; no anticipated effect on competitiveness	ST: No, LT: Co-operation producers–recyclers to develop recycling techniques and product properties	Influence legislation; develop recycling technology; Different techniques by recyclers prevent cost savings by product design	Corporate task force
B, Ger lamps		≈ 60%[b]	Yes; no anticipated effect on competitiveness	ST: No, LT: Co-operation producers–recyclers to develop recycling techniques and product properties	Influence legislation; develop recycling technology; Highly standardised products prevent competitive advantage through eco-design	Corporate task force
C, Swe lum	Individual: contractors	Costs not calculated nor added to product prices	No. Low WEEE volumes → low costs incurred	ST: (Reduced take-back; not actively applied method), LT: Contract renegotiation: costs variable with eol properties. Not considered currently	Cost-reductions in all business activities, not end-of-life specifically	Env managers
D, Swe lum	Joint (PRO)	≈ 0.5–3%[c]	Yes; no perceived effect on sales/competitiveness, (Yes; no anticipated effect on competitiveness)	ST: No, LT: Yes, due to large market share	None related to cost transferred to customers (cost savings in material input)	Env manager,
E UK SME lum	Not considered*	Not estimated	(Yes; no anticipated effect on competitiveness)	Not considered	Not considered	not considered
F, Ger SME lum	Low faith in joint schemes	Not estimated	(Yes; no anticipated effect on competitiveness)	Not considered	Not considered	Jointly by various functions
G UK, SME lum	Not considered	Not estimated		ST: No, LT: Not considered	None. Costs would be transferred to customers	Not considered
H, Swe SME lum	Joint (PRO)	≈ 0.5–3%[d]	Yes; no perceived effect on sales/competitiveness	ST: No, LT: Not considered	None related to producer responsibility; costs transferred to customers	Managing Director

Producer responsibility for WEEE only applied to cases C, D and E. Responses from the other cases were based on anticipatory action or assumptions.

[a] Estimates by trade association.

[b] Estimates by trade association.

[c] Estimation based on unit prices published by PRO applied to sample product prices. No weighting has been carried out for the relative sales volumes of different product; Not estimated or not considered by companies.

[d] Estimation based on unit prices published by PRO applied to sample product prices. No weighting has been carried out for the relative sales volumes of different product; Not estimated or not considered by companies.

Appendix E. Waste minimisation and eco-design drivers and constraints by case companies

	Product size reduction		Product longevity		Disassembly		Recycling potential		Substance restrictions		Energy savings	
Drivers	Cost savings in material input (packaging and transport)	B*, C, D, E, G	Customer demand	A, B (F)	Replacement of lamps and control gear	E, G, H	Material reuse (=cost saving)	A, B	Public debates and regulations	A, B C, D	Sales argument (win–win economic-env)	A, B, C, D, E, G
	Customer preference for unobtrusive fittings	F			Easy assembly → easy disassembly	F	Environmental life cycle considerations	A, (B) C, D, (H)	Specific mention of the ROHS Directive	B, C		
	Ease of installation	D					(Products already easily recyclable)	(B),E, F, G				
Constraints	Large rooms requiring large individual product	D, H	Replaced before end of service life due to fashion changes	D, E, F, G, H					No current substitute	A, C	Trade-off with restriction on heavy metals	B
	Small components = difficult/expensive to produce	A, F	Need for more durable expensive materials and investment in tooling	E								
	Compromised safety and quality (smaller surface to dissipate heat)	G										

*Letters indicate case identity. Dr: Driver. Con: Constraint.

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