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Producer responsibility for WEEE as a driver of ecodesign

Case studies of business responses to producer responsibility charges

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ABSTRACT

Due to potential environmental, resource and health problems associated with waste, waste minimisation is a prioritised waste management strategy in many countries. Producer responsibility policies promote waste minimisation by stipulating separate collection and recycling of particular waste streams. In addition, a purpose of the policy is to encourage product development that reduces waste generation and improves recyclability. It is sometimes assumed that the financial responsibility assigned to producers for collection and recycling of their end-of-life products will instigate waste minimising product development in order to reduce costs. However, this view has also been contested.

Following the adoption of the WEEE Directive (2002/96/EC) all EU member states have to implement producer responsibility for WEEE. Taking a qualitative multiple case study approach, this study explores company responses to the costs of existing national producer responsibility policies for WEEE in relation product development. The purpose is to inform policy-making on the effectiveness of producer responsibility charges in achieving waste minimising product development.

The study comprises both large companies and SMEs in the lighting equipments sector. It also includes companies in EU member states without producer responsibility for WEEE in order to see if there are any differences in waste-minimising product design among countries and if national policies have an impact beyond national borders. Economic principles and previous research findings on ecodesign make up the analytical framework for the study.

Quantitative data on cost-benefits of ecodesign and waste minimisation achievements were scarce. However, the company responses show that the costs imposed on the producers by the WEEE policy have had little effect on product development so far. The costs can generally be transferred to customers via product prices. The price increases were generally small and without any negative effects on competitiveness. Other drivers such as bans on certain substances, environmental industry product declarations, commercial advantages including direct customer demands from for instance public procurers, are more effective.

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Terms and abbreviations

EEE:	Electrical and electronic equipment
EPD:	Environmental product declaration
WEEE:	Waste electrical and electronic equipment
Collective producer responsibility scheme:	Producers pay a fee to an organisation that is set up specifically for administrating operations related to producer responsibility, such as collection and recycling
Ecodesign:	Environmental considerations in product development
Individual solution (to producer responsibility)	Producers arrange their own individual systems for collection and recycling with contractors
Luminaire:	Light fitting
ROHS	Restriction of hazardous substances (in electrical and electronic equipment)
Waste minimisation:	Strict avoidance (eliminating consumption), reduction at source (reducing material intensity and hazardous substances), product reuse, recycling (OECD, 2002)
Waste prevention:	Strict avoidance, reduction at source, product reuse

1. INTRODUCTION

1.1. Background

An increasing amount of legislation from the European Union (EU) on waste and the scarcity of suitable landfill sites in the UK forces the country to move from a heavy reliance on waste disposal to landfill to other waste management methods such as recycling and waste reduction (Davoudi, 2000). These approaches covered by the term 'waste minimisation' form part of the government waste strategy for England and Wales (Department of the Environment Transport and the Regions, 2000). Economic instruments have gained popularity in environmental and waste policy (Dryzek, 1997; Hogg & Hummel, 2002). This MSc project was identified by the Environment Agency (EA) to study economic measures as incentives for increased recycling and waste reduction, drawing on experiences in countries, such as Germany, the Netherlands and Sweden, which are considered to be forerunners in the field (Cooper, 2000; Dryzek, 1997).

The focus of the thesis was set in the context of the impending implementation of the EU Directive on producer responsibility for waste electrical and electronic equipment (2002/96/EC), also called the WEEE Directive (Official Journal of the European Union, 2003). Producer responsibility policies aim at making producers responsible for the collection and recycling of their end-of-life products, and are often coupled with quantitative recycling targets (OECD, 2001). The costs imposed on producers are sometimes assumed to stimulate product development for waste minimisation in order to reduce the costs to companies for the handling of their end-of-life products (Cooper, 2000; Lindhqvist, 2000). Article 4 of the WEEE Directive (2002/96/EC) caters for product design that facilitates disassembly, reuse and recycling (Official Journal of the European Union, 2003).

Although there are studies that show that government policy and producer responsibility are important stimuli of product design that take environmental impacts into consideration,

there also indications that economic policy instruments may influence product development to lesser extent than theory presumes (Hemmelskamp, 2000). Furthermore, the European Commission claims that the impact of producer responsibility on product design is largely unknown (Commission of the European Communities, 2003b).

1.2. Aim

This study aims to explore empirically how the costs imposed on companies by producer responsibility schemes have influenced product development in the electrical and electronic equipment sector, with a view to inform policy-making.

1.3. Objectives

In order to achieve the aim, four subsidiary objectives were formulated. These objectives are:

1. To establish any link between the policy aims of waste minimisation and the waste minimisation performance in product development
2. To establish whether the responsibility of producers to finance the collection and recycling of their end-of-life products has affected product development
3. To identify alternative influences on waste minimisation in product development
4. To provide policy recommendations for the implementation of producer responsibility for WEEE in the UK, with regards to product development

2. LITERATURE REVIEW

A literature review of previous research was conducted in order to identify key concepts, theoretical and methodological approaches in the subject area. Chapter two comprises this literature review. Firstly, the starting point in the problems with waste is presented. Secondly, the environmental and waste policy context is discussed in terms of a move from end-of-pipe and end-of-life towards preventative measures, in particular policy priorities of waste prevention; the policy-ambition to stimulate corporate innovation and an account for environmental policy instruments and evaluation criteria. Thirdly, the concept and economic mechanisms of producer responsibility for WEEE are discussed. Fourthly, drivers, focus areas and measurements of ecodesign are examined. Finally, the economic mechanisms and other drivers of ecodesign, the focus areas and measurements of ecodesign are drawn together into an analytical input-process-output framework.

2.1. Waste

Production and consumption are cornerstones in modern industrial societies since they contribute to economic growth. Economic growth is generally understood to generate welfare (Begg, 2003). However, production and consumption also gives rise to unwanted by-products, such as waste (European Environment Agency, 2003; Lewis & Gertsakis, 2001). The legal definition of waste is 'any substance or object […] which the holder discards or intends or is required to discard' (Bates, 1997; European Council, 1991). Waste is an indication of excessive and inefficient use of natural resources (Commission of the European Communities, 2003a; Jacobsen & Kristoffersen, 2002; Read, 1999). Furthermore, the pollution that arises from waste disposal and treatment is a potential threat to humans and other organisms, as well as to renewable natural resources and eco-system services (McDougall et al., 2001; Schnurer, 2002).

Waste generation continues to grow, often at a rate exceeding or equalling the economic growth rate. Only a in a small number of countries in Western Europe are there signs of decoupling of growth in the economy and in waste generation (European Environment Agency, 2003).

2.2. Environmental and waste policy

The emergence of environmental problems on the political agenda led to the development of government policies aimed at mitigating negative environmental impacts. Largely, environmental policies have focused on controlling pollution, and punishing perpetrators after the damage has been done. There, is however, a shift in emphasis towards integrating pollution control with preventative measures (Connelly & Smith, 2003; Dryzek, 1997; Gouldson & Murphy, 1998). Typically, environmental policies targeting businesses have focused on the environmental impacts of production processes (Dalhammar, 2002). However, since a large part of environmental impacts emanate from the use phase and end-of-life products, policy attention to products and product development has recently been recognised as an opportunity for pollution prevention (Commission of the European Communities, 2003a).

A similar extension of interest from end-of-pipe solutions to prevention can be seen in the waste policy area. Although much effort is still directed towards alleviating the environmental impacts of landfill and incineration, there is a change in perception towards viewing waste in a resource management perspective starting with product development (Commission of the European Communities, 2003b; Wilson et al. 2001).

A hierarchy of preferred options for waste management is an often cited guideline for waste management decisions (figure 1). Waste reduction is the top priority for abatement of environmental impacts, followed by reuse, materials recycling and energy recovery, while disposal is to be avoided (European Council, 1991; Department of the Environment Transport and the Regions, 2000; Strategy Unit, 2002).

Figure 1 A hierarchy of preferred waste management options (Davoudi, 2000 p. 171)

The waste hierarchy in figure 1 is sometimes contested for being simplistic. A point of debate is whether recycling and incineration with energy recovery should be treated as equally desirable or, if not, which option is more environmentally friendly (Jönsson et al. 2003). An alternative hierarchy has been developed that addresses this disagreement (figure 2).

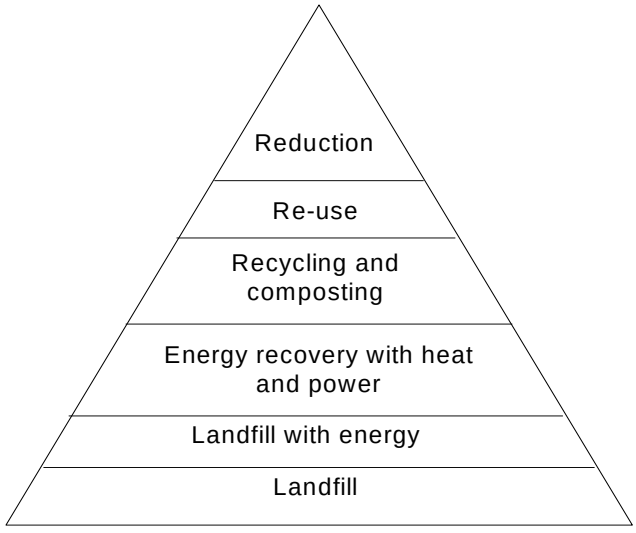

Figure 2 A detailed version of the waste hierarchy (Strategy Unit, 2002 p. 44)

Regardless of its higher level of detail, this version of the waste hierarchy fails to address another critique of the model: the lack of a cost-benefit dimension of the different options in the waste hierarchy in relation to specific materials, geographic location and

infrastructure (Davoudi, 2000; McDougall et al., 2001; Strategy Unit, 2002). These shortcomings notwithstanding, the waste hierarchy still informs many waste policies.

Different pieces of legislation have been adopted in Europe both at the national and the EU level, that are expected to drive this move towards waste minimisation and away from disposal and incineration. Table 1 shows examples of waste related EU legislation.

Table 1 Example of waste related EU legislation. From Wolf (2002)

Legislation	Key contents
The Waste framework Directive (75/442/EEC) as amended by Directive (91/156/EEC)	Defines waste and outlines waste management priorities; outlines requirements for disposal infrastructure and waste management authorisations
The Landfill Directive (99/31/EC)	Defines types of landfills and specifies technical and management requirements for them; poses quantitative restriction on disposal of biodegradable waste to landfill
The Directive on Packaging and Packaging Waste (94/62/EC)	Determines requirements to establish collection and recycling infrastructure for packaging waste; sets quantitative targets for the collection and recycling
The Directive on End-of-life Vehicles (2000/53/EC)	Outlines requirements to establish collection and recycling provisions for end-of-life vehicles; assigns the costs of this to the producer; sets quantitative recycling targets

Recent policy documents discuss further developments in the area, for instance towards an integrated product policy (Commission of the European Communities, 2003a), a thematic strategy on the prevention and recycling of waste (Commission of the European Communities, 2003b) and a framework Directive on ecodesign of energy-using products (also called the EuP proposal) (ENDS, 2003a).

EU Directives supersede national legislation and member states are obliged to implement EU Directives into national policies, although they have some discretion as to how the legislation is implemented (Connelly & Smith, 2003). In the UK, EU waste regulations are implemented into national law through pieces of legislation such as (Wolf et al., 2002):

- the Environmental Protection Act 1990 and 1995
- the Waste Management Regulations 1994
- Producer Responsibility Obligations (Packaging Waste) Regulations 1997

In Finland, the policy instruments utilised for national implementation of the legislation have been found to move waste management up the waste hierarchy only partly, failing to achieve the highest priority of waste prevention (Kautto & Melanen, 2004).

2.3. Environmental policies and innovation

The effect on competitiveness is a often a cause for grievance from industry when environmental policies are enacted (Clark & Guy, 1998; Dryzek, 1997). This is a reason for policy-makers to try and incorporate incentives that will stimulate competitiveness (Ernst and Young & Science Policy Research Unit, 2001). Innovation is often seen as a key to competitiveness, both at the company level and at a national level (Clark & Guy, 1998; Trott, 2002; VINNOVA, 2002). As a result, promoting innovation has become an important part of national policy in developed countries (Clark & Guy, 1998; VINNOVA, 2002). Environmental policies have not traditionally been designed to drive innovation. Therefore environmental and innovation policies need to be co-ordinated (Dalhammar, 2002; Naturvardsverket, 2002a; Rennings et al., 2000).

The term 'innovation' comprises the conception and implementation of new ideas, technologies, devices, organisational processes and marketing approaches (Markusson, 2001; Trott, 2002). Business innovation is a wide subject area with many possible analytical methods. Examples are technological, economic, and systems-based approaches (Baumann et al. 2002; Rennings et al., 2000). Contingency theory offers yet another viewpoint (Sanchez & McKinley, 1998). A systems based approach appears to be particularly useful for understanding the wider context of corporate environmental innovation, including technological and economic influences along product chains. However, this approach is also demanding in terms of time and data accessibility. This thesis is limited to environmental aspects of product development in line with the aims of producer responsibility (see section 1.1 and 2.5) and will draw on previous findings in ecodesign research (see section 2.6).

2.4. Policy instruments and evaluation

A range of policy instruments are available for mitigating environmental problems. Usually they are divided into regulatory, economic and voluntary (informative) instruments (Connelly & Smith, 2003; Markusson, 2001). These policy instruments are described in this section, followed by a note on policy evaluation.

2.4.1. Regulations

Assuming that an agency is in place to monitor legal observance and to sanction breaches, regulations are held to be effective in setting environmental standards and securing achievements. These achievements may be reached without the time delays that occur with economic and voluntary instruments. The disadvantages of regulations are that they require monitoring by authorities who may have significantly less knowledge about the issues than the companies they are regulating (Connelly & Smith, 2003). Furthermore, the same standards are imposed on all polluters regardless of individual possibilities for abatement and consequent differences in cost of compliance. Legislated standards are said not to stimulate performance beyond the targets and it is relatively complicated to change the standards (Connelly & Smith, 2003; Markusson, 2001; Panayotou, 1998).

The ability of environmental regulation to stimulate innovations and lead to competitiveness and economic growth is an issue open to debate. The traditional view is based on the assumption that companies are profit maximisers always operating at an optimal level of profitability. According to this line of reasoning there is no further scope for improvements. Costs of compliance with environmental regulations are seen as inhibiting more productive investments and thus resulting in disadvantages compared to unregulated competitors (Markusson, 2001; William et al., 2002).

A counter argument is that due to inertia and imperfect information, initially optimised business systems may not have kept up with change. Thus there may be some scope for improved profitability. Porter and van der Linde (1995) hypothesized that regulations

designed to stimulate innovation leads to competitive advantage that may offset the cost of regulatory compliance. The hypothesis has, however, been criticised for being based on a very specific kind of regulation that bears little resemblance to regulation in practice (William et al., 2002).

Empirical evidence as to the role of environmental regulations for competitiveness is inconclusive. At a micro level cases can be found that both support and reject Porter and van der Linde's (1995) hypothesis. At the macro level, William et al. (2002) suggest that research indicates a positive relationship between environmental regulation and competitiveness at the macro level. The effects of direct regulations depend on how the standards are implemented, monitored and sanctioned.

2.4.2. Economic instruments

Economic policy instruments receive increasing interest (Drake et al. 2003; Dryzek, 1997; Tews et al. 2003). Dryzek (1997) claims that countries with a social democratic social organisation, such as Germany and the Netherlands have led the way in environmental economic policy.

In general terms, economic instruments are claimed to be more flexible than regulatory regimes and thus more cost-effective (Connelly & Smith, 2003). With economic policy incentives, companies with lower costs of compliance are assumed to seek continuous improvements. Companies that would need to make relatively large environmentally related investments may choose to pay a higher cost of the economic instrument instead. In this way, the same overall achievements are reached to lower total compliance costs than is the case with regulations. The need for policing is reduced, resulting in lower costs for authorities. Another benefit of economic instruments is the ease with which they can be modified to cater for changes in desired environmental standards. Disadvantages are that some firms may not be responsive to the costs, and the mechanism becomes a pure revenue generator. The desired outcome may not be achieved or may occur only after a significant time lapse.

Deposit refunds, tradable permits, taxes and charges are examples of economic instruments. These will be described below.

2.4.2.1. Deposit refund systems

In deposit refund systems the buyer pays a deposit at the point of purchase and receives a receipt for the deposit. This deposit is refunded when the waste product is returned for recycling. The system aims at securing a material flow for recycling. The deposit should cover the costs for the collection and the refund should reflect the value of environmental costs avoided through collection and recycling (OECD, 2001). Deposit refund systems have yielded high return rates for short-lived products such as beverage containers (ibid). For durable goods, however, such as many WEEE products, the value of the refund may have been reduced by inflation to the extent that it is no longer an incentive for the user to return the product at its end-of-life (Department of Trade and Industry, 2002).

2.4.2.2. Tradable permits

In the OECD guidelines to governments on producer responsibility, tradable permits are not discussed, but are mentioned as a potential support for producer responsibility policies (OECD, 2001). Tradable permits are based on the creation of property rights for pollution and the exploitation of certain environmental resources that were previously free. The target level of pollution is set to a desired standard and industries are given the right to pollute up to a certain level, or to sell spare rights to other companies. The price is determined by supply and demand, which will depend on the companies' costs of reducing pollution (Connelly & Smith, 2003).

Tradable permits are believed to be an incentive for companies to reduce pollution continually in order to be able to sell rather use permits. If leased by authorities, rather than sold, permits can be withdrawn in order to target a higher environmental standard. Unlike taxes, the level does not need to be adjusted by authorities.

These properties are said to make tradable permits a flexible and efficient instrument, while achieving the desired environmental standard. However, difficulties may arise in establishing the carrying capacity of the receptor, and in determining the standard for one type of pollutant when multiple pollutants cause the negative impact. Furthermore, tradable permits may neglect differences in loads and sensitivity of receptors. A differentiation of markets for different receptors leads to increased transaction costs. Similarly, administrative costs will be high if there are many polluters in the market (Connelly & Smith, 2003; Hanley et al., 1997).

A kind of tradable permits system has been applied in the UK for the producer responsibility of packaging and packaging waste, although it has been argued that it was not designed as one (Green Alliance, 2003). Recyclers issue compliance notes, which companies buy and use to demonstrate regulatory compliance. Increased competition between recyclers, potentially leading to lower recycling costs is a potential advantage of tradable permits for producer responsibility. However, the system with packaging notes has been criticised on the grounds that recyclers have not used the revenues to develop the infrastructure for collection (ENDS, 2003b). The estimation of waste arisings on which to base the targets for the permits is another problem (Department of Trade and Industry, 2002).

Tradable permits have not been used anywhere for producer responsibility for WEEE (Department of Trade and Industry, 2002). Consequently, the effects of such a system on ecodesign cannot be studied empirically.

2.4.2.3. Charges

Charges are a common form of economic policy instrument. The terms environmental charges and environmental taxes are sometimes used interchangeably, see for example Connelly and Smith (2003). Both impose an additional cost on a commodity for the purpose of internalising an environmental externality. Panayotuo (1998), however, points out that taxes are a way of generating revenue for the government budget, whereas charges

are payments for a service, simultaneously recovering costs and controlling demand. Turner et al. (1994) distinguish between emission charges, product charges and user charges. The former two are related to the amount of environmental damage caused by the emissions or the products, whereas the latter is aimed at recovering costs for the service provided, such as waste collection and treatment, without any direct link to environmental damage. Unlike market prices, charges are set by authorities or other types of 'regulated natural monopoly' (Panayotou, 1998 p. 37).

The diagram in figure 3 illustrates the effects of pollution/product charges on supply and demand of a good, *ceteris paribus*. For this purpose, the terms taxes and charges are used interchangeably.

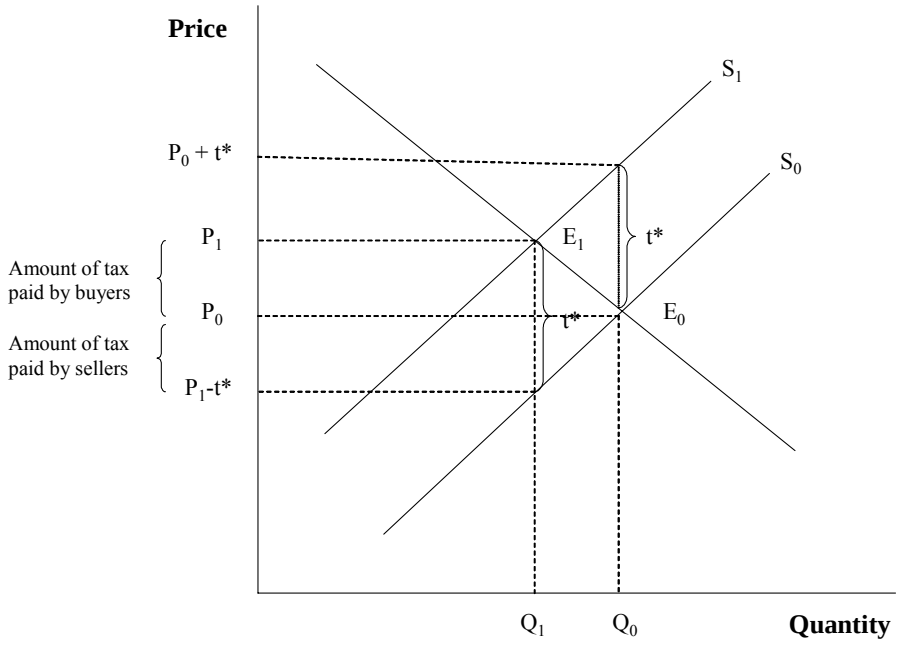

Figure 3 Supply and demand with a product charge (Turner et al., 1994 p. 172)

When a charge is imposed on a product, companies are likely to want to maintain profit margins by adding the cost of the charge to the original product price (P_0 + t*) while upholding sales volumes (Q_0). The supply curve S_0 shifts to S_1. However, demand is likely to decrease if the price rises. Supply and demand find a new equilibrium at E_1. The price will drop to P_1 and the quantity will fall to Q_1. The burden of the charge is shared between buyers and sellers. Sellers now receive the price at P_1- t*, which is a drop in the marginal revenue from the original price P_0. Customers pay the price at P_1, which is an increase compared to the original price P_0 (Turner et al., 1994).

The incentive effect of charges on innovation depends on the proportions of costs borne by producers and customers respectively. If producers can raise prices without it affecting prices and quantities sold, there is little incentive for them to innovate in order to reduce costs. If, on the other hand, producers have to accommodate a larger share of the charge so that their profit margins shrink as a result of lower revenues per sold unit and reduced quantities, they may seek ways of reducing costs. The price elasticities of supply and demand of a good determine what proportion of the charge will be borne by producers and customers respectively (the tax incidence) (Turner et al., 1994).

2.4.2.4. Price elasticities

Price elasticity of demand is a measure of the change in demand in response to a change in price. If a given increase in price leads to a proportionally larger drop in demand, demand is elastic. If a given increase in price leads to a proportionally smaller drop in demand, price is inelastic. Demand elasticity depends on the value a buyer places on an additional unit of the commodity (Lipsey & Chrystal, 1995). If the price of a product rises and a close substitute is available at a price that remains lower, the demand of the former is likely to be more elastic than if no substitute were at hand.

The availability of substitutes depends on how narrowly the product is defined. Broadly defined products such as food do not have any substitutes and thus have inelastic demands. Similarly, some durable electrical and electronic equipment, like refrigerators, have no

close substitutes and therefore demand is inelastic. All the same, purchases of new durables as replacement for old can usually be more readily deferred than products with a short functional life span, although the product category may be a necessity without a close substitute (Lipsey & Chrystal, 1995). In the long term, development of substitutes may have taken place. Thus, for many products, demand can be expected to be elastic in the long term. Also, the demand for individual brands may be elastic even if demand for the product category is inelastic.

Supply elasticity is a measure of the change in supply when prices change. Supply is elastic when suppliers can and do change their output volume of a product to an extent proportionally larger than the change in price. Supply is usually more elastic in the long term than in the short term (Lipsey & Chrystal, 1995).

If customers are relatively insensitive to increases in price, they will carry the largest burden of the charge. Figure 4 illustrates the tax incidence of a product charge when demand is inelastic.

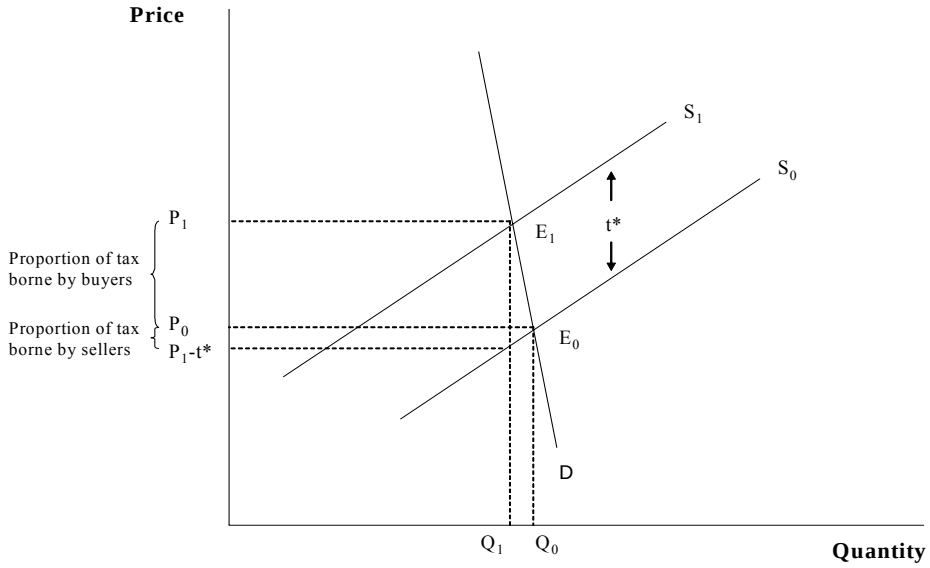

Figure 4 Tax incidence for a product with inelastic demand (Turner et al., 1994p. 173)

Despite the price increase, buyers only reduce their purchases to a small extent. Given the costs of production and technology reflected in the supply curve, the equilibrium after the charge (E_1) occurs at a relatively high price level (P_1) and only induces a small reduction in sold quantities (Q_0-Q_1). As a consequence, buyers pay the largest proportion of the charge.

Figure 5 illustrates the opposite situation where suppliers carry the largest part of the charge as a result of elastic demand.

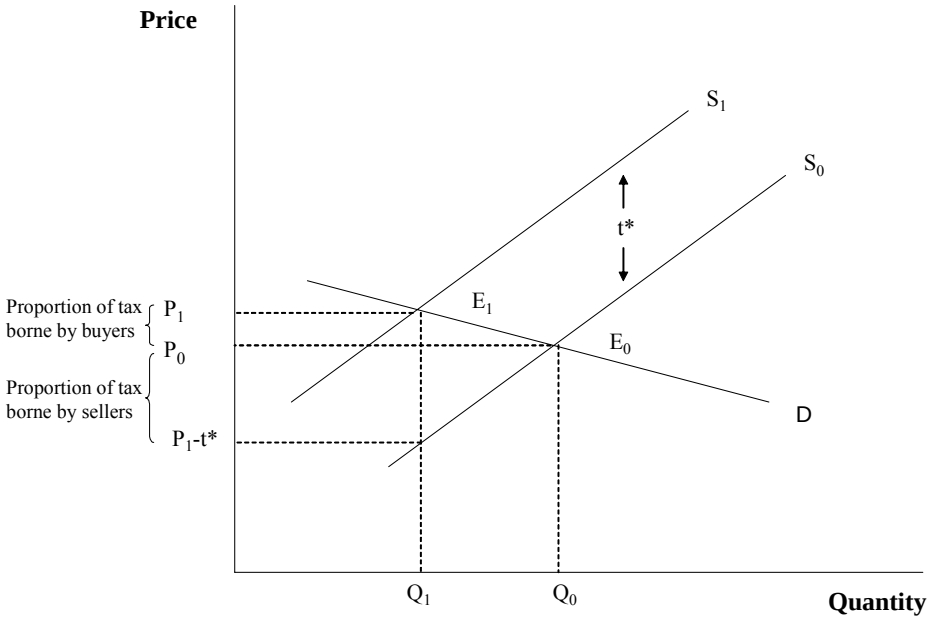

Figure 5 Distribution of tax burden for a product with elastic demand, after Turner et al. (1994)

For products with elastic demand, buyers respond to price increases by reducing their demand to a proportionally large extent. The new equilibrium (E_1) means a relatively large decrease in quantities sold (Q_0-Q_1) and that buyers bear a small part of the charge.

In reality a number of factors other than price determine customer demand, whereas these factors are assumed to be constant in the theoretical principles related above (Drury, 2001).

In practice, it is difficult to calculate price elasticities for individual products because they are differentiated and thus not directly comparable. Many companies also produce a large number of products with complex inter-relationships (cross-price elasticity). Thus, in this study no attempt will be made to calculate price elasticities. Instead, information will be sought as to whether companies pass the costs of producer responsibility on to the product price, and whether they feel that this has affected their sales.

The extent to which the charges will achieve a change in corporate behaviour depends on the size of the charge. Too low rates may not be noticeable and have the desired incentive effect on demand (Connelly & Smith, 2003). The cost-reducing behaviour of producers will also depend on whether or not they can avoid the additional costs, in the context of this study through product development.

2.4.2.5. Cost behaviour

When companies make decisions that regard costs, sometimes a distinction is made between costs that can be avoided through the decision, and costs that cannot be avoided (Drury, 2001). Whether or not costs can be avoided depends on whether they are fixed or variable, and also on the time frame. Variable costs change in relation to a certain feature, and can thus be reduced through decisions relating to that feature. Fixed costs are constant in the short term. Examples are production capacities and current technologies. Fixed costs cannot be avoided in the short term. However, over a longer period of time it is usually possible to make changes that affect costs that are fixed in the short term. Therefore in the long term, all costs are variable and can be avoided.

2.4.3. Voluntary agreements

Similarly to economic measures, voluntary agreements have received growing attention as environmental policy instruments (Cabugueira, 2001; Gouldson & Murphy, 1998; Rosen, 2002). Voluntary agreements can be established between government and industry, or between individual firms (OECD, 2001). The Netherlands is known for its application of

consensual policy approaches (Gouldson & Murphy, 1998). For instance, producer responsibility for packaging waste in the Netherlands was implemented as a voluntary agreement (Lindhqvist, 2000). (However, the subsequent national producer responsibility for WEEE was implemented as a regulation).

Benefits of voluntary agreements include the provision of sector specific needs which enhances the sense of fairness and acceptability; ease of introduction compared with regulations; reduced administrative costs resulting in increased cost-effectiveness; and inter-organisation learning (Cabugueira, 2001; Connelly & Smith, 2003; Gouldson & Murphy, 1998).

Other aspects detract from these benefits. Voluntary agreements need to be monitored for effectiveness and often work under the threat of enforcement of legislation. Thus, the size of the cost reduction for administration may be smaller than initially assumed (Markusson, 2001; Panayotou, 1998). Furthermore, the negotiating process entails transaction costs. The transaction costs for companies can be reduced if negotiations are managed by trade associations (Cabugueira, 2001). However, not all firms are members of trade associations. This may detract from the sense of fairness, acceptability and joint learning. It also increases the risk of non-members taking advantage of the absence of regulatory pressure, while not bearing the transaction costs and the potential costs for fulfilling the environmental standards of the agreements. This ‘free-riding’ behaviour reduces the fairness of the measure. Furthermore, industry use of trade associations and voluntary agreements to reduce the impacts of the policy are threats to the effectiveness of voluntary agreements (Cabugueira, 2001).

Standards are a particular kind of voluntary agreement that can apply to both processes and products. Whereas the scenario above suggested transaction costs for negotiations of agreements, standards can reduce the transaction costs of stakeholder communication, including customers and suppliers (Rosen, et al. 2002). On the other hand, the design of certain standards, like environmental management systems, makes them costly to implement and maintain.

The effectiveness in achieving the environmental goal depends on the type of standard. With no requirement of an absolute environmental performance level, the level of reduced environmental impacts on the receptors cannot be guaranteed (Gouldson & Murphy, 1998). However, this kind of standard may instead encourage continuous improvements. Like many regulations, standards with specific performance requirement guarantee continuous improvements, but provide little incentive for further improvement.

2.4.4. Policy evaluation

The effectiveness of producer responsibility charges in stimulating ecodesign is the main focus of this thesis. Policy recommendations on this aspect will be made on the basis of the findings in this study. It should be remembered that policies need to be evaluated against other criteria as well (Connelly & Smith, 2003; Field, 1997; Panayotou, 1998) including:

- the effectiveness in achieving the environmental objectives
- the cost-effectiveness with regard to different agents, including society
- the incentive to seek continuous improvements
- the ease of introduction and adjustment to changes in environmental status, technology or market conditions
- the predictability of enforcement and development
- public acceptability
- ease of monitoring and enforcement

Policy instruments have different effects depending on the policy mix and the context in which they are applied. The scope of this study does not allow a full policy assessment of all findings.

2.5. Producer responsibility

This section begins by explaining and defining the concept of producer responsibility, sometimes referred to as extended producer responsibility. After that, a background to producer responsibility for WEEE is provided. Finally, economic principles are related to producer responsibility for WEEE.

2.5.1. The concept of extended producer responsibility

Traditionally, producers' responsibility for their products ended at the point of sales or after-sales service. The cost of collecting and treating the end-of-life products fell on local authorities and were shouldered by the tax-payers. Increasing volumes of waste and complexity of products has led to mounting costs for waste management, while the scope for taxation remains limited. By extending the producers' responsibility to the end-of-life management of their products, the cost will fall on producers and may be passed on to the consumer through the price of the product. Thus, producer responsibility can be seen as a market based policy. By buying products that will eventually become waste, it is consumers rather than tax-payers that cause waste to arise (Runkel, 2003).

The costs of end-of-life management are often determined at an early stage in the product development process (Drury, 2001). Of the actors in the product chain, producers are found to be in the best position to change the product design to improve the environmental performance of products. Thereby, producers are also believed to be able to off-set increases in price by reducing the cost of waste management (OECD, 2001).

The notion that producers should have a responsibility for their products after the products' useful lives has existed since the 1970s, although in the early days the idea was generally not implemented in policy (Levy, 2000; Lindhqvist, 2000). An analysis of existing and emerging systems for collection and recycling of waste led to the use of the term Extended Producer Responsibility (EPR) (Lindhqvist, 2000). EPR offered a systematic, preventative method preferable to the previously more piecemeal approaches to waste management,

entailing a combination of regulatory, economic and informative instruments (Tojo, 2001). The EPR principle has been laid down in the waste management laws or environmental framework laws in all EU member states except the UK (Mugnier et al. 2003).

2.5.2. Definitions of extended producer responsibility

EPR has been defined as

> a policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling, and final disposal of the product. […] Extended Producer Responsibility (EPR) is implemented through administrative, economic and informative policy instruments (Lindhqvist, 2000:v)

A similar definition is provided by the OECD:

> [Extended Producer Responsibility is] an environmental policy approach in which a producer's responsibility, physical and /or financial, for a product is extended to the post-consumer stage of a products life cycle. There are two related features of EPR policy: (1) the shifting of responsibility (physically and/or economically; fully or partially) upstream to producers and away from municipalities, and (2) to provide incentives to producers to incorporate environmental considerations in the design of their products (OECD, 2001:18).

The word 'extended' refers to the extension of the producers' responsibility for its products to the after-use phase, implying a concern with the whole life cycle (OECD, 2001). Sometimes the word 'extended' is omitted and 'producer responsibility' stands on its own. One explanation of this is that it is more convenient to use the shorter term 'producer responsibility' but that the meaning remains the same (cf Lindhqvist, 2000). An alternative interpretation is that 'producer responsibility' refers to end-of-life issues while EPR assumes a responsibility for the whole product life cycle (Naturvårdsverket, 2002b).

EPR is sometimes used as an abbreviation for Extended Product Responsibility. This term is used by the U.S. Council for International Business to denote the shared responsibility of all actors in the product chain for the environmental impact of the product over its life cycle (Lindhqvist, 2000). This thesis will not explore the concept of extended product

responsibility further. Here the term 'producer responsibility' will be used to mean the responsibility that the WEEE Directive (2002/96/EC) or similar national legislation puts on producers of electrical and electronic equipment.

2.5.3. Producer responsibility for waste electrical and electronic equipment

An increasing number of product categories have become subject to producer responsibility. A recent contribution is WEEE. Due to the complexity of the products, often containing many different materials and components, including hazardous substances, and the increase in the waste stream, WEEE has been considered to have a particular potential for negative environmental impacts (Mayers & France, 1999). The growth in WEEE arisings has been estimated to some 3-5% annually (Cooper, 2000) compared to the annual average growth rate in the EU of 1.1%(Crowe et al. 2002) (OECD, 2003)

In the early 1990s producer responsibility for WEEE entered the EU agenda. The discussions were lengthy and failed to resolve a number of questions. By the mid 1990s the policy still was not much closer to materialising (Cooper, 2000). Member states like the Netherlands, Sweden and Germany chose to pursue the issue in their national policy processes (Cooper, 2000; Department of Trade and Industry, 2002). A Dutch decree on producer responsibility for WEEE was adopted in 1998 and enforcement for some product categories started the same year (Netherlands Ministry of Spatial Planning Housing and the Environment, 1998). A similar Swedish Ordinance (Förordningen om producentansvar 2000:208) was adopted in 2000 and took effect in 2001 (Naturvardsverket, 2002b), while Germany chose to await the development in the EU.

Faced with threats to the operation of the single market resulting from the pending national policies, an EU Directive on waste from electrical and electronic equipment (WEEE) was drafted (Davis, 1996; Cooper, 2000; Mayers & France, 1999; Official Journal of the European Union, 2003). After more than a decade of discussions, the Directive on waste electrical and electronic equipment (WEEE) (2002/96/EC) was adopted 27 January 2003 and is to be implemented by August 2004 (Official Journal of the European Union, 2003).

The Directive applies to equipment which falls within the legal definition of waste and is 'dependent on electric currents or electro magnetic fields in order to work properly […] ' (Official Journal of the European Union, 2003 p. 27).

The overall objective of the WEEE Directive (2002/96/EC) is to prevent WEEE and to stimulate its reuse, recycling, and other forms of recovery. Quantitative targets for the collection and recycling of WEEE, and a requirement to set up an infrastructure for these operations are the main provisions for this objective. Member states are required to collect 4 kg of WEEE per person from private households by the end of 2006. It has been estimated that the UK already exceeds this target (Department of Trade and Industry, 2003). In 2001, on average 10 kg WEEE per person was collected separately. Furthermore, it has been estimated that producer responsibility for WEEE in the UK could lead to between 133000 and 339300 tons less WEEE being landfilled per annum (Department of Trade and Industry, 2002).

Producers are assigned the financial responsibility for these activities. Systems for collection are to be available to the users free of charge. Producers are also obliged to provide information about the collection systems available and the requirement to segregate WEEE at source.

The WEEE Directive (2002/96/EC) includes an article aiming to encourage product design that facilitates the waste prevention objective. This article does not contain any measurable targets, but states that 'Member States shall take appropriate measures so that producers do not prevent, through specific design features or manufacturing processes, WEEE from being reused, unless such specific design features or manufacturing processes present overriding advantages, for example with regard to the protection of the environment and / or safety requirements' (Official Journal of the European Union, 2003 article p. 27). Contacts with civil servants in the Swedish and UK governments respectively, indicated that the EU has not yet conveyed what measures it deems appropriate to this end.

2.5.4. Producer responsibility for WEEE and economic principles

The WEEE Directive (2002/96/EC) and the national WEEE laws in Sweden and the Netherlands share the objectives of making legal provisions for collection and treatment of WEEE, assigning the responsibility to producers, and in addition, to create incentives for waste prevention through ecodesign (Naturvårdsverket, 2002b; Netherlands Ministry of Spatial Planning, 2003; Official Journal of the European Union, 2003).

The Netherlands and Sweden have mainly made use of user charges, that is, charges recovering the costs of a service such as collection and treatment of WEEE. The main costs entailed by these activities are presented in table 2.

Table 2 Business costs of producer responsibility

Cost categories	Key cost drivers
Transaction costs	Identifying appropriate solutions and contractual partners; negotiating contracts (Lipsey & Chrystal, 1995)
Collection	Containers at collection points, other equipment, maintenance, labour, transport; depending on waste volumes and distances between collection points (Theisen, 2002). Opportunity space for 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; information between different stakeholders

In the Netherlands, an organisation for ICT collects payment for waste management costs from producers in retrospect. Other categories of WEEE are covered by an organisation which runs a system of visible fees added to the price of new products. The fees are set so that the revenues cover the costs during a year (Ministry of Housing, 2001). The fees do not vary with the end-of-life properties of the products and the producers cannot opt out of this system. In Sweden there is one predominant not-for-profit organisation to which companies pay a fixed entry fee (3500 Skr≈ £270), an annual membership fee (500 Skr≈ £40) and a fee per type of product and market share (0.08 SKR ≈ £0.01 – 240 Skr ≈ £13 per

product unit). The fees are not variable with the waste-management features of the product. Consequently, the fees for the collective systems in Sweden and the Netherlands are not avoidable for producers in the short term.

In Sweden, EEE producers can also choose to fulfil their responsibility individually, either by collecting and recycling the products themselves, or by contracting out the activities (Naturvardsverket, 2002b). Like collective schemes, the fees for individual schemes cover the costs of the services used, but at market prices. Consequently, the market conditions for recycling services influence the size of the fees. Individual solutions are sometimes believed to be a stronger incentive for product development since the charges allow for variability with the waste end-of-life features of the products (Department of Trade and Industry, 2002; Spicer & Johnson, 2004). Due to the high transaction costs involved in individual solutions, in particular for companies active in many different national markets, and the limited opportunity for economies of scale compared to collective schemes, individual responsibility is not an option for many companies (Department of Trade and Industry, 2002).

In order for an individual solution to have an effect on product design, the recycler needs to know the end-of-life properties of the products, the fees need to be related to these properties and it has to be possible to identify the brand of the waste products (Spicer & Johnson, 2004). Separating collected products according to brand is a potentially costly process. This is particularly true for highly standardised, large volume (number) products with low value (Commission of the European Communities, 2003c). With low product value, the cost of brand separation allocated as cost per unit, might surpass the value of the product. Furthermore, the benefit of design changes to highly standardised products may be limited for individual companies, as there may either be a limited scope for these changes, or the changes may quickly be adopted by competitors. It is also recognised that the influence of future costs on the development of durable products is likely to be limited (Commission of the European Communities, 2003c; Markusson, 2001).

2.6. Ecodesign

This section starts by discussing different terms for product development that takes environmental issues into consideration. After brief comments on incremental and radical design, and different research approaches to ecodesign, research findings of external and internal drivers of ecodesign are explored, along with company characteristics that may influence corporate ecodesign activities. Waste prevention aspects and potential environmental trade-offs are outlined and finally performance measurements are discussed.

2.6.1. Definitions

Concepts related to the reduction of environmental impacts of products have existed since the 1960-70s, but surged in the 1990s. The interest in this area gave rise to terms like green design, Design for Environment (DfE), environmentally conscious design and ecodesign, to mention a few (van Hemel, 1998; McAloone, 1998; Sherwin, 2000). The terms may imply different perspectives but the same terms may also assume slightly different meanings when used by different authors.

McAloone (1998) views green design and DfE as focusing on one or more single issues, the former with a public relations slant, and the latter entailing an engineering approach related to different stages of the product development process. Van Hemel (1998p. 18) takes the term DfE to mean 'the environmental aspects in each stage of the product development process, striving to achieve products which have the lowest possible impact throughout the entire life cycle'. This definition seems to be consistent with McAloone's (1998) view of ecodesign and environmentally conscious design as the integration of environmental considerations in every stage of the product development process, from the very conceptual phase. However, the focus of van Hemel's (1998) research is on different product and production features, whereas McAloone's (1998) area of interest is the product development process and the transition from design to ecodesign.

Lewis and Gertsaki (2001) play down the differences between DfE and ecodesign, pointing to the fact that both concepts essentially seek to facilitate decisions during the product development process which consider environmental impacts. In a similar way, Sherwin (2000) uses ecodesign as an overarching term for environmental considerations in product development. This thesis adopts the term ecodesign in the same generic sense.

2.6.2. Radical versus incremental ecodesign

Ecodesign can be referred to the wider discipline of product development. One of the conceptual distinctions in the vast academic research on product development is between incremental and radical changes. The former are marginal improvements to existing products whereas the latter mark more substantial deviations from previous practices (Gopalakrishnan & Damanpour, 1997). Ecodesign is believed to have the potential to move beyond product improvement and product redesign to innovations that concentrate on the desired product /service function and systems. However, current research suggests that to date incremental changes are predominant in ecodesign (Sherwin, 2000). Furthermore, it has been proposed that more radical practices occur only when a company has gained experience of ecodesign for a number of years (Brezet et al., 2000). This is illustrated in figure 6.

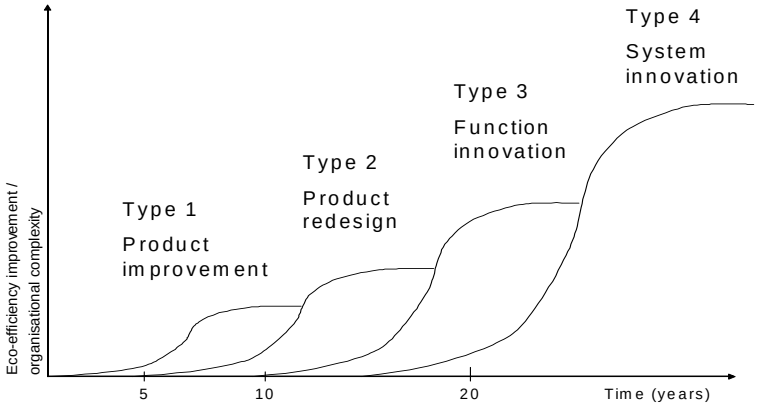

Figure 6 Incremental and radical ecodesign over time (eco-efficiency improvement) (Brezet et al., 2000 p. 859).

Thus, the attention in this study is on incremental changes, even if evidence of more radically new products will be noted should they emerge.

2.6.3. Research approaches to ecodesign

Similarly to research on innovation and general product development, ecodesign studies take different theoretical perspectives as their starting points. Many studies have attended to the development of decision-support tools for ecodesign and often such research has been undertaken in conjunction with or tested on case companies (Bergendahl et al., 2000; Bervoets et al., 2000; Jones et al. 2001; Lewis & Gertsakis, 2001; Lofthouse, 2001; Maxwell & van der Vorst,). Other examples are strategic evaluations of corporate ecodesign programs (Sarkis, 1999), more operational issues and life cycle aspects (Gungor & Gupta, 1999; van Hemel, 1998) and driving forces (McAloone, 1998; van Hemel, 1998).

This thesis is mainly interested in the focus areas, driving forces and outcomes, in order to establish the influence of the financial responsibility of producer obligation for WEEE.

2.6.4. Drivers of ecodesign

This section looks at motivations for companies to undertake ecodesign. These can be divided into external and internal drivers. In addition, company characteristics may influence ecodesign activities (van Hemel, 1998).

2.6.4.1. External drivers

There seems to be a consensus that legislation and customer demand are the most important drivers of ecodesign, external to the organisation (Argument et al. 1998; McAloone, 1998; van Hemel, 1998). There is some disagreement as to the third most influential driver. Argument's et al., (1998) and McAloone's (1998) finding suggest that competition is among the three most important stimuli, whereas van Hemel (1998) found industrial sector initiative to take this place. It is worth noting that different industry sectors and company sizes provide the information for the studies. Argument et al. (1998) and McAloone (1998)

concentrated on large companies, across three industry sectors, and in the electrical/electronics sector respectively. Van Hemel (1998) on the other hand focused on SMEs across a number of industry sectors.

Figure 7 summarises the main external drivers found in the above mentioned studies.

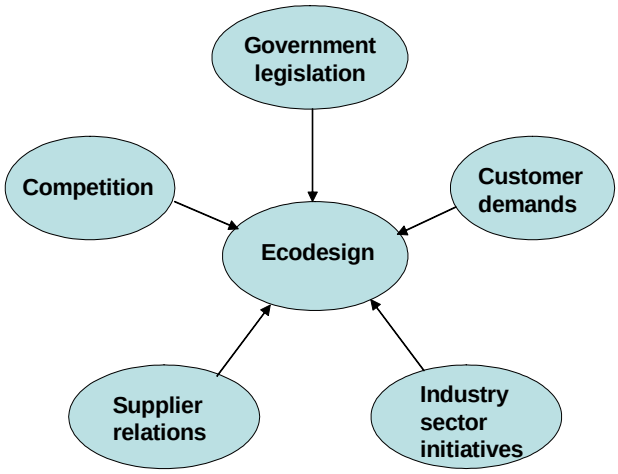

Figure 7 Main external influences on ecodesign, derived from McAloone (McAloone, 1998) and van Hemel (1998)

The importance of legislation for ecodesign activities, in particular producer responsibility policies, is supported by Argument et al. (1998), Tojo (2001) and Zoboli (2000). Studies of changes in product design catalysed by producer responsibility in the packaging, automobile and electrical and electronic equipments (EEE) sectors have found that in some companies the anticipation of legislation has induced efforts to change product design (Davis, 1996; Lindhqvist, 2000; Tojo, 2001; Zoboli, 2000). Reasons for this can either be that they wish to prevent or influence legislation. On the other hand, other studies show that many companies in the EEE sector are not aware of their responsibility (Naturvardsverket, 2002b; Trenchard & Gowland, 2003).

In addition to legislation, customer demands have been found to drive ecodesign. Dalhammar (2002) notes that the importance of market drivers is increasing. It may be, however, that environmental legislation has stimulated these customer demands. For

instance, customer demands on suppliers may be expressed in technical terms and not explicitly mention legal requirements such as producer responsibility.

While supplier relations were mentioned as a motivating factor, McAloone (1998) found supplier relations to be an untapped source of information and influence rather than an actual driving force.

2.6.4.2. Internal drivers

The findings regarding internal drivers were more varied than the external drivers. The most influential stimuli in van Hemel's (1998) study were the opportunity to innovate, increase product quality and realise new market opportunities. Benefits to the environment, cost reductions and image improvements were other frequently mentioned motivations.

The opportunity to innovate was not at all mentioned by McAloone (1998), but was instead supported by Sherwin (2000) who had also studied ecodesign in large EEE companies. He also found costs savings to be subordinate to the possibility to innovate, whereas McAloone's (1998) research showed it to be an important motivational factor.

Other internal drivers were staff commitment at all levels, in particular top and middle management, and design groups (McAloone, 1998). Van Hemel (1998) on the other hand, found that the environmental commitment of the owner/ managing director was less important than expected.

On the whole, van Hemel found internal drivers to be more important than external ones. McAloone (1998) made a similar observation in that external drivers may be more influential at an initial stage, but may be surpassed by internal drivers. For this study, this means that for companies that have been engaged in environmental management for some time, ecodesign may have evolved from these practices instead of being directly influenced by external driving forces.

2.6.4.3. Company characteristics

Research suggests a variety of contextual and organizational company characteristics as influencing product development, corporate environmental management and reporting (Brown & Eisenhardt, 1995; Marshall & Brown, 2003; Perez-Sanchez et al. 2003; Sharma, 2000; van Hemel, 1998). Many characteristics proposed by different research perspectives require in-depth studies intense in time and company access, beyond the scope of this study. Since that is not an aim in this study, company characteristics as alternative or complementary drivers of ecodesign will be considered to a limited extent. For instance, contextual factors such as organisational culture or innovative capacity will not be studied, in any detail.

Corporate environmental management and proneness to reporting is sometimes said to depend at least partly on a company's home country origins (Kolk et al. 2001). Political decision-making structures with different levels of business involvement, and environmental legislation may influence corporate environmental behaviour. 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 considered to be an environmental laggard in the past few decades (Connelly & Smith, 2003; Drake et al. 2003; Dryzek, 1997).

Companies that operate in many countries are subject different national environmental laws. Therefore, the impact of the home country origin on exporting companies may be limited. Nevertheless, Kolk et al. (2001) found national differences in environmental reporting behaviour among large multinational companies. These differences go beyond the national legislation to national social pressure. Drake et al (2003), on the other hand, found that legislative compliance was the strongest driver of environmental management even in Germany where purportedly the social interest in the environment is relatively high (2001). Despite the lagging environmental image attributed to Britain, the social pressure for environmental reporting was found to be relatively high in the UK as well.

For the purpose of this study it is important to bear in mind that producer responsibility for WEEE may have had an effect on companies in countries other than where the policy is already in place, if the companies export to a WEEE country. This study will draw on business experiences in companies from countries both with and without national WEEE legislation. It will also include both (alleged) environmental leaders and laggards as this will allow for potential national influences other than producer responsibility to surface. Due to the inconclusiveness of the influence of company national home origin on environmental performance, this variable can only provide tentative explanations of corporate behaviour.

The influence of company size on corporate environmental commitment and ecodesign has been studied with varying results. Since large companies are sometimes assumed to have more resources to devote to environmental issues and more exposed to publicity, they are sometimes assumed to be more prone to environmental activities (Argument et al. 1998; van Hemel, 1998). In her literature review, van Hemel (1998) finds evidence both supporting and contradicting size as a determinant of environmental management. Her study of ecodesign in Dutch SMEs suggests that the size of the SMEs does not bear a relation to the performance of ecodesign but with the industry sector (van Hemel, 1998). Both large companies and SMEs will be covered in this study to account for this potential influence. The particular policy in focus applies to one industry sector. However, the sector covers product categories with many varying features and therefore differences in ecodesign may be partly attributed to these features.

2.6.5. Waste prevention aspects and potentially conflicting goals

Environmental impacts of products can stem from all stages of the product life cycle and producers can choose to address one or more of these areas for waste minimisation (fig. 8).

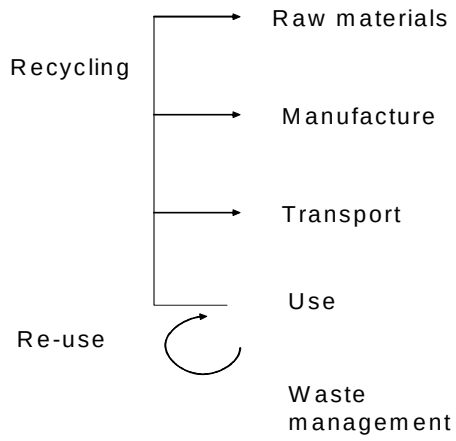

Figure 8 Product life cycle stages. After Rodrigo and Castells (2002 p. 27)

The different aspects of waste minimisation are not always in concord with each other. This may force decisions on trade-offs in the product development process which may affect the achievements in the waste policy area. Also, policy-makers need to be aware of these trade-offs in order to accommodate them in the policy making. Below, some central aspects for waste minimisation are described and a few examples of potential trade-offs given (Table 3).

Table 3 Aspects of waste prevention in ecodesign and potential trade-offs. Adapted from (Lewis & Gertsakis, 2001) and (van Hemel, 1998)

Focus area	Addressed by	Potential trade-off
Reduced product size	Using lighter materials Avoiding over-dimensioning Making products foldable	Light materials may be more complex and thus unfavourable for recycling Increased efficiency may be off-set by increased total output
Extended product life	Using durable materials Facilitating repair through easy dismantling and replacement of components Avoiding highly fashion-sensitive styles (facilitating reuse)	New products may have lower environmental impacts in the use phase that off-sets the environmental gains of a long life
Improved recycling potential	Facilitating disassembly Reducing number of components Reducing complexity of materials	Some complex materials are lighter, saving energy during the use-phase, or are more durable than alternative materials Easily recyclable materials may have substantial environmental impacts during other life cycle stages, eg. virgin aluminium.

In addition to the above waste prevention areas, other life cycle stages can be the focus of ecodesign. For instance, the environmental impacts of materials used are related to product recyclability and their impacts during the waste management stage are sometimes referred to as a part of waste prevention. The product use phase often involves consumption of energy and/or different consumables. Similarly, a number of environmental impacts are generated during production and product transport (Lewis & Gertsakis, 2001; van Hemel, 1998). Identifying whether or not companies are active in these areas can help uncover alternative and complementary motives for ecodesign other than producer responsibility.

2.6.6. Measuring the ecodesign waste prevention

Different kinds of results can be ascertained, depending on the slant of the study and/or the company focus. Examples are the organisational learning that has occurred, the number of new ideas or ecodesign projects that have materialised, or the actual environmental improvements (van Hemel, 1998). A practical example from one company that undertakes

ecodesign is the identification of key areas for improvements, and measuring the number of products and areas in the products, to which these improvements have made (Philips, 2003).

The main focus of this thesis is the results in the waste minimisation area. Ways of measuring environmental product performance include life cycle assessments and different indicators.

2.6.6.1. Life cycle assessment

Life cycle assessment (LCA) is a method of assessing the environmental impacts of a product, process or activity over its life time and identifying opportunities for improvements (Fatta & Moll, 2003). Firstly, the aim of the assessment is established. Thereafter, system boundaries are decided for the phenomenon under study, an inventory is made of the inputs and outputs of the system, and the environmental impacts of these inputs and outputs are assessed. Finally, the results are interpreted against the aim of the assessment.

Viewed as a rational toolset, LCA can assist in the evaluation of different product or policy options. However, certain drawbacks limit the usability of LCAs. It is difficult to establish the relevant system boundaries, and different studies with the same aim can choose different boundaries in order to generate desirable results. Also, the importance and quantification of different impacts may be uncertain. Thus, LCA can be a source for confusion rather than clarity (Heiskanen, 2000). LCAs also require large amounts of data. The activities of collecting and evaluating the data are time-consuming and therefore costly (Bervoets et al., 2000).

2.6.6.2. Corporate environmental indicators

Indicators are condensed and simplified measures of a phenomenon, deriving from more comprehensive and complex data. Appropriately constructed, indicators can gauge the status of a phenomenon at different points in time and hence track progress and

deterioration. As a result, they facilitate communication of and comparison of results against targets (Fatta & Moll, 2003; Persson, 2001). The underlying purpose of using indicators is to support decision-making, provoke action and promote accountability (OECD, 2002).

Criteria for environmental indicators are presented in table 4. The table format draws on Walz (2000) but is modified to accommodate points from OECD (2002) and Persson (2001). It is not an analysis of similarities and differences among the authors, but rather a synthesis of key criteria that recur in the different texts, although sometimes phrased in slightly different words.

Table 4 Criteria for environmental indicators, based on OECD(2002), Persson (2001) and Walz (2000)

Scientific criteria	Functional criteria	Pragmatic criteria
Relevance to ecologic context	Policy relevance	Cost-effective development and data collection
Transparency and unambiguouty	Adaptable to different audiences	Realizable in the short to medium term
Reference value (baseline)	Allow for regular updates	
	Facilitate international comparison	

Companies can develop their own environmental indicators or apply guidelines developed by organisations such as the World Business Council for Sustainable Development (WBCSD) and the Global Reporting Initiative (GRI). These guidelines describe different forms of indicators. One type of indicator are made up of total output figures. Eco-efficiency or ratio indicators relate an environmental variable to another environmental, social or economic variable. Emissions per unit production output is an example of this type of indicator. Another type of indicators refers to the impact of a certain activity on the capacity of the receptor (Global Reporting Initiative, 2002).

With regard to waste prevention, both GRI (2002) and WBCSD (2000) include measure of material consumption, waste generation and recyclability in their indicator guidelines. However, the recyclability measures are not clearly specified. Neither of the guidelines includes product longevity, repairability or disassembly. Environmental activities and

performance measures in companies may focus on a number of areas other than, or in addition to the waste policy issues described above.

Companies differ with regard to the extent to which they measure and monitor their environmental performance. Marshall and Brown (2003) present statistical patterns in the reporting of environmental measures in business. At the same time these patterns are expressions of differences among company characteristics. In general terms, company size, country and adherence to an environmental management system were found to account for some of the differences. Since a comprehensive literature review on this issue has not been undertaken caution should be observed in generalising these results, although the methodology on which the conclusions are based allow for generalisation. However, the findings in the article are relevant for this study in the sense that they show that it is likely that the companies in this study will not display comparable performance measures. Thus it may not be possible to make a quantitative statement of the extent to which producer responsibility has achieved the waste policy goals through product development.

2.7. Drawing together the concepts – an analytical framework

The literature has identified waste minimisation as an overarching waste policy aim, to which producer responsibility for WEEE contributes. Product development for waste minimisation is a part of the purpose, both in the recently adopted WEEE Directive (2002/96/EC) and existing national WEEE policies. However, there are no quantitative targets for product development or prescribed methods for ecodesign incentives.

Enforced through legislation, the re-allocation of costs for collection and treatment is a key mechanism for the operation of the WEEE policies. Some authors assumed that the costs imposed on producers would act as levers for product changes. However, a review of economic principles applied to producer responsibility for WEEE, indicated that the incentive of the costs may be limited, although potentially larger with individual solutions than collective schemes. On the other hand there were studies that showed that producer

responsibility for different waste categories had had an effect on product development. These studies were mainly focused on large companies.

In view of the imminent implementation of the WEEE Directive and the conflicting views regarding the effects of the costs imposed on companies, an investigation into the effectiveness of costs as a driver of ecodesign would benefit to policy-making. Drawing on experiences of existing producer responsibility policies for WEEE, the results will show whether the cost of producer responsibility is a sufficient motivation or whether it needs to be supported by other incentives.

The literature review led to the development of an analytical framework comprising theoretic principles and empirical findings on drivers of ecodesign, waste prevention aspects in product development and performance measurement against policy aims (fig. 9).

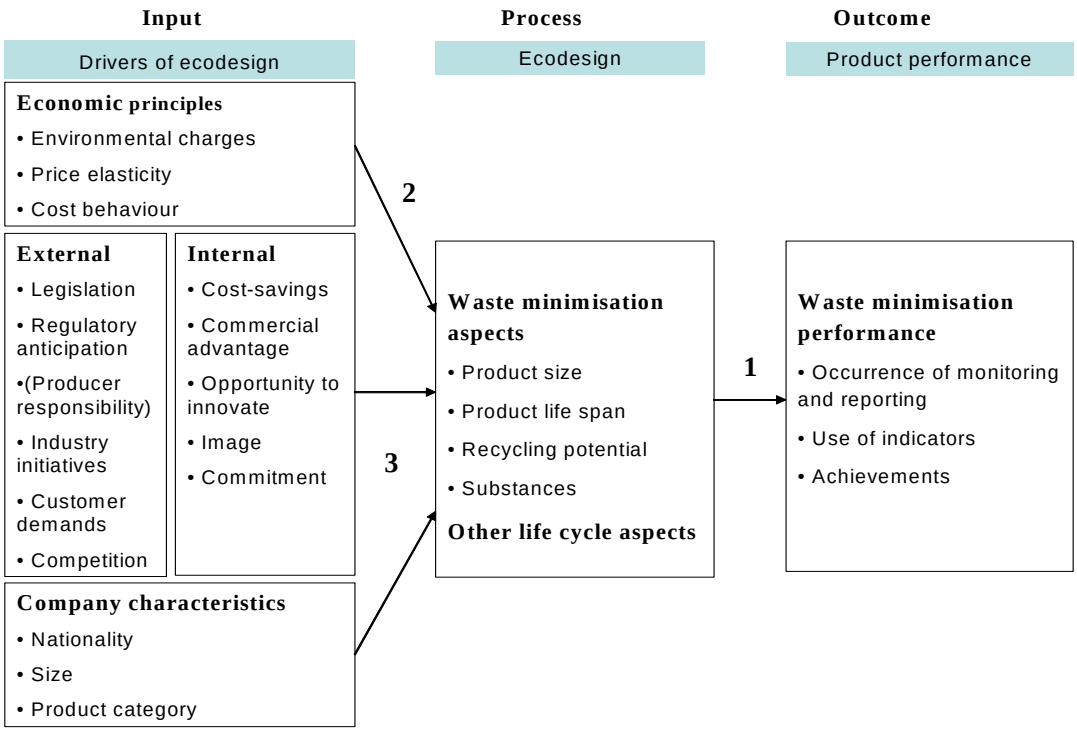

Figure 9 Analytical framework

The elements of the analytical framework in figure 9 leave open the possibility for many interlinkages and feed-back loops, all of which will not be explored in this thesis. The analytical framework corresponds with the objectives of the study represented by the numbered links. These links are the primary focus.

Starting with the first link, the monitoring of waste minimisation aspects for products, the use of indicators and potential achievements will be examined. There are no quantitative targets to measure achievements against, so improvements in the waste minimising aspects will be viewed as complying with the policy aims. According to the literature, comprehensive and comparable achievement measures may not be at hand.

The link between the economic concepts and waste minimising ecodesign will be examined in terms of the size of the charges, whether the company or its customers carry the costs (price elasticity) and whether the cost behaviour of the charges make it possible for companies to avoid the costs in the short term through ecodesign. The literature indicated limited avoidability of costs for collective producer responsibility schemes, whereas individual solutions were potentially more conducive to ecodesign. Furthermore, it was suggested that demand for durable goods with no close substitutes was inelastic in the short term. This would mean that the customers carry the largest part of the cost burden, limiting the innovation incentive for the producers.

In addition, a number of external and internal stimuli and company characteristics may interact with each other and influence waste minimisation in product development. The analytical framework serves as a tool to capture these potential influences in the data collection, but each aspect will not be investigated as such.

In the next chapter, the methods are discussed by which this analytical framework is made operational.

3. METHODOLOGY

In the previous chapter an analytical framework was developed to facilitate an empirical study of how the costs imposed on companies by producer responsibility schemes have influenced product development in the EEE sector. This chapter contains an account of the methods that were chosen to make the analytical framework operational.

3.1. Multiple case study approach

The literature review revealed a scarcity of empirical research findings on how firms respond to the costs of producer responsibility. In previous research, qualitative methods have proved useful for understanding how industry responds to waste policy instruments (Kautto & Melanen, 2004) and drivers of ecodesign (McAloone, 1998; Tojo, 2001). In a setting of many interacting causes, the explanations given by the informants in qualitative methods reveal their level of understanding of the issues at hand. This provides a richer conception of the phenomenon (Miles & Huberman, 1994; Neumann, 2003; Yin, 1993). The question under study was a contemporary problem in real life. The interaction of the variables discussed in the literature review was potentially complex and could not be controlled by the researcher. Information from different groups of informants in each company studied, as well as secondary data, was considered beneficial for the understanding of the relations between the variables (cf Yin, 1993). In addition, the literature review indicated limited availability of quantitative data of for instance waste minimisation performance, and difficulties in quantitative analysis of for instance price elasticities of a company's products. Therefore an analysis of the content and context of case studies was chosen for this research.

The transferability of case study results to contexts beyond that in the study is of importance for policy-making. While not seeking or allowing for statistical generalisations, qualitative information facilitates the understanding of contexts to which the results may be extended (Kvale, 1997). Multiple case studies selected for the purpose of displaying how

typical, different or effective a particular feature is can facilitate a deeper understanding and analytical explanation of the phenomena under study. Thus, a multiple case approach may strengthen the theory and enhance the transferability of the results to contexts beyond the individual case. (Miles & Huberman, 1994). For this reason a multiple case approach was chosen for this study.

3.2. Case selection

Eight cases were selected that were found to be pertinent for the aims of the study. The impending EU WEEE Directive was the background to the study and the purpose was to draw on experiences of similar national legislation. Therefore, cases were selected from EU member states with such national laws. In order to make possible visits at case sites geographical vicinity to Sweden and the UK where the study was carried out was a selection criterion. In the literature, Sweden and the Netherlands were held up as good examples of recycling and with national producer responsibility for WEEE. They also fulfilled the above criterion of geographical vicinity. The literature depicted Germany as a forerunner for environmental policy and Britain as a laggard. Cases from Germany were included in the study in order to see whether producer responsibility in one country affects product development in companies in other countries. It would also allow the identification of potential nationality-related similarities and differences other than producer responsibility.

In the literature it was suggested that business fulfilment of producer responsibility through individual contracts with collection and recycling firms would be a stronger incentive for ecodesign than membership of a collective scheme. For this reason it was deemed desirable to include a case that had chosen an individual solution. The case also needed to conduct its own product development. It was very unusual for EEE producers to take an individual responsibility. A company that did and was willing to provide informants produced lighting equipment. Therefore lighting equipment was selected as the product category to focus this study on. A disadvantage of this choice was that the Dutch producer responsibility for

WEEE did not cover lighting equipment. However, the inclusion of the company with an individual solution was felt to outweigh this limitation.

It was still relevant to include a Dutch case since one company in the lighting equipments sector was known for its good practice ecodesign. This reputation was substantiated through the company's position in the Dow Jones Sustainability Index, and published research in collaboration with a university. The other cases were identified through industry directories and trade associations. Companies of different sizes were targeted as the literature review suggested that company size may be an influencing factor both on ecodesign and the awareness of WEEE legislation. Accessibility of informants was a determining factor in the selection.

Informants were sought among product developers and designers, marketers, environmental managers and accountants. The first three functional groups were identified by McAloone (1998) as influential in ecodesign decisions. The accounting/financial function was selected due to its potential influence on economic decisions related to producer responsibility for WEEE. Where possible, more than one informant was sought for each case. The functions of the informants varied depending on what staff functions the company employed and whether they felt in a position to answer the questions. In particular the accounting/financial functions showed a limited awareness of producer responsibility for WEEE and involvement in product development and referred to other informants.

3.3. Data collection

In order to fulfil the objectives data was needed on case characteristics in terms of company, size, home nationality and markets; quantitative performance measures of achievements in product waste minimisation; company responses to the costs of producer responsibility, preferably both qualitative explanations of decisions and attitudes, and quantitative in the form of cost figures, effects on prices and demand, and costs and benefits of ecodesign; explanations of reasons for undertaking or not undertaking ecodesign or product waste minimisation.

Both secondary and primary data were used. Company reports were the main sources of secondary data. Primary data collection relied on focused interviews. Focused interviews are based on a set of pre-determined but open-ended questions (Yin, 1989). This ensured that the relevant issues were covered but still allowed the informant to elaborate on answers and the researcher to follow up the responses. The open-endedness was also useful for gaining information about influencing factors that did not appear in the literature review. The questions asked in each interview varied depending on the secondary information that was available about the companies and the targeted informants. 15 interviews were carried out. In addition, a few requests for interviews were made where the potential informants did not feel in a position to answer the questions but where these answers in themselves were revealing for the case.

Most interviews were carried out via telephone. An initial contact with a potential informant indicated that access to informants may be greater with telephone interviews than face-to-face interviews. Telephone interviews were also found to be time and cost effective compared to face-to-face interviews (Neumann, 2003). With telephone interviews, visual information about the surroundings and reactions of the informants was not possible. One face-to-face interview was carried out on the company site to estimate how the lack of visual information would affect the result. Although some informant reactions were observed, this was not felt to impact on the quality of the data in any significant way.

The length of the telephone interviews varied but most often was 20-30 minutes. In one extreme case, the questions were answered in only five minutes. A few interviews lasted up to about 45 minutes. Although the duration was limited compared to face-to-face interviews, the length was found to be sufficient for the information needed from the different informants. Contrary to Neuman's (2003) suggestion that telephone interviews reduce the possibility of using open-ended questions, the interviews for this study provided satisfactory open-endedness within the frame of the focused interview method.

The order of the interviews was dictated by the accessibility of the informants. Notes were taken during the interview, summarised and sent to the informants to allow comments or

clarifications. Not all informants provided feedback on the summary. Of those that did, some informants made some corrections whereas others agreed with the original text. Further questions from the researcher were expressed in e-mails or further telephone calls.

3.4. Data analysis

Qualitative data analysis typically involves pattern identification (Miles & Huberman, 1994; Neumann, 2003; Yin, 1993). Different strategies can be used depending on the type of study. According to Neumann (2003) the 'illustrative' method of analysis organises empirical data according to a theory of a social phenomenon. Comparing the data with the theory confirms or rejects the theory. This method is conducive to case study methodology applied in this study. The data was first considered case-wise to provide an understanding for the case contexts. Then, the data was analysed according to the framework developed in chapter two, on the basis of the theoretic concepts and empirical research findings contained in it. For each element of the framework, patterns and explanations were sought among the cases.

3.5. Critique of methodology

On the whole the case study approach provided an appropriate methodology for the research. Nevertheless, some limitations were identified in relation to certain aspects of the research.

The study was undertaken at a time when the WEEE legislation had only been in place for two years in Sweden. Additional consequences and corporate responses may develop over time. However, in view of the impending implementation of the WEEE Directive, it was considered useful to draw on current experiences. Also, this study captured perceptions of likely policy impacts and responses.

As expected, there was a lack of quantitative data on environmental performance from the case companies, either because they did not undertake measurements, the data were not

made available to the researcher or did not exist in forms that could easily be adjusted for the purpose of this study. In the cases where data were published, they were not comparable between companies. Thus, it was not possible to establish actual achievements in the area of product related waste minimisation based on existing data. Collecting primary data on environmental product performance was not considered feasible, partly due to the limited access to the companies, and partly due to the time requirements of such an exercise. The lack of quantitative data, the application of guidelines and informants' explanation of the issues of enquiry were felt to give a sufficient picture of the influence of producer responsibility on product development. Comparable quantitative data on performance alone could not achieve this.

For the case companies where environmental issues were a concern, decisions relating to this area in general and producer responsibility in particular were part of a process that had evolved over time. Informants' retrospective responses at a single point in time may have affected the accuracy of the description of a decision process influenced by many factors. Furthermore, there was a tendency to exaggerate the environmental awareness of the companies. These limitations may have been avoided by a more in-depth longitudinal study of the decision-making processes. However, the time frame for the project and accessibility to companies did not allow for this kind of approach. The use of multiple informants and information sources, and the cross case analysis compensated for the potential retrospective bias.

In order to improve data accessibility, the case companies were ensured confidentiality. Although common practice in case studies, and recommended by Neumann (2003), an inherent problem is the limited possibility for readers to evaluate the researchers handling of the material. The methodological procedures and case descriptions were written as to minimise this restraint.

4. RESULTS

In this chapter a summary of the results is presented in the form of five matrices. The matrices provide an overview of the main variables and facilitate a cross-case comparison. They draw on more detailed case descriptions built on the primary and secondary data. These case descriptions are available in appendices three to ten.

Table 5 shows the general case characteristics that may influence the effect of the costs of producer responsibility on product development. It also gives an overview of the informants that were interviewed in each case.

The companies all produced lighting equipment. Most of the cases produced luminaires, but lamps were the main products in cases A and B. Lamps and luminaires are complementary products. The design of luminaires partly depended on the lamps. However, they have different end-of-life properties. This affects the possibility for waste minimisation through product design. Both businesses and households were end-users of the products from all cases, although there was a stronger emphasis on one market in some cases. The category of customer affected the extent to which environmental demands were made for product purchases.

The cases comprised SMEs and large companies from four EU member states. Since they all export products to some extent, they may be affected by producer responsibility for WEEE in some of the countries where the products are sold. The data available did not reveal how large portions of the sales occurred in countries with policies in the cases. However, the information suggests that the portion of turnover generated in a country with producer responsibility is potentially larger in two of the Swedish cases, D and H, than in the other cases. Five of the eight cases were members of trade associations. Trade associations were influential in alerting the companies to the forthcoming producer responsibility legislation and through voluntary environmental product declarations.

Table 5 Case characteristics

Case	Main product type	Household / business markets	Home country	Export	Employees	Trade assoc.	Informants
A	Lamps (luminaires, lighting electronics)	Both households and businesses	The Netherlands	Across the world	47 000 (lighting division)	Member	Ecodesign manager
B	Lamps (luminaires, lighting electronics)	Both households and businesses	Germany	Across the world TO: Europe 35%, Americas 50%, Asia Pacific 12%	35 000	Member	Head of Environmental affairs/technical director
C	Luminaires	Mostly households; special B2B department in the retail outlets	Sweden	Subsidiaries in 31 countries in Europe, North America and Asia; TO: 80, 17, 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 TO outside Sweden: ≈50%	1200	Member	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&D/marketing manager Engineering manager (products)
F	Luminaires	Both households and businesses	Germany	Sales offices in 30 countries across the world	150	Member	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	Member	Managing/marketing director Product development and production manager

Table 6 shows the environmental profiles of the companies and their environmental monitoring and reporting activities. The three largest companies had a longer history in environmental management than the other companies. Public environmental interest, in particular related to dangerous substances was a common trigger in the environmentally active companies. The large companies and the Swedish SMEs all showed some manifestation of environmental management, contrary to the German and UK SMEs. The four largest companies took a life cycle approach and conducted environmental monitoring. The Swedish SME applied an environmental product declaration (EPD). The environmental indicators in the different companies were incomprehensive and of varying quality with regards to transparency and comparability.

Table 6 Environmental profile; monitoring and reporting activities

Cases	Start of env awareness	Env management	Env Monitoring and reporting	Comments on indicators and reporting
A Neth L lamps	Resource and env 'scares' in the 1970s - 80s. Corporate env policy since 1987	Env managers, EMS Ecodesign managers Corporate sustainability board	3rd party verified sustainability report (whole company): GRI guidelines, cross referenced Performance indicators for materials, products and services not inventorised Life-cycle perspective Computer-based monitoring tools for processes and products	*Indicator types:* Total emissions or resource use; % or times change - Figures are adjusted for changes in production output - All indicators contain reference value, consistent for production indicators in each company but different for the two companies - Reported aspects are environmentally relevant but indicators not related to receptors and carrying capacities
B Ger L lamps	Resource and environmental 'scares' in the 1970s - 80s. Central env office created 1990 after separate activities	Env managers, EMS Board member env responsibility	Web-report on processes and products: Life cycle perspective, mass flows and environmental benefits of products	- The indicators are highly aggregated and little information given on the principles for data aggregation → low cross-case comparability - No overall indicators for products; individual products used as examples
C Swe L fittings	Public env interest, in particular harmful substances 1980s; internal env audit 1989	Env managers Env action plan	Environment brochure; Life cycle perspective; (production is outsourced, but report on work with suppliers), mostly qualitative information Experiments with LCA,	*Indicators:* Proportions eg of modes of transport, % of waste recycled - Few and varying baselines; unclear relevance of baselines
D Swe L fittings	Public env interest mid-late 1990s, customer demands (public procurers) EMS late 1990s;	Env Manager, EMS	Environmental report Quantitative measures for production, qualitative targets for other life cycle aspects. Experiments with LCA but not widely applied; EPD	*Indicators:* Total emission or resource use for three plants -no ratios for comparison with other environmental, economic or social aspects - values for four consecutive years for comparison over time, but values not adjusted for changes in production output
E (UK), F (Ger), G (UK), SME fittings	N/A	No	No	N/A
H Swe SME fittings	Public env interest mid-late 1990s; EPD 1996	Env Manager EPD	EPD applied in new products; not followed up for existing products	EPD states whether or not a product contains certain substances, but does not mention amounts. No reference values are provided.

Table 7 shows general drivers behind ecodesign, indicators used for waste minimisation aspects and reported achievements. The three largest cases reported achievements in waste minimisation aspects but only for sample products. Although waste minimisation aspects for individual products were monitored and compared to previous products, there were no data on overall improvements. Ecodesign was usually a continuation of previous environmental management activities. Customer demands contributed to the motivation to undertake ecodesign. Public procurement was specifically mentioned in two Swedish cases.

Table 8 shows the main drivers and conflicting aspects of product waste minimisation that emerged in the interviews and secondary data. The companies were not given a predetermined list of drivers and conflicting aspects to rank. Instead the responses emerged from their mention of drivers or spontaneous explanations of why a particular aspect was not pursued. Therefore, all cases are not represented for all aspects. Likewise, the possibility cannot be excluded that a driver or trade-off is present in a case although not mentioned as the primary reason for attending or not attending a certain aspect. However, table 8 shows that there is generally a consensus on drivers and conflicting factors among the companies regarding the different aspects.

The aspect with the most differing motivations was product size reduction. Except for that aspect, product life extension was subject to the most conflicting factors. No conflicting factors were mentioned for disassembly and recyclability. This does not mean that there are none. The view that the products are already easily recyclable without any special attention being required may be a hindering factor as much as a driver. The WEEE Directive was not mentioned as a driver at all. On the contrary, three cases specifically claimed that the WEEE legislation had not had an impact, when asked. Instead, the ROHS was mentioned as a more important regulatory driver.

Table 7 Ecodesign and waste minimisation –general; indicators and achievements

Case	General ecodesign drivers and practices, including supply chain pressure	Waste minimisation indicators	Achievements
A Neth L lum	Early 1990s management envisaged the business importance of ecodesign; co-operation with academics Computer-based tool to measure env impacts of products; Increasing customer demands from customers for environmental management and green products; env demands on suppliers through a staged model: from substances via env management to env 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 L lum	Examples of material reuse, product size reduction and improved recyclability in the 1960s, 70s and 80s driven by cost-saving potentials; now environmental considerations from product planning stage. ROHS Directive more important for ecodesign than WEEE Directive. Env demands from European business customers; demands on suppliers re substances and env programmes		Example of reduced size, but no indicator or over-all figures; examples of increased product lives but no over-all figures; 100% recyclability (no baseline);
C Swe L lum	Product size reduction since the start due to cost-saving potentials; ecodesign 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 env 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 L lum	Late 1990s: ecodesign opportunity to ensure continuous improvements required by EMS, although requirement not directed at products; environmental checklist applied in product development; Some env 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 env customer demands. Waste minimisation and env 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 env demands from architects and public procurers	No	Claimed: changes in substance contents; no absolute over-all achievements reported

Table 8 Waste minimisation and other ecodesign aspects, drivers and conflicting factors

	Product size reduction		Product longevity		Disassembly		Recycling potential		Substance restrictions		Energy savings	
D I:	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 re-use (=cost saving)	A, B	Public debates and regulations	A, B C, D H	Sales argument (win-win economic-env)	A, B, C, D, E, G
D II:	Customer preference for unobtrusive fittings	F			Easy assembly → easy disassembly	F	Part of env life cycle considerations	A, (B) C, D, (H)	Specific mention of the ROHS Directive	B, C,		
D III:	Ease of installation	D					(Products already easily recyclable)	(B),E, F, G				
Con I:	Large room requiring large 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
Con II:	Small components = difficult/expensive to produce	A, F	Need for more durable expensive materials and investment in tooling	E								
Con III:	Compromised safety and quality (smaller surface to dissipate heat)	G										

D: Driver
Con: Conflicting factor

Table 9 shows the different solutions the companies have chosen for fulfilling their producer responsibility or their attitudes to different solutions where applicable. Collective schemes were the most commonly applied and advocated solution. In two of the Swedish cases environmental managers were responsible for the decision of how to fulfil the producer responsibility for WEEE. In the smallest Swedish company, the decision was made by the managing director who was also the marketing director and who introduced an active environmental awareness in the company. In case A and B, special task forces had been assigned to deal with the anticipated impacts of the WEEE directive.

The companies that were subject to producer responsibility in their country of origin did not keep track of the exact costs of the producer responsibility charges. In case C with an individual solution, the amount of WEEE returned was monitored but its proportion of the total costs for collection and recycling of waste from other business activities was not recorded. This was reflected in the company's cost-reducing strategies: to reduce costs in all business activities rather than end-of-life management specifically. The recycling charges did not vary with the product properties and thus were not avoidable in the short term. The company had not calculated the cost and benefits of waste minimising product development.

In case D and H the costs were transferred to the price of the products. Case D estimated the added unit cost to one or a few percent of the product price but was not concerned with the exact rates since the costs could be passed on to the customers without any negative effects on the sales. The same was true for case H. Therefore, neither of the companies had calculated the costs and benefits of waste minimising product development.

In cases A and B a trade association had estimated the potential costs to make up a considerably larger part of the product price than for luminaires. Nevertheless, the cases predicted that the costs could be passed on to the consumers without any negative effects on competitiveness. The main cost-reducing strategy was improvements in recycling techniques rather than product design.

Table 9 Results relating to the 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 L lamps	Advocate visible fees; (collective)	≈60% [1]	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 L lamps	Advocate collective	≈60% [2]	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 ecodesign	Corporate task force
C Swe L fittings	Individual: contractors	N/A	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 L fittings	Collective (PRO)	≈0.5-a few[3]	Yes; no perceived effect on sales/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 and G UK SME fittings	N/A	N/A	(Yes; no anticipated effect on competitiveness)	N/A	N/A	N/A
F Ger SME fittings	Low faith in collective schemes	N/A	(Yes; no anticipated effect on competitiveness)	N/A	N/A	N/A
H Swe SME fittings	Collective (PRO)	≈0.5-a few[4]	Yes; no perceived effect on sales/competitiveness	No	None related to producer responsibility; costs transferred to customers	Managing Director

[1],[2] Estimation made and published by trade association

[3],[4] 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 products

5. ANALYSIS

In this chapter, differences, similarities and explanations for the case activities in waste minimisation, ecodesign and responses to producer responsibility for WEEE will be discussed. This discussion covers the first three objectives of the study, which were made operational in the analytical framework presented in figure 9. The same framework is presented below (fig. 10).

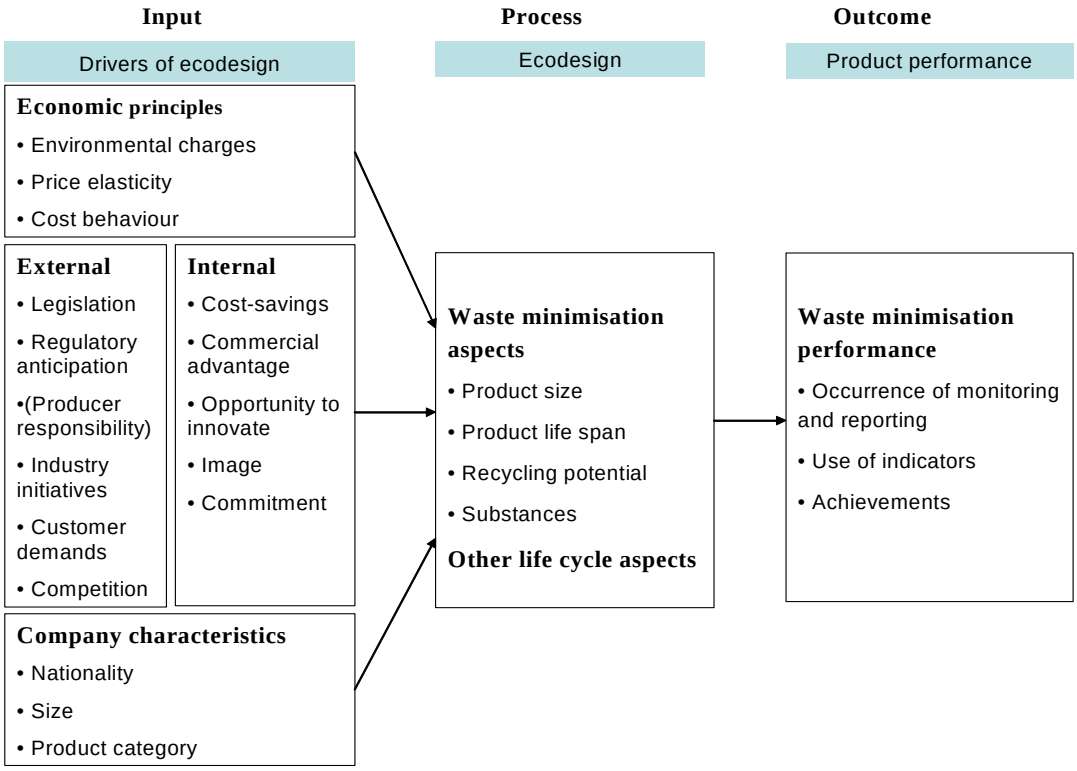

Figure 10 Analytical framework

Firstly, the outcome, the achievements in waste prevention through product design is examined. This is done by evaluating environmental monitoring and reporting activities in the cases. Secondly, the economic mechanisms of producer responsibility are discussed as incentives for cost control for product development and ecodesign. Finally, additional drivers of waste prevention and ecodesign are discussed.

5.1. Achievements in waste minimisation through product development

This section gives an overview of environmental monitoring and reporting and waste minimisation achievements in the cases. The possibility to draw conclusions of product waste minimisation on the basis of available information is discussed.

5.1.1. Overview of monitoring and reporting

The UK and German SMEs, case E, F and G did not engage in environmental measuring and monitoring, whereas the Swedish SME, case H provided environmental declarations for its products with regards to the contents of different materials and substances. The four large companies, case A to D, undertook environmental monitoring and reporting from a life cycle perspective, although with varying levels of comprehensiveness. Case A had developed and applied computer software for monitoring environmental aspects of products and processes. While it appeared to be the most advanced of the cases in its environmental management, case A admitted that there were gaps in the monitoring data. Case A published a sustainability report in accordance with GRI-guidelines and verified by an independent body. Case B published environmental data on mass flows and product aspects on its website. Case C published a mostly narrative environmental brochure. Case D published an environmental report with quantitative data on the production and qualitative goals including products. Both case C and D had experimented with LCA but the method was not widely applied.

The companies used their own indicators, mostly in terms of total outputs or efficiency measures such as improvements relative to an earlier state. In terms of light performance and energy efficiency, comparisons in terms of functional units instead of product units were sometimes used. The published information was usually highly aggregated with limited transparency as to the principles underlying the data condensation and resulting low

comparability across the cases. The environmental performance of products was usually provided as examples of single products.

5.1.2. Monitoring, reporting and achievements in product waste prevention

All the monitoring companies provided estimates for achievements in reductions of product size. In most cases, the estimates related to individual products that were highlighted in the environmental reports. Company A reported weight reductions of 25-60 percent for individual products compared to their predecessors or conventional products. Case B reported on a reduction in the diameter of a product as early as the mid 1970s, resulting in substantial material savings. In both cases, no size reductions were reported for the total product range. Reducing material input and packaged and transported volumes of products had been a part of company C's business strategy since the mid 20th century. However, no figures were published for lighting products.

There were no reports on reuse of products. One explanation for this may be that second hand use of lighting products has not been within the company realm as it does not bring in any money to the company. Neither has it been targeted in the creation of government policies and infrastructure to the same extent as for instance recycling.

Recycling potential for products from case A and B were claimed to amount to near 100 percent. No baselines were presented against which these improvements could be gauged. However, company B reported that increased recycling potentials through new disassembly techniques had occurred as early as the early 1980s. No data for the development of recycling potentials were published for the period up until the late 1990s, when new uses were found for recyclate residual, leading to near 100 percent recyclability. This instance shows that recyclability is not an absolute entity but depends on the value of the recyclates. C and D mentioned recyclability as goals for their product development, but did not present any data of current performance in the area.

Extended product life was a waste minimisation feature that was important for lamps, especially in conjunction with energy efficiency. Increased life spans were expressed in

terms of the number of times of longer use than the products they replaced, or in terms of hours of use compared to older types of lamps. Case A and B claimed some lamps to last five to six times longer than their conventional equivalents. However, for many lamps that were said to have extended use lives, no information was given of the scale of improvement and what the benchmarks were. Case C and D did not give any information about the life spans of their luminaires.

In addition to the waste minimisation aspects, all monitoring and reporting companies reported on other life cycle aspects, such as use of dangerous substances, packaging, transport, impacts through the use-phase. This would indicate that they were motivated by other factors than producer responsibility.

5.1.3. Section conclusion

To sum up, some evidence of achievements was presented in the form of quantitative and qualitative examples of size reduction, product longevity and recyclability. There was, however, a lack of monitoring activities, particularly in the SMEs. The inadequacy of the data prevented any objective conclusions as to the quality of the information and the over-all performance in waste minimisation.

5.2. Economic mechanisms of producer responsibility as a driver of ecodesign

In this section, we will examine whether or not the economic mechanisms described in the literature review have had any incentive effect on waste prevention in product development. Since most cases in the study conduct export, all companies except possibly case E and G may be exposed to producer responsibility for WEEE to some extent. The companies tended to keep the same product design for all markets except for voltage and particular national fire regulations. Apart from that, the only foreign environmental policy influences were said to be the German packaging regulations and certain substance bans. Therefore, this section looks primarily at the companies where a national WEEE policy

applies in their home country, i.e. Sweden. Case A and B, Dutch and German respectively, will also be discussed as they have taken anticipatory actions.

Both cases D and H, the Swedish large company and SME respectively, assigned the costs of the fees to the product prices. Neither of the companies noticed any negative effects on sales and competitiveness. Like all other cases in the study they felt that their competitors were equally affected by the policy, and therefore they were not concerned about effects on competitiveness. Although both cases exported goods, neither expressed a concern about the fact that Swedish national WEEE was implemented before the EU WEEE Directive, nor about potentially different cost burdens in case of different implementations in the member states. Consequently, the customers carried out the largest part of the cost burden and there was little incentive for the companies to undertake ecodesign to reduce the costs. This was reflected in limited ecodesign efforts directed at end-of-life and lack of cost control of end-of-life costs in product development.

At the time of the study the Swedish WEEE legislation had only been operational for two years. The literature suggested that demand for some electrical and electronic durables without any close substitutes was inelastic in the short term. This may be one explanation to the results described above. However, it was also noted that in the literature that new purchases of durables could often be deferred. Thus, an effect on sales of a price increase could have shown shortly after the implementation of the WEEE legislation. The perceived negligible effect on sales may instead be explained by the fact that the added cost only amounts to one or a few percent of the total product price.

The limited incentive for ecodesign was reinforced by the fact that that the fee is fixed for a particular type of product rather than the end-of-life properties of a brand (otherwise it would have been an individual solution with added handling costs). The companies could not avoid the costs in the short term through product development. An informant in case D remarked that due to their large market share, changed product design would have an effect in the long term, but this was not currently a consideration in the company.

With an individual responsibility the fees may vary with the end-of-life properties of the products and thus be avoidable in the short term. Neither case D nor H had considered this option, let alone calculated the costs and benefits of it. Both felt that the transaction and handling costs involved in an individual solution would be too high to compensate for any ecodesign benefits. In case D a contributing factor may be that the decision about producer responsibility for WEEE was taken by the environmental manager and only later presented to the financial and accounting functions which appeared to look at it as an environmental issue with no direct cost implications for the company. However, in case H with only 15 employees, the choice of producer responsibility for WEEE was made by the managing director who was also the marketing manager and the person that introduced environmental activities. This mixed role would seem to provide a good understanding of the cost implications of decision. Consequently, the relatively low costs incurred by the collective scheme compared to the perceived transaction costs of an individual solution is the most likely explanation.

Case C the Swedish large company producing luminaires as a part of its interior design range, had chosen an individual solution. The existing collection and recycling infrastructure in the form of a network of retail outlets with bring banks and existing contracts for recycling of electrical and electronic waste was a key reason for the choice. It reduced the company's transaction costs. However, the charges were not based on the recyclability of the WEEE. The returned volumes were said to be a small part of the company's total WEEE recycling[5]. The contracts had not been renegotiated at the introduction of producer responsibility for WEEE. The issue may become topical when the implementation of the WEEE Directive has been in place for some time, as this is likely to increase the volumes of WEEE. On the other hand, electrical and electronic products only make up a small part of the company's total sales. Furthermore, a portion of the take-back consisted of products and product categories of WEEE that the company did not produce

[5] The company monitored the take-back in terms of weight, but did not have any figures on the proportion compared to the other WEEE.

itself but accepted. Therefore, the overall benefit of a renegotiated contract may be negligible and no discussions regarding such a renegotiation had taken place.

One informant held the view that it was too easy and cheap for end-users to dispose of their WEEE in the residual municipal waste stream for the take-back of WEEE to be effective. The high rates of total collection and recycling of WEEE in Sweden contradicts this suggestion. An implication might be that households find it easier to return the end-of-life products to municipal collection points for WEEE.

One informant in case C claimed that the company had not increased product prices following the implementation of the Swedish WEEE legislation. In contrast to the costs in case D and H, the costs in case C are not based on a unit cost for sold products, but are mingled with the overall costs for the electrical and electronic waste from all business activities. Also, the returned products include product categories other than the ones that the company itself develops. Thus the costs are not as readily assignable to products as in the other two cases.

Consequently, the company carries the costs of producer responsibility rather than its customers. This does not necessarily have a direct effect on product development. In general, products are not pursued that are estimated to be too expensive. However, so far the cost increase has been limited due to the relatively small volumes of returned WEEE and end-of-life costs are not controlled in product development. One informant suggested that opportunities for cost-savings are sought across all business activities and not end-of-life costs specifically.

To sum up, the effectiveness of the producer responsibility charges as incentive for waste prevention through product development appeared to be limited. According to theory, the relatively low cost increases may explain this. Are higher charges more effective? There were no cases in the study where producer responsibility for WEEE applied and where the relative price increases were considerably higher. However, the lamp producing case A and B estimated the additional costs to amount to up to 60% of the product price. Since the

legislation was not in place in case A and B[6] no consumer responses could be estimated. However, both cases had anticipated the legislation and had assigned corporate task forces to attend the issue. Therefore, the business responses could be explored. These results indicated that the incentive effect of the higher costs on ecodesign was limited due to product and legislative features.

Lamps are highly standardised products. New innovations are soon copied and therefore an informant in case B said that there was little possibility to gain competitive advantage through ecodesign. Furthermore, this feature in addition to the small size, large number and low value of products meant that the costs of sorting according to brand for an individual solution and individual benefit of ecodesign would outweigh the ecodesign benefits. Therefore, a collective producer responsibility solution was advocated. As noted above, the fees charged by collective organisations are not avoidable in the short term.

An informant in case A claimed that design for recycling was inhibited by the fact that different recyclers used different techniques. Case A and case B had formed an association with recyclers to develop recycling techniques. This occurred when the EU discussions about a WEEE policy were at an early stage. The informants claimed that the formation of the association was not related to the WEEE policies.

The increased costs in case A and B would be added to the prices of the products and the companies were not worried about the overall competitiveness. All producers would be subject to the same rules and there are few substitutes to lamps as a product category. On the contrary, the legislation was perceived as creating a competitive advantage compared to producers from outside Europe. Some of these competitors, which had previously competed with low-priced but more environmentally harmful products, would now have to invest in development that European producers had done previously.

[6] Both companies exported across the world, but producer responsibility for lamps only applied in a small part of their total markets. The legislation did not yet apply in their home countries.

Instead, substitutes within the product category were of concern. Filament bulbs (conventional incandescent light bulbs) are exempt from the WEEE Directive. If the price of energy-saving lamps increases customers may substitute them with filament lamps, leading to increased energy consumption during the use phase. One of the responses to the WEEE Directive to was to try and influence the legislation with regards to what was seen as unduly high costs compared to other product categories and an unfortunate environmental trade-off.

In conclusion, the economic principles seem to apply to the empirical case studies. However, the application of the economic instrument and product properties appears to prevent the financial responsibility from having the desired effect on waste minimisation through product development.

5.3. Motivations for ecodesign

In the next section, we shall see whether there are any differences in ecodesign activities between companies that are already subject to producer responsibility for WEEE and the other cases that would indicate any effects of the legislation despite the weak economic incentives. Furthermore, alternative or complementary stimuli will be examined.

5.3.1. Product size reduction

All cases except the Swedish SME, case H, claimed to consider size reduction in their product development. Producer responsibility was not mentioned as a motivation for product size reduction. Neither did the differences among the cases show any patterns that would suggest any such influence of the policy. Instead, the potential for cost savings in input materials, packaging and transport were main reasons to address this focus area. Technical and fashion design requirements sometimes outweighed the perceived benefits of the potential cost savings. The data revealed that lighting equipment could to some extent be considered a fashion industry. Thus, if the fashion was to turn towards large luminaires, the premium paid for this feature might override the cost savings in materials. This implies

the possibility that policies influencing material costs might be a way of changing this balance.

5.3.2. Product life span

There were no implications that producer responsibility had influenced the corporate attitude to product longevity. No differences were found between the companies for which producer responsibility for WEEE was already a reality, and the other cases. Instead, a dividing line could be distinguished between the development of lamps and of luminaires. Product life was a selling argument for lamps and as such featured the product development agenda. In the companies producing luminaires, extending the product lives was less of a concern. The industry average was a life span of about ten years. Although none of the companies monitored product life spans, all cases believed that their products matched or exceeded this average. The control gears were the limiting factor for the physical durability of the products. The products were usually designed to allow dismantling for replacement of control gears and lamps. This was not related to producer responsibility.

The companies producing luminaires shared the view that many of their customers replace the products well before the operational obsolescence because they want new styles. One case reported that this behaviour varied depending on the type of customer. Industry customers were believed to keep the lighting systems until the end of the systems' physical lives, whereas retailers were more susceptible to fashion trends.

Although the objective of the WEEE Directive is to prevent waste, article 4 does not prescribe product longevity. Instead it states that product reuse should be encouraged. Neither lamp producers, nor producers of luminaires showed any interest in design for reuse. Traditionally, secondary use has been outside the producers' remit. Luminaires, however, were said to have a physical life span that often exceeded the time of initial use. Thus, this aspect of the product design already facilitated reuse, without any additional effort on the side of the producer. Except where fashion styles compromise disassembly and recycling, the possibilities to regulate fashion design would appear to be limited.

Consequently, policy measures to increase product longevity appear to be needed on the demand side rather than the supply side.

5.3.3. Disassembly and recycling

The four largest companies and the Swedish SME expressed an interest in the recycling potential of their end-of-life products. Since only case A and B measured the recycling potential of their products, no comparison of actual recyclability could be made. Case B had started using recycled glass as material input in their products to save costs in the 1960s. For the same reason, recycling techniques were improved in the early 1980s. Material recycling had the same resource efficiency purpose in case A. Neither of the cases saw any real possibilities for cost-savings on producer responsibility through ecodesign of their lamps.

In all environmentally active companies, recycling appeared to be a part of a life cycle thinking that was the norm. Policy debates about recycling and producer responsibility may have contributed to this. However, neither case C nor D, the two Swedish large companies, considered producer responsibility for WEEE to have had any direct influence on their product design. Despite the ecodesign guidelines in case C, the end-of-life aspects were said not to be prominent in current practice.

The awareness and concern about recycling appears to be related to general environmental awareness, which was larger in the large companies, while limited in the SMEs. The difference between the Swedish SME and the UK and German SMEs could not be explained by producer responsibility alone. Case H did not measure the recyclability of its products. Furthermore, it became aware of the producer responsibility policy for WEEE legislation after it had adopted an EPD. Unlike the other SMEs, case H had experienced environmental demands from public procurers.

5.3.4. Substance bans

Although not directly regulated by the WEEE Directive, the contents of dangerous substances in a product affect its recyclability. Public debates and government bans or restriction of certain substances were strong ecodesign incentives, in particular in the four large companies and the Swedish SME. The EPD on certain substances in lighting equipment developed by a Swedish trade association in conjunction with national authorities contributed to the uptake of environmental issues in case H, the only environmentally active SME in the study. The fact that the EPD was a part of a product label related to work environments and the natural environment, particularly requested in public or semi-public working environments may have contributed to the emphasis on substances and the uptake of the EPD.

Use of dangerous substances in EEE is to be regulated by the ROHS Directive. Two cases mentioned the ROHS Directive, saying that it was a stronger motivation for ecodesign than the WEEE Directive. This indicates the effectiveness of bans compared to economic incentives.

5.3.5. Energy efficiency

Energy consumption during the use phase is one of the most significant environmental impacts of lighting equipment. It is not covered by producer responsibility for WEEE, but frequently emerged in the case studies as an environmental aspect in product development. In particular, the SMEs with low manifest environmental commitment were keen to emphasise their efforts to reduce energy use during the use phase as an environmentally conscious action. Energy efficiency was a sales argument and environmentally beneficial at the same time. For other aspects such as product size it was noted that other design requirements often outweighed the resource efficient option of size reduction. For other categories of EEE customers may consider high energy consumption to be a sign of the products power to fulfil its function satisfactory. Therefore the findings on energy efficiency in this study cannot be directly transferred to other product categories.

5.3.6. Supply chain pressure

Most of the cases in this study sold their products to other organisations. Environmental demands were relatively rare, but were mainly experienced by the large companies and the Swedish SME. In the other SMEs architects were the more quality and artistic aware clients as compared to constructors seeking low-prices. These cases expressed the style awareness as opposed to environmental performance. However, case H found that architects enquired for environmental performance. Case D and H had also experienced environmental demands from public procurers. However, some evidence of environmental commitment was requested, rather than the actual contents of for instance the EPD.

Producer responsibility may have an impact on product development beyond the legal definition of 'producers' if producers demand waste minimising product properties of their suppliers. The three largest companies claimed to pose environmental requirements on their suppliers. The general environmental supplier requirements usually comprised compliance with legislation, restrictions of certain substances and some degree of environmental management. Case A and C had developed purchasing codes that contained a number of steps indicating the level of environmental performance of the supplier and a lowest acceptable level. These codes applied to all product categories in the companies, and did therefore not seem to be motivated by producer responsibility for lighting equipment. However the majority of the products produced by case A were subject to the Dutch producer responsibility for WEEE. Thus, the purchasing guidelines may have been influenced by that. On the other hand, the majority of case C's products were not subject to producer responsibility for WEEE.

5.3.7. Trade associations

Trade associations appeared to have a big role to play in the awareness and formulation of producer responsibility for WEEE. Case F and H, the only SMEs that were members of trade associations, had become aware of the forthcoming legislation through their trade associations respectively. Case H even felt it had had an opportunity to influence the policy

formulation through its membership. The trade association had also developed the aforementioned EPD. Case E, on the other hand, not member of any trade association, had been made aware of the policy through one of its large suppliers, case A. Case A and B were both active in a trade association working to adjust the WEEE legislations to the conditions of the lighting industry.

6. CONCLUSIONS AND RECOMMENDATIONS

The context for this project was the need for waste minimisation and the recently adopted EU Directive on producer responsibility for WEEE (2002/96/EC) which had waste minimisation as an objective. The main remit of the WEEE Directive was to ensure separate collection and recycling of WEEE by setting quantitative collection and recycling targets, and allocating responsibility for collection and recycling infrastructure. The transfer of financial responsibility from taxpayers to producers was a key point. In line with the concept of producer responsibility (see section 2.5.1), the WEEE Directive also comprised an article encouraging ecodesign. In the literature it was sometimes assumed that producer's financial responsibility for their end-of-life products would lead to changes in product design. This thesis aimed to explore how the costs of producer responsibility for WEEE imposed on companies had influenced product development, if at all.

Drawing on companies' experiences of national WEEE policies in eight qualitative case studies, this thesis indicated that the main effects of producer responsibility for WEEE were in establishing systems for collection and recycling of WEEE and thus increased recycling rates, and internalising costs for these activities. The costs imposed on the companies did not have any direct effect on product development. This was revealed in the companies limited efforts to keep track of and control the costs for their products' end-of-life stage, and lacking the interest in making economic cost-benefit calculations for ecodesign in relation to the costs of compliance with the WEEE policies. This behaviour could be explained by economic principles. The waste minimisation efforts that occurred in product development mainly had other motivations. For this reason, and due to the scarcity of existing data, quantitative measurements of improvements in product waste minimisation did not reveal the impacts of producer responsibility for WEEE.

The results of this study are in conflict with previous studies demonstrating that product development was affected by producer responsibility policies. The differences may be explained by the mechanisms studied: other studies may have included elements such as

substance bans in their definitions of producer responsibility, whereas this study concentrated on the costs imposed on producers. Furthermore, the other studies focused on large companies, whereas this study included SMEs. Finally, the other studies were at least partly directed at producer responsibility for other waste categories and other product categories in the WEEE sector.

There was a lack of quantitative economic and product data, the qualitative information was satisfactory in revealing company responses to producer responsibility for WEEE. Ultimately, company responses based on perceptions determine the effectiveness of the policy. The policy implications of derived from this study are that

- incentives for ecodesign other than or in addition to producers' financial responsibility for their end-of-life products are needed
- the circumstances under which the charges work as an incentive for eco-design, need to be modelled to enable charges to be effective design incentives as well as user charges

Below, the conclusions of the study are presented in accordance with the objectives set out in section 1.3.

6.1. Objective 1

The first objective of the study was to establish any link between the policy aims of waste minimisation and the waste minimisation performance in product development. Neither the national WEEE policies, nor the WEEE Directive contained any quantitative measures for product development. This makes enforcement and monitoring of this policy aspect difficult. In this study, improvements in waste minimisation aspects were taken as indications of achievements.

Some examples were found of improvements in resource efficiency through product size reduction; extended product service lives and improved recycling potential. However, the data available from the companies were not sufficiently comprehensive, transparent and comparable to show whether the achievements were consistent or counterbalanced by

deteriorations in products not reported on. Therefore, it was not possible to draw strong conclusions about achievements in waste minimisation through product development. Particularly SMEs were wanting in environmental monitoring. This result is in accordance with the literature reviewed in chapter two.

6.2. Objective 2

The second objective of the study was to establish how, if at all, the responsibility of producers to finance the collection and recycling of their end-of-life products has affected product development. The costs to the companies of producer responsibility had not had any evident effect on product development in the cases where the legislation already applied, regardless of whether a collective or individual solution was chosen.

The cost imposed on the companies where producer responsibility already applied were relatively low both for the collective and the individual solutions. User charges for the collective scheme were set at a rate that would recover costs for the collection recycling and support activities, without any additional profit. In the latter case, low transaction costs and small volumes of returned WEEE limited the costs. None of the companies could avoid the costs through ecodesign in the short term since the fees were not variable with end-of-life properties of the products. Neither had the charges stimulated deliberations of product changes for cost-savings in the long term. For the individual solution, the small proportion of WEEE compared to the total waste fraction, the relatively small proportion of EEE in the company's total product range and the mixed brands and product types accepted by the company limited the economic value of fees varying with end-of-life properties of the products developed by the companies.

The company with individual producer responsibility did not transfer the costs directly to the product prices because the costs were integrated in other waste management costs. Costs would be recovered through savings in all business activities rather than product development for waste minimisation specifically. The other two cases assigned the producer responsibility costs to their customers without any perceived negative effect on

demand. This might indicate low elasticity of demand for the products, but was more likely attributed to the low price increases. For this reason, the companies had not calculated the economic benefits of ecodesign. Both cases claimed that producer responsibility for WEEE had not affected their product development.

Other cases that predicted significantly higher price increases were not concerned with effects on competitiveness, since the legislation was felt to affect competitors to the same extent. However these cases had taken joint efforts to bring costs down by improving recycling techniques rather than product development. This may lead to efficiency gains in recycling and contributes to the overall policy aims of waste minimisation, but not to the specific article of product design in the WEEE Directive.

Recycling was a part of a life cycle thinking that was apparent in the environmentally active case companies, manifest in ecodesign guidelines. Producer responsibility might have contributed to the awareness of the importance of recycling. However, for other waste minimisation aspects of product development other motivations appeared more important.

6.3. Objective 3

The third objective of the study was to identify alternative influences on the environmental and waste minimisation performance of product development. A number of factors other than the costs of producer responsibility influenced ecodesign in the companies under study. This was shown by the fact that companies other than those directly affected by producer responsibility for WEEE displayed similar behaviours. Although many of the case companies exported to countries such as Sweden with producer responsibility for lighting products, this was not said to be a driving force behind product waste minimisation. Legal restrictions on substances appeared to be more effective than economic policy incentives in bringing about product changes. The ROHS Directive was said to be more important than the WEEE Directive to this end.

Product size reduction was mainly driven by potentials for cost-savings in material input, packaging and transport. In some cases this occurred well before producer responsibility for WEEE and was not originally environmentally driven. Other functional, quality and cost considerations counteracted product size reduction. While a long service life was an important customer expectation for lamps, luminaires were often replaced before the end of their service lives, due to a customer preference for new fashion styles. Therefore there was little interest among producers of luminaires to extend the service lives of their products. Facilitating replacement of control gears and lamps seemed to be industry practice which in effect extended the life of products. The replacement of functional products allows for reuse, but the companies were not concerned with or aware of the extent to which their products were reused.

Easy disassembly was regarded for the purpose of component replacement in luminaires. This appeared to be common practice in the industry, rather than recycling rationale. Innovation and product design for containment of mercury was a concern for the lamp producers due to the need for mechanical disassembly before recycling. Cost-savings in material input and life cycle thinking were reasons for companies to attend to the recycling potential of their products, even if there was little evidence of actual improvements other than among the lamp producers.

Commercial advantages such as promoting energy efficiency during the use-phase in order to minimise user costs was a strong influence in particular for the SMEs that otherwise showed a low environmental awareness. The environmental awareness of one SME was also stimulated by industry wide environmental product standard issued by a trade association in conjunction with authorities. This led the SME to make product changes, although the improvements were not of a continuous nature. Trade associations appeared in a double role in this study. They alerted the companies on the forthcoming legislation. They were also used as a vehicle to reduce the impact of the legislation on the companies, mainly the largest companies, but also one SME.

The environmental awareness and ecodesign activities in the above mentioned SME were to some extent supported by environmental requirements from public procurers. However, public procurers were more interested in the fact that the company had an environmental product declaration, than the actual contents of it. Whether or not public procurement would support waste minimisation depends on how the environmental demands are formulated. Environmental customer demands were not common, but had been felt by the environmentally aware companies. (This may be a cause for their environmental awareness or an effect of being perceptive to environmental issues). The environmentally aware companies made environmental demands on their suppliers to some extent. These requirements appeared to be phrased in terms of and driven by general environmental management rather than producer responsibility.

6.4. Objective 4: policy recommendations

The fourth objective was to make a partial policy assessment of the results, leading to policy recommendations for the implementation of the product development aspect of producer responsibility for WEEE. At the time of the completion of this thesis the EC still had not made a statement on its interpretation of adequate measures for compliance with article 4 of the WEEE Directive. Therefore, the recommendations below can only be presented in general terms and are not related to the final EC legal interpretation. Furthermore, each of the recommendations below has consequences on a range of issues not covered in this thesis. Therefore, they need to be assessed in their context before implementation.

- The financial responsibility on producers for collecting and recycling WEEE is effective in recovering costs for these operations without any noteworthy negative effects on business sales and competitiveness.
- Financial responsibility alone is not effective in stimulating ecodesign.
- In order to stimulate product design, the charges need to be large enough to make a difference for customers, outweigh contradicting product/fashion requirements. The product properties need to allow significant improvements.
- Since the policy is considered to be fair in the sense that competitors with similar

products bear similar costs, relatively high charges may not have a negative impact on (perceived[7]) competitiveness. Concerns about competitiveness in markets outside Europe did not emerge in this study, partly because some Asian countries were adopting similar legislation.

- Individual responsibility is not more effective in driving ecodesign than collective schemes are, unless: products are differentiated and difficult to copy; possible to sort according to brand to a relatively low cost; each product unit has a high value and the transaction costs for the collection and recycling is relatively low, and; the number of returned products is relatively high.
- Command and control in the form of substance bans was an effective external driver of ecodesign. Substance bans will take effect through the ROHS Directive. It may be possible to regulate end-of-life standards. The standards need to be modified as recycling technologies develop. However, end-of-life standards may face trade-offs with other environmental properties and stifle other aspects of product development.
- Environmental product declarations as a voluntary industry initiative can stimulate ecodesign in SMEs not previously environmentally active but responsive to environmental issues.
- The effect desired from product standards need to be considered. The EPD in this study did not lead to continuous improvements, but one-off changes. For the WEEE Directive, continuous improvements may not be needed. Standards prescribing a level of ease of disassembly and recycling according to current technologies may be sufficient.
- In order to be effective, the use of a standard may need to be supported by, for instance, environmental demands in public procurement. Regulated environmental requirements in public procurement may serve as an evidence of compliance with article 4 in the WEEE Directive. A prerequisite is that end-of-life characteristics are specified.
- Trade-offs between end-of-life characteristics and other environmental aspects over the product life cycle should be regarded.
- Corporate environmental measuring and reporting needs to be incentivised, especially in SMEs. Particular focus should be on making the measures transparent and comparable as far as practical. (An initiative for supporting the use of LCA in SMEs in under way in some EU member states, including the UK).

[7] The companies had not changed their behaviour since they did not perceive any negative effects on competitiveness. A study of whether or not competitiveness had actually changed and whether or not it was due to producer responsibility, was outside the scope of this thesis. However, company *perception* determined their response to the policy

6.5. Future research

The limitations of this study provide opportunities for further research:

- The findings in this study monitor business responses to the WEEE legislation when it has been in place only for a few years. Since additional effects may emerge in a longer term, an evaluation of the effects of the WEEE Directive on product design should be made at a later date.
- There are many different influences on company decisions in general, as well as on ecodesign. In order to better understand the interaction of the influences and their effects, a more comprehensive study from a systems perspective may be useful
- Longitudinal studies would enhance the understanding of the processes by which the WEEE Directive affects product development. Longitudinal studies minimise the risk of memory distortions that may occur when informants account business processes in retrospect, or due to accounts made by staff that joined the company before a part of the process occurred.
- Although the existence of reliable quantitative data of performance outcomes does not in itself establish any causal links, such data would give a clearer picture of actual business achievements in waste minimisation through product development
- If producer responsibility charges are to be used as a policy incentive for ecodesign, the conditions under which these costs will have an effect on product development need to be further understood. These conditions may include product properties, numbers of returned products; logistics, costs and benefits relative investments required and market demands.

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Appendix 1 Interview guidelines

The interviews were carried out as thematic telephone interviews. An interview guide was used to ensure that the relevant themes were covered, but there was scope for informants to elaborate on answers and the interviewer to follow up on the answers. Furthermore, the questions were adjusted to the individual informants and the secondary sources available about the companies. Below is the interview guide on which both the interviews and the questioning of the secondary sources were based. The order of the questions was not strictly followed in the cases where the informants elaborated on an issue in a way that it led into another theme on the questionnaire.

Question themes for interviews

Informant
Role in the company; time in this position; background
Environmental criteria in product development and driving forces
Who determines the product criteria?
Are there any environmental criteria in the product development process?
When and why were they introduced?
What are the focus areas? (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 kind of solution did the company choose for fulfilling its producer responsibility for WEEE?
What were the reasons for the choice?
Who were involved in the decision?
Did you consider any options? Why/why not?
What is the basis for the charges for producer responsibility? (fixed or variable)
Costs, prices, competitiveness
What costs are controlled in the product development process?
Does/ will the costs of producer responsibility affect product prices?
How has this affected sales and competitiveness?
Has the company tried to influence its costs for producer responsibility; how?

Appendix 2 Sample interview summary

Below is a sample interview summary and personal reflections about the interview, noted by the interviewer. The name of the informant and the company has been removed in order to maintain confidentiality. The summary was sent to the informant for comments, but in this instance no response was returned.

Interview summary with (Name), (Company)

Type of contact	Semi-structured telephone interview
Date	06/08/2003
Informant	*Name*
Position	R&D and marketing manager (recently resigned); *Company*
Contact details	*E-mail address; telephone numbers*
Interviewer	Annika Gottberg, Cranfield University at Silsoe; *(contact details)*
Interview report sent for comments	yes
Comments received	No

Case characteristics

- The Company was founded 1986 and started exporting in 1988.
- (The turnover doubled in 1996)
- The Company employs some 90 people and sells on the UK market as well as exports to France, Holland, and the Middle east
- The informant has been with the Company for 18 years and is now leaving to take up a post at (company confidential)
- The Company is not a member of any trade associations
- The clients are retailers, but some of the end-users may be households

Customer demands

- Clients specify the products, but do not always know what to specify. The lighting industry is a mixture of science and art. The client specifications often involve the visual impression of the product, light performance, and size
- Energy efficiency is of importance to the customer due to the costs during the use phase, but otherwise the selection of light fittings is not environmentally based since lighting is a fashion business
- There are no environmental requirements from the export markets, except for

German packaging requirements

Product development and environment/waste minimisation

- The products are adapted to the markets in different countries with regards the voltage
- Material selection is based on function, optical performance, low emissions in case of fire (=public safety)
- The main materials are aluminium and steel which are recyclable. The recyclability and the content of recycled materials in the products are not measured as such
- Records of material input exist in the form accounting documents, but is not measured otherwise
- The company tries to reduce the weight and volume of its products in order to save resources, similarly to all industries. In addition to savings in product material, this saves packaging material and transport. The changes in size are not monitored
- The generally accepted design life of light fittings is ten years. Materials age and break down because of the heat. Also technology develops, and people want new designs. Therefore no attempts are made to extend the product life of light fittings
- If the product life time were to be extended it would require more expensive materials and increased specifications in plastics, and investments in tooling for these materials
- The light fittings are designed to be serviceable and the Company holds spares. The ease of disassembly is not monitored but based on experience of the products
- The amount of packaging is measured in accordance with the requirements of the packaging regulations
- The recyclability of packaging materials is not measured, but is sought where possible
- Energy efficiency is a criterion in the product development process because it is a major sales argument, but there are no formal environmental criteria in product development
- The Company promotes energy efficiency to the customers
- Energy consumption during the use phase is monitored and significant improvements have been made over the years (no figures provided)
- Categories of energy efficiency are determined by the building standard and there is a government scheme for energy efficiency in new buildings

The WEEE Directive

- The company first heard about the WEEE Directive about 8 years ago through a large supplier

- So far there have been no discussions about the WEEE Directive in the Company as it is not clear what the final implementation will look like
- The cost of producer responsibility (the WEEE Directive) will not affect the competitiveness since it is the same for the competitors

Product pricing

- Pricing is based on market intelligence and pressures from the client (target pricing). Labor, material and simplified designs and investments in tooling are used to keep the costs down

Personal reflections: Informant worked from home (got mobile phone number from the switchboard; phoned informant and he gave out home number). Had been with the company a long time. Very helpful. Good at talking. Keen to emphasise environmental friendliness, like energy efficiency. Stiffened a bit at the questions on whether the different 'environmental' aspects were monitored – no monitoring occurred. Informant may have assumed that I took it as a sign of lacking environmental awareness. Aware of the WEEE Directive, contrary to the other informant. Slight disagreement with MD on some issues?

Appendix 3 Case A

Case company A is a large Dutch company developing, manufacturing and marketing a range of electrical and electronic equipment. From the outset at the early 19th century, lamps were one of the main product types. In the first part of the 20th century, the company spread both geographically and in terms of product range. The company now employs some 170 000 people in about 60 countries and lamps, luminaires and lighting electronics are comprised in a business division. Lighting products are sold both to professional and consumer markets.

The case was based on an interview with the eco-design manager for the lighting division, written information published by representatives of the company and a video lecture by a leading eco-design manager and academic linked to the company. This information gave a fair representation of the company's stance on producer responsibility for WEEE and ecodesign.

Environmental profile

Resource and environmental scarce in the 1970s and -80 contributed to the company's environmental awareness. To begin with, the environmental work focused on end-of-pipe solutions to environmental impacts of production processes. Subsequently, the company realised the cost-effectiveness of preventative actions. LCAs were carried out in the late 1980s and ecodesign commenced in the early 1990s. Management envisaged that the business relevance of the environmental performance of products. Ecodesign has developed from defensive mandatory design rules regarding the substance use in products, to proactive ecodesign practices with computerised design and monitoring tools. The company also has close research links in ecodesign with a university. Ecodesign is now an important part of the brand imaging as an innovating company offering the best technology and best environmental practice.

The company has published environmental reports since 1998. From the current year the environmental report was replaced by a sustainability report comprising environmental issues and measures. The lighting division also publishes its own environmental review. The lighting division introduced ISO14001 certified environmental management systems in the mid 1990s. At the time of the study 95 percent of the manufacturing plants were ISO14001 certified. The lighting division had action plans and targets for ecodesign. General ecodesign achievements were measured as a percentage of the total product portfolio to which the company's ecodesign principles were applied.

Focus areas, measurements and ecodesign

The environmental report of the lighting division stated that weight and volume reduction as a goal for the product development, as this was a way of saving resources. This statement was supported by the interview. According to the informant, the reduction in product size was primarily driven by the potential for cost savings in materials rather than environmental concerns. On the other hand, the informant perceived a trade-off since soldering techniques and handling of small components incurred additional costs. The environmental review mentioned achievements for individual products. Reported weight reductions for individual products ranged from 25 to 60%. The informant did not have any figures of the total achievements for the whole product range. The company's monitoring was used as a tool for internal improvements, and therefore, comparisons to previous products were of more immediate use than overall achievements.

Extended product lives were seen as beneficial from the point of view of waste prevention but it was also a major sales argument. The opinion of the informant was that the latter was a stronger driver for extending the product life time. Achievements were stated for individual products. The measure used was use time in hours or times extended product life. The service life of one product was said to have been extended by six times compared to a product with a similar use function. The informant did not have any figures of overall achievements

The informant considered energy efficiency was considered to be a more important criterion for the ecodesign than end-of-life characteristics. Energy efficiency was also a major selling point. The possibilities to improve the ease of disassembly and recycling potential for products were considered to be limited due to the fact that different recyclers use different recycling techniques. In order for disassembly to be economically viable, it needs to be done mechanically. The recycling potential for some products was reported to be high. One example was 98% recycling potential for one type of product.

In addition to waste minimisation aspects of product development, the company also concentrated on dangerous substances, packaging and other environmental aspects of its activities in a life cycle perspective.

Producer responsibility

The company advocates a collective solution for producer responsibility for lighting products. Lamps are highly standardised and therefore it would be difficult to separate the end-of-life products by brand. The high volumes of lamps would further increase the costs of separation by brand. According to the informant, the recycling cost per lamp may exceed of the cost of the lamp itself. A trade association in which case A was active, had calculated the additional costs to amount to 60% of the current retail price. A collective solution would allow for economies of scale. Due to the product characteristics mentioned above, an individual solution was not considered to be economically viable.

The cost of producer responsibility would be transferred to the price of the products. In the Netherlands, this is currently done through a visible fee for new products. Company A advocated this approach for the future as well. The informant did not see any possibilities to reduce the costs of producer responsibility through the design of the products since different recyclers were said to use different methods and different product features may entail higher or lower costs with different recyclers. The interview revealed that producer responsibility for WEEE was not seen to affect product development in the lighting division of the company. Furthermore, the informant said that there was currently no way

of calculating the costs and benefits of ecodesign/increased eco-efficiency, but the company was convinced that is of importance not only for the environment, but also for future commercial advantage. End-of-life costs were not controlled in product development

Instead, company A's main tactic for reducing the costs was to try and influence the policy formulation with regards to the take-back and recycling systems. The company had assigned a special corporate task force to work on the implications of the forthcoming WEEE Directive.

The competitiveness of the company was not felt to be affected by the increased price since competitors are required to comply with the same legal requirements. No concerns were expressed regarding competition in markets outside Europe.

Conclusion

Case A reported achievements in the area of waste minimisation in quantitative terms. However, the underlying data and principles were not published, and hence achievements were not comparable to other companies. Neither were there any data on achievements across the whole product range. Producer responsibility for WEEE was not considered as a driver of ecodesign. Corporate image appeared to be a main driving force for environmental adaptations. The company's products had already reached a high level of recyclability and few opportunities were seen to reduce costs of producer responsibility through product design. Instead, the company tried to influence the formulation of the legislation and to improve recycling techniques. The company did not think that anticipated large increases in product prices would have a negative effect on the competitiveness.

Appendix 4 Case B

Case B develops, manufactures and markets lamps, light fittings, control gears and semi-conductors. The brand was established in Germany in the early 20th century when three companies joined their lamp manufacturing activities together. The products are aimed at business customers as well as consumer markets in about 140 countries across the world. The largest part of the turnover is generated in Europe and the Americas. The company employs some 35 000 people throughout the world.

The case was based on a telephone interview with the head of Environmental Affairs, and information published by the company. The information was felt to be a fair representation of the company's stance to ecodesign and response to the producer responsibility legislation.

Environmental profile

In 1990 the department of Environmental Affairs was established, following a number of separate actions relating to natural resources and the environment over the previous decades. The environmental awareness was propelled by public debates about issues such as CFC and mercury. The company also experienced environmental demands from customers. Mainly, these demands came from European business customers.

In the mid 1990s all German plants had environmental management systems (EMSs) certified according to ISO14001. Subsequently, sites in other countries were certified. The company published qualitative and quantitative environmental information on its webpage. On the Swedish webpage, the information was collated in an environmental report.

The quantitative information comprised both products and processes over a period of nearly ten years and was said to be aggregated from comprehensive data collection. The information on processes was presented both as percentage changes compared to a baseline year attributed the figure 100%, and as absolute figures. It covered issues such as energy and water consumption, waste generation and CO_2 emissions. Economic output was

published for the same period to enable readers to make their own comparisons of environmental aspects per output.

Focus areas, measurements and ecodesign

Efforts to reduce the size of products were driven by potential for cost saving for material input. Size reductions were recorded in the 1970s well before the company had embarked on a systematic approach to environmental issues. Later, the environmental benefits of reducing material input were found to reinforce the potential for cost savings, according to the informant. Productivity improvements of some 10 percent were said to be needed to compensate for price erosions. No overall figures were presented for the changes in product size over time.

In a similar way, product longevity presented a potential for an environmental–economic win-win situation. Low energy lamps consume less energy than normal lamps and last longer, which results in less waste, less CO_2 emissions and lower costs for the user. Thus, product longevity and energy saving were important sales arguments. The company presented several products with increased lives and reduced energy consumption over the life time. The figures usually expressed improvements in energy efficiency as percent and increased product life as number of hours compared to another product. However, no overall and comparable figures were presented.

The informant called attention to the fact that currently low energy lamps had to contain a small amount of mercury, which was not the case in normal lamps. Likewise, led-free glass required lower temperatures during the processing than unleaded glass. Thus there was a trade-off between environmentally hazardous substances in products and energy efficiency.

Dangerous substances contributed to the environmental awareness of company B. At the time of the interview, the informant viewed the ROHS Directive (2002/95/EC) banning lead solder and leaded glass, and restricting the use of mercury, as a stronger influence on product development than the WEEE Directive (2002/96/EC). Innovation was occupied with ways to contain the mercury in the lamp in a way that did not pose a risk for pollution

or a health treat when the lamps broke or were disposed of. According to the official webpage, company B made environmental demands on their suppliers. The requirements appeared to relate mainly to hazardous substances.

Increases in life spans were reported for individual categories of lamps and compared to a conventional product with a similar function. However, no overall figures and comparisons were published. Similarly, the substance contents for different products were declared, and aggregated figures for mercury reductions over twenty years were presented, but more complete and comparable figures were not reported.

Use of recyclates and improved recyclability of lamps were items on the company's environmental agenda. In the early 1980s a way of dismantling fluorescent lamps and collecting the heavy metal containing lighting powder was developed to enable recycling. Company B claimed to have developed this technique in order to recycle lamps that were scrapped before sales and reuse the processed material as input in new products. A telephone interview with a Swedish recycler revealed that company A claimed to be the innovator behind this technique. Nevertheless, it shows that recycling had been a concern long before the EU WEEE discussions commenced. In the late 1990s innovations had led to new uses of recyclates from lamps which allowed 100 percent recycling of lamps that could not be used as input material in new lamps. The discovery of new areas of use made possible additional revenues from recycling.

The interview revealed that the development of recycling techniques was as important for company A as focusing on the recyclability of the products. Company B had formed an association with other lighting companies, including company A, and a number of recyclers in order to exchange information for further development of recycling techniques and product features. This association was formed around the same time that the discussions about the WEEE legislation entered the EU agenda. The informant claimed that the WEEE debate had not influenced the development of the association.

The informant predicted that producers' financial responsibility for end-of-life lamps would lead to significantly higher product prices, since the cost of recycling lamps could amount

to some 60 percent of the production cost per unit. However, the price increase was not believed to reduce competitiveness since the legislation created equal conditions for all companies. On the contrary, the informant felt that the company had and advantage compared to Asian competitors. The European companies already met many of the requirements whereas some Asian companies would have to undertake far-reaching changes to their products to comply with the law. However, this effect related to the contents of heavy metals and thus stemmed from the ROHS Directive rather than the WEEE Directive.

Due to the fact that company B's lamps were already considered to be 100 percent recyclable there was felt to be little scope for reducing the cost for WEEE by changing the product design. It was also suggested that the high level of standardisation of lamps made it difficult for an individual company to gain competitive advantage through product design changes. New innovations were estimated to have been copied by competitors within a short space of time after the release. Therefore, company B advocated a collective solution to producer responsibility in the lighting sector. An additional reason for this was the costs involved in sorting the lamps according to brand, due to the high volumes of small and highly standardised products. The informant envisaged a fee structure based on the market share of different companies.

The company had established a working group to deal with the implementation of the WEEE and ROHS Directives (2002/96/EC), (2002/95/EC). This group reported to the corporate board which could then make decisions on the company tactics on the issue. Moreover, the association of lighting companies and recyclers was a forum for developing an industry approach to meeting the legislation, as well as influencing the formulation of the legislation. The association criticised the Directive for distinguishing between household and business WEEE. Since it was not viable to sort the waste products according to this distinction, there was a perceived risk of cross-sector dumping, i.e. that lamps from businesses would be disposed of in the domestic waste stream. Another point of criticism was that the recycling targets were expressed in weight, while lamps where relatively low

in weight and high in unit quantity compared to other categories of WEEE. This feature was felt to justify specific legal provisions.

Conclusion

Company B reported achievements in the area of waste minimisation in quantitative terms. However, the underlying data and principles were not published, why achievements were not comparable to other companies. Neither did the information reveal the achievements across the whole product range. Size reduction and recycling initiatives were reported for times well before the WEEE discussions entered the policy agenda. Cost savings, public debates and legislation about certain substances appeared to be the main driving forces for environmental adaptations. The company's products had already reached a high level of recyclability and few opportunities were seen to reduce costs of producer responsibility through product design. Instead, the company tried to influence the formulation of the legislation and to improve recycling techniques. The company did not think that anticipated large increases in product prices would have a negative effect on the competitiveness.

Appendix 5 Case C

Case C is a Swedish company developing, purchasing, distributing and selling home furnishing, including light fittings. Most of the customers are households, but there are special departments in the retail outlets that deal with business customers. Since the start in the mid 20th century the company has expanded and now employs some 70 000 people. There are franchised retail outlets in 22 countries across Europe, Asia and North America. 80 percent of the turnover is generated in Europe.

This case description was built on material published by the company and telephone interviews. The informants were three environmental managers at different levels: the head of environmental affairs internationally, the environmental manager for Swedish retail outlets which was the post most directly involved in producer responsibility for WEEE, and the environmental product manager. In addition a product engineer from the lighting division was interviewed.

The information from the different sources was largely consistent although two informants appeared to accentuate certain environmental activities. Two of the informants had worked in the company for less than two years. One of the informants had worked in the company for over ten years, but had taken up the current post only a year ago. The relatively short time in the positions of the informants may limit their knowledge about decision processes in the past, but the balanced accounts of two informants, and the information taken together was believed to be a fair representation of the case.

Environmental profile

The environmental activities of the company started in the late 1980s and early 1990s. The public debate about environmental issues, in particular about different substances such as brominated flame retardants and PVC, was a trigger for this. Today the company has a central environment departments and environmental co-ordinators in each business unit to

support the general managers in the work with environmental issues. The company publishes an environmental brochure on their webpage. The brochure contains mainly of qualitative descriptions of environmental activities and sparse quantitative information.

Focus areas, measurements and drivers of ecodesign

Case company C applied environmental guidelines in the product development, covering the whole life cycle of the products, from raw material input, through production and use, to the after-use phase. The guidelines emerged from trials of life cycle assessments in the early 1990s and had been implemented gradually since 2001. The same guidelines were applied to all products as relevant. Except for bans of certain substances, compliance with the guidelines was not obligatory and there were no quantitative measurements of the actual achievements. However, two informants mentioned that measures were being developed.

Cost awareness and resource efficiency had been a part of the corporate culture since the outset and was a reason for the company to strive to reduce the size and weight of products. In addition to reducing the amount of raw material used in the actual products, the need for packaging was reduced and the number of items that could be send in one load increased, leading to more efficient transports. In the mid 20th century, flat packages were introduced to this effect. A few decades later, environmental awareness and cost-saving resource efficiency were found to present a 'win-win' situation. Size reduction was an ongoing ambition in product development. Although examples of individual products were held up in the environmental brochure, product size was not monitored across the whole range.

The products were designed to be easy to assemble and disassemble due to the fact that the buyers receive a flat package containing modules to be assembled. The product engineer also mentioned the easy disassembly as an environmental criterion for product development. This statement was consistent with the company's reported ambition to facilitate recycling. It was not clear whether easy disassembly for recycling coincided with the kind of modularity required for easy assembly by the user. Although a part of the environmental guidelines for product development, ease of disassembly and recyclability

were currently not prominent in the product development, according to the environmental product manager. The same informant said that attempts had been made to measure the end-of-life properties of the products, but that the methods were still too imprecise to yield accurate measures.

There was no mention of increased product durability as an environmental criterion, but attention to environmental impacts during the use phase was exemplified by increased energy efficiency of a particular lamp. No account was given for energy efficiency across the product range.

Specific substances with negative environmental impacts were reported to be among the earliest directly environmental influences on the company, both by the environmental brochure and an informant. Similarly, the restricted use of heavy metals in products, posed by the ROHS Directive, was felt to be a more urgent concern for the development of lighting equipment than the WEEE Directive.

The environmental guidelines for product development contained some binding specifications regarding the use of particular substances. Substances ruled out by legislation as well as by corporate policy were specified in the guidelines. Since the company exports to many different countries, they were obliged to observe legislation and standards in these countries. In order not to have to modify the products for the different markets, the strictest standards were applied everywhere. Every product had a certificate specifying the contents and levels of dangerous substances. There was some control of the substances *ex post*, in addition to the guidelines up-front.

Case company c screened its suppliers for their environmental performance. Environmental requirements on suppliers started well before producer responsibility for WEEE. Demands on suppliers applied as much to other product categories as electrical and electronic equipment. The purchasing guidelines also included social aspects. This would indicate that the supply chain pressure was not directly related to the WEEE legislation.

Producer responsibility

The company had chosen an individual solution to its producer responsibility. Since three of the four informants had worked in their current positions within the company less than two years, the explanations of this choice were slightly diverging. One possible explanation or at least contributing factor was the generally individual stance of the company. The company was not a member of any trade associations, only of business networks where they had taken the initiative.

Another reason for the choice was the fact that the company segregated the waste from its own activities into a number of fractions, one of which was electrical waste, and had a satisfactory collaboration with contractors. It was felt that the ease with which users could access the retail outlets to return their end-of-life products, and the established relations with the contractors, producer responsibility for WEEE could be managed efficiently with the existing system. The informant was not aware of any comparison of the costs of individual and collective producer responsibility previous to the decision.

The costs of this arrangement included the rent for the skips, a fee per volume and transport costs. Emphasising the company's environmental consciousness, one informant stated that recycling was a part of the company policy and that costs of this were not a consideration. In the long run all costs would have to be recovered and in that sense producer responsibility for WEEE would be included in the product price. However, the informant did not believe that the costs had led to increased product prices to customers. He also pointed out that the recycling costs for electrical equipment was only a small part of the company's total costs for recycling. His view was that cost reductions were sought across the board, aided by the cost aware corporate culture.

Cost awareness had a prominent position in the company processes but the costs of the end-of-life features were not controlled in the product development process. According to the product engineer, the main focus of cost control in the product development process were staff time and time to market. However, decisions influencing product costs may also be

made at more strategic levels. One informant mentioned the involvement of strategic procurement in keeping the product costs down. Products would not be pursued if the costs were anticipated to be too high.

Another informant mentioned that the electrical products only made up a small part of the company's total sales and that the amount of returned electrical products was also insignificant. One informant mentioned this as a possible contributing factor for the individual solution to producer responsibility. The inference of the different interviews taken together was that without the costs of setting up a new system, and with charges based on collected volumes, an individual solution may be cheaper than paying a fee to a collective scheme for on the number of products placed on the market. This should however not be taken as to mean that the company tried to avoid the take-back of end-of-life products. One informant emphasised the company's duty to inform users. Another informant held the opinion that other means of disposal was still easier and cheaper for households than returning the end-of-life products to the retailer/producer.

The contracts with the electrical equipments recycler had not been renegotiated after the Swedish WEEE legislation came into force, and no changes had been decided on for the implementation of the WEEE Directive, due to the uncertainty of the final form of the implementation.

Conclusion

No quantitative measurements of environmental performance were carried out across the product range. Thus, achievements in terms of waste minimisation of products could not be established. Environmental guidelines were applied in the development of all product categories and covered all life cycle stages. The end-of-life phase was not particularly prominent. These guidelines were developed before the WEEE legislation was introduced.

Substance bans and potential for cost savings were important drivers of environmental awareness and ecodesign efforts. The individual solution of producer responsibility for WEEE was not chosen to reap the benefits of ecodesign. The contractors charges were currently not related to the products' end-of-life characteristics. End-of-life costs were not controlled in the product development process. No changes were reported to the solution of WEEE at the introduction of the WEEE Directive. This would indicate that producer responsibility for WEEE had had no direct effect on product design in case company C, other than possibly drawing attention to the continued societal interest in recycling.

Appendix 6 Case D

Case D is a Swedish concern designing and manufacturing lighting equipment on customer demand. The product range includes both light fittings for public environments and domestic lighting fittings but it is unusual that households are the end-users of the products. 25-40 percent of the sales are customer specific. Since the start in the mid 20th century the company has expanded and now has subsidiaries in Denmark, Norway, Germany, the Netherlands and the UK. It employs some 1200 people, 740 of which are working in Sweden.

The case was based on telephones interviews with the Environmental Manager (EM) and the Accounting Manager, and e-mail responses from the Development Manager (DM). The EM and DM had held other posts within the company previous to their current ones. The e-mail response was the preferred by the particular respondent. It prevented immediate follow-up questions, but the information taken together gave a sufficient picture of the company's approach to ecodesign and response to the WEEE Directive. The informants gave consistent information independent of each other.

Environmental profile

The public interest in environmental issues in the mid 1990s led the company to implement an ISO14001 certified environmental management system (EMS). The EMS did not make demands on products, but required continuous improvements in the operations. The environmental performance of the products in a life cycle perspective was seen by the company as an opportunity for continuous improvements. The launch of an industry standard for environmental product declarations around the same time may have been a contributing factor, as well emerging environmental demands from public procurers. Although the customers' environmental interest was fluctuating, it was perceived to fluctuate around an upward trend. Most environmental demands came from customers in the Nordic countries. The environmental activities had led the company to pose environmental demands on its suppliers, usually requiring some kind of EMS.

The corporate environmental product requirements were decided on jointly by the management, marketing and development functions and had not undergone any significant changes since they were introduced. At the time of the interview, the company also had an environmental manager and published an environmental report. The report presented quantitative data on raw material input, energy and water use, emissions, waste and noise from three production plants in Sweden for four consecutive years. The figures were not related to the system in which the company was active, nor to any output measure. There was no description of the contents of the figures. Thus the information could not be directly compared to other companies.

Focus areas, measurement and ecodesign

Material efficiency was a goal for the product development. It was mainly driven by possibilities of cost savings, but also to make it easier for the electricians to install the fittings. The size of the products was not monitored, but one informant estimated that a decision to develop products only for the T5 fluorescent lamp had led to some 40 percent in volume reductions of the products compared to the situation before the implementation of the decision.

The life span of the products were not measured but estimated to between 10 and 25 years. The company tried to develop cool light fittings to reduce the stress on the electronic control gear. Retail customers were found to replace the equipment before the end of its physical life time, whereas industry customers were said to keep the products for the entire physical life time.

Recyclability and ease of disassembly were reported goals for the product development but were not measured. At the time of the interview, the company had not received any feedback from the recyclers on these issues.

Energy efficiency was a main criterion in the product development process and the company had decided only to develop products for the energy efficient T5 fluorescent lamp. One informant stated that energy efficiency was not primarily driven by

environmental concerns, although it was environmentally beneficial. Instead the lower cost for the user during the product life made energy efficiency and important sales argument. The average energy consumption of the products today was reported to be 20 percent of that 25 years ago.

Another important environmental criterion in the product development process focused on material use and substances. Avoiding dangerous substances such as PVC, brominated flame retardants and solvent based paints were company goals although there was no legal ban on these substances. Achievements are measured as a percentage of the use of the environmentally beneficial option relative the use of the precluded material. These figures had neither been made available to the public, nor the researcher. Recycled materials were said to be used to some extent, but quality and price superseded recyclables as determining criteria.

Producer responsibility for WEEE

The company had opted for joining a collective scheme in order to fulfil its producer responsibility for WEEE. The company paid a fee to the organisation based on the weight of the products, and the company's market share. The company could not influence its costs for producer responsibility in the short term since the fee was only variable with the type of product and the market share rather than the end-of-life features of the products from a particular company. Due to the large market share of company D, they perceived that changes in end-of-life features of the company's products may have a relatively big impact on the overall cost of the recycling of WEEE in the long term. However, time lapse before the new products become waste meant that it would take a few years before the impact on the costs was seen.

The cost of the fee was allocated to the price of the new products based on the products' weight and was estimated to one or a few percent of the total product cost. The increase in price was not perceived to have any significant impact on the company's sales or product-mix as the competitors are subject to similar increases.

Both the product specifications and prices were set by the marketing department with customers demands and competitors supply in view, as well as cost recovery and profit margin. The development department had a budget and the investment costs, staff time and other costs were controlled for every project. The costs of end-of-life management of obsolescent products were not controlled in the product development and there were no plans to change that.

According to the informants producer responsibility has not had any direct influence on the product development process. The changes that occurred were, as mentioned above, attributed to the implementation of the EMS, which in turn was the result of an increased public and customer interest in environmental issues.

Conclusion

Increased public interest in environmental issues, emerging customer demands and the issue of an industry standard for environmental product declarations propelled company D's environmental commitment and attention to the environmental performance of products. Product related waste minimisation features were not monitored, but there were some estimations of and goals for improvements. Consequently, no achievements could be established objectively. The company had chosen a collective solution to its producer responsibility and could not influence its costs in the short term. The costs were allocated to the price of the products. This was not felt to have any impact on the company's competitiveness and had not led to control of the products' end-of-life features in the product development process.

Appendix 7 Case E

Case E is a UK company developing, assembling and marketing light fittings. The company started in the mid-1980s and entered export markets a few years later. The company now employs some 90 people and exports to other European countries as well as the Middle East. The clients are retailers, but some of the end-users may be households. An estimated 30% of the products are designed on demand. The rest are standard products for retail. The company was not a member of any trade association.

The case was based on two telephone interviews. The informants were the engineering manager who had worked at the company for four months at the time of the interview, and the R&D and marketing manager who had worked in the company for nearly 20 years and was leaving to take up a post in another company. Their information was consistent, but the informants each contributed issues that the other did not bring up. Both were keen to highlight the environmentally friendly aspects of the business.

Environmental profile

The company stated on its webpage that it expected its customers to be environmentally aware. There was, however, little evidence of the company's own environmental awareness. The company did not have an environmental manager, apply any formal environmental guidelines in the product development, or measure and report on environmental performance.

Focus areas, measurement and ecodesign

Customer requests formed the basis for product specifications on which the marketing department then decided. The marketing director described the lighting industry as a mixture of science and art, meaning that customer requirements were based as much on the visual impression of the products, as technical specifications. Neither of the informants had noted any environmental requirements from customers, neither from the domestic nor the export markets, the exception being packaging requirements from the German market. The

lack of environmental demands was attributed to the fashion features of the lighting industry. This would imply that either the customers are indifferent to environmental issues, or that they do not believe that they can have both good environmental performance and fashionable design at the same time.

Aware of the environmental slant of the study, one informant expressed efforts to choose materials that were recyclable and safe to humans and the environment. He admitted, though, that environmental considerations do not carry very well against criteria for function and safety, quality and price. The recyclability or contents of recycled materials were not monitored.

Attempts were made to reduce the weight and volume of the products since this leads to savings in the cost of product and packaging material as well as transport costs. The achievements in weight and volume reductions were not monitored.

No attempts were made to increase the durability of the light fittings beyond the industry average of ten years, which the products were believed to match at the time of the study. The life span was said to be determined by the effect on the materials of the heat generated. Increasing the life time would require different specifications of the materials which would probably be more expensive. It would also require investments in tooling required for those materials. Furthermore, retailer customers were perceived want new designs and technologies regularly, which contributed to a lack of interest in prolonging product life. As standard business practice, the light fittings were designed to be serviceable during their life time.

The energy efficiency of the products was an important sales argument as the energy consumption during the products' use-phase incurred a considerable cost. One of the informants emphasised the environmental aspect of energy efficiency and the company's activity in promoting energy efficiency to the customers. He also mentioned government initiatives in the UK supporting energy efficiency as an additional incentive.

Producer responsibility for WEEE

The company became aware of the political discussions about the WEEE Directive (2002/96/EC) some eight years ago through one of its large suppliers. At the time of the interview, the effects of the legislation had not been discussed in the company. The informant attributed this to the uncertainty about the UK interpretation and implementation of the Directive. The engineering manager claimed to be aware of the legislation, but his understanding appeared to be wanting.

The cost control in the product development process mainly focused on the cost of the products. Material made up the largest cost, followed by labour. The costs of end-of-life management were not a concern. Product pricing was based on market intelligence and pressures from the clients. Increased product costs due to the coming producer responsibility were not believed to affect the competitiveness since the competitors would be equally affected by the legislation.

Conclusion

Company E did not undertake any measuring and monitoring of product aspects relating to waste minimisation. Therefore it was not possible to establish achievements in that area. Neither did it control the costs of end-of-life features of the products. Customer demands and cost savings were behind the features that sometimes presented environmental – economic win-win situations. The awareness of the forthcoming producer responsibility for WEEE had not generated any actions in the company and was not believed to have a negative impact on sales.

Appendix 8 Case F

Case company F is a German SME employing some 150 people. The company started developing, manufacturing and marketing domestic lighting products in the late 1980s. A good decade later the company expanded its range to include public and semi-public environments. Architects and light planners are the primary clients. The end-users cannot buy directly from the company. The company has about 30 sales offices across the world.

This case was based on an interview with a design engineer. The informant had worked in the company for eight years and was therefore believed to have good general knowledge about the business activities that he was involved in. An accountant and a finance manager were approached but did not feel in a position to answer the questions. They had not heard about the WEEE Directive, which in itself revealed information about the case. Additional information was drawn from the company webpage.

Environmental profile

The company had not experienced any environmental demands from its customer or other stakeholders. It did not have an environmental manager, nor did it measure and report on environmental impacts of the business.

Focus areas, measurements and drivers of ecodesign

Apart from regulations that had to be observed in the different markets, customer demands were said to be the main determinants of product design. The informant held the view that customer demands were based on fashion trends. Visually attractive lighting performance but unobtrusive light fittings were perceived to be the customer preferences. This was an incentive for the company try to reduce the size of the physical products. However, a trade-off was perceived between size reduction and cost considerations, since smaller products were more difficult to produce and therefore entailed larger costs. The costs associated with small products were felt to out-weigh the potential cost-savings in materials.

Costs were also a determinant of customer purchases. Since the purchase made up a considerable outlay for the customers, the company felt an expectation for the products to be of good and durable design. The product life time was not monitored but according to the informant, product durability was warranted through the choice of high quality materials and components of well-known brands. The company expected the products to have a physical life time of at least ten years. However, although the customers expected products of high durability, the perception was that they often replaced the light fittings after only a few years due to changes in desires and fashion.

The company did not pay particular attention to the repairability of the products in the product development. However, a modular system is applied that results in easy assembly and disassembly, which facilitates repair. Easy assembly reduces labour time and thus costs. Easy disassembly is a result of easy assembly. A trade-off was perceived between the ease of assembly and other design features.

Users were believed either to give psychologically obsolete products to family and friends, or to dispose of them as waste. No particular efforts were made to increase the recyclability of the end-of-life products as the products were already thought to be easily recyclable as the materials were mainly high quality metals.

Aware of the environmental slant of the study, the informant mentioned energy-saving and the design of fittings for low-energy lamps as an environmental initiative. This would also reduce the cost for the user.

Producer responsibility for WEEE

The informant was aware of the impending implementation of the WEEE Directive (2002/96/EC) through a German Trade Association of which the company was a member. This awareness in parts of the company had not led to any particular actions. The informant believed that business decisions related to the WEEE legislation would be made jointly by different functions such as purchasing, production, marketing and sales. The informant's view was that an individual solution would be the most adequate way for the company to

fulfil its producer responsibility for WEEE. This assumption was based on a perception of collective organisations for packaging waste as generating revenue for itself at the expense of value for its customers. The WEEE Directive was not seen as affecting the company's competitiveness as the same rules would apply to the competitors. Product prices were based on prevailing market prices for similar products.

Conclusion

In conclusion, no environmental considerations were made in case company F. The awareness of the forthcoming WEEE legislation was located to product development rather than accounting, indicating that decisions were not directly related to cost control. Since product competitors were going to be subjected to the same rules, the legislation was not believed to influence the sales. Although it did not appear likely that the legislation would affect product design, no conclusions could be drawn from the experiences and information at the time of the interview.

Appendix 9 Case G

In the early 1990s the UK SME that makes up case G, opened. It designs, manufactures and sells lighting fittings mainly to other businesses but also for the domestic market via their homepage. The main business clients are architects, contractors and interior designers. Most of the products are sold on the UK market, but there is also some export, for instance to Russia. The company employs fifteen people including designers, manufacturing staff and sales force. The company was not a member of any trade association.

The case drew on a face-to-face interview with at product engineer at the company site, and a telephone interview with a project engineer. The information provided was consistent.

Environmental profile

The company does not have an environmental manager, report on environmental activities or make considerations that are directly environmentally related.

Focus areas, measurements and drivers of product development

Most of the production is made to order from construction projects, within a standard range of products. The clients and the project engineers specify the design briefs together. Clients' requirements were often related to the visual impacts. Architects wanted good quality products and good lighting performance, whereas contractors were found to be more interested in the lowest possible price. The project engineer stated that he was more interested in the quality than the price of the product, as his professional reputation hinged on the quality.

The price was based on the tenders for the different projects. Thus, prices could not be allowed to exceed those of competitors significantly. Management control was exerted mainly in the tender and the decision of whether or not to accept a project at a certain price. Within the financial frames of the contract, improvements to the products and cost reductions could be sought. The price of the contracts and products should cover materials,

labour and overheads, as well as a profit margin. The awareness of producer responsibility for WEEE was low, but the future costs of the forthcoming legislation would be included in the product price. The informant did not believe that this would have an effect on sales since the competitors were subjected to the same rules. The issue was not topical in the company.

One informant said that size reduction of the products was a potential for cost savings, but that there may be a trade off between size and safety. The other informant elaborated on the theme, explaining that the size of the products was governed by the lamp: reduced size of the lamp meant reduced beam. Implicitly, the size of the product depended on the lighting specifications for a project. Another consideration with regards to size was that too small a lamp holder reduced the surface area that dissipated the heat from the lamp and could therefore compromise the safety and product longevity. Thus, size reduction did not appear to be an environmental criterion in the product development, and was not monitored.

Both informants perceived the products to be durable beyond the customer demands. The products were believed to have a physical life time of at least ten years, which was said to be the industry average. The customers were believed to want new fashion and therefore the company did not seek to increase the physical durability of the products. One informant also said that the improved energy efficiency of new products was a reason not to further extend product lives.

Energy efficiency during the use phase was an important customer demand, since the energy consumption may be a significant cost to the user. Thus, energy efficiency was a sales argument. Aware of the environmental perspective of the study, one of the informants emphasised the environmental benefit of reduced energy consumption.

The energy consumption was said to depend on the lamp. Products were designed to be separable for replacement of light bulbs and control gears. Dismantling was not an environmental consideration. Neither was the ease of disassembly monitored.

Price quality and suitability for the environment in which the products would be located, were the main considerations in the selection of materials. Recyclability was not a concern per se, but the fittings were said to be easily recyclable due to the fact that they were mainly made of pressed steel and aluminium. The recyclability or contents of recycled materials was not monitored. The company had no knowledge of the products being reused or recycled at the end of their initial use, or how the products are disposed of.

Appendix 10 Case H

Case H is a Swedish company developing and marketing light fittings mainly for public environments. Having worked as an agency for other brands since the 1960s, case company H started developing and marketing its own products in the 1980s. The founder of case company H had previously worked in a family owned business developing and manufacturing light fittings. All products are sold to business clients, but households are the end-users of a small part of the sales. The main clients are architects and builders on the Swedish market. A small part of the sales is exported to the other Nordic countries and Germany. The company now employs some 20 people.

Environmental profile

The public debate in the mid 1990s about the environment made the company aware of the potential business relevance of these issues. The managing director propelled environmental issues in the company and later an environmental manager was appointed. In 1996 an environmental declaration was introduced for each product. The declaration had been developed the same year by the Swedish Environment Agency, a Swedish agency for industry development and the Swedish trade association for lighting products. The product declarations are not published but are available to interested parties. Apart from the product declaration, environmental aspects were not monitored. However, environmental issues were discussed in the company's product committee.

Focus areas, measurements and drivers of ecodesign

Product size was not an environmental consideration in company H. The weight and volume of the products were determined but design criteria. If the products were going to be used in a large room with a high ceiling they could be rather voluminous. This in turn required larger quantities of packaging and transport.

The products time in use was believed to be considerably shorter than the operational life time due to fashion changes and customers desire for new designs. Thus, no attempts were

made to increase the physical durability of the products. The electronic control gears in the light fittings were said to have the shortest life span. The product life would increase if the control gears were replaced. The need to dismantle the products to replace components during the use phase was regarded in the product design. One informant said that recyclability and ease of disassembly was considered in the product development process, but these aspects were not monitored.

The environmental product declaration focused on materials and substances such as PVC, heavy metals, flame retardants and solvents in the products, production and packaging. The introduction of the declaration led to changes in the product development. Once the changes were made, no further improvements were undertaken in existing products. The checklist was said to be applied when new products were developed.

Occasionally customers made enquiries about the company's environmental awareness, although environmental requirements were not usually binding for purchase. Furthermore, the clients were more interested in the fact that the products had environmental declarations than the contents of the declarations. The fact that the same criteria were used in the label for products that are safe from a working environment point of view and from and ecological perspective was felt to add to the strength of the declaration.

Architects and public procurers were felt to be the most environmentally aware client groups. However, one informant pointed out that there were environmental trade-offs between different products and the buyers have to decide what they prioritise. For instance, one product may contain no PVC but solvent-based paint, and the opposite may be true for another product. It was believed to be difficult for the customers to evaluate the trade-offs.

The company asked their packaging suppliers about the rate of recycled materials in the packaging, but admitted that they did not monitor the suppliers' observance of the request.

Producer responsibility

The company became aware of producer responsibility for WEEE through a trade association of which it was a member, about two years before the legislation was implemented. One informant claimed that the company influenced the design of the legislation through the trade association. The Managing Director made the decision to join a collective producer responsibility scheme for WEEE. An individual solution to the responsibility was never considered due to the administrative costs and other resource requirements associated with product take-back. Instead, a fee per type and numbers of product sold were paid to a collective scheme. The costs to the company were added to the product price. This was not perceived to have led to any changes in the sales or the product-mix, since the same rules applied to the competitors. Also, the costs had not affected product design, since the company could not influence the costs.

The cost control in the product development process focused on the product cost, of which components and materials make up the largest part, followed by the labour cost. The costs for disassembly and recovery at the products end-of-life were not controlled.

Conclusion

To sum up, an environmental awareness was demonstrated in the appointment of an environmental manager and the introduction of environmental product declarations. The contents of the declaration regarded certain materials and substances. A trade association and to some extent customer demands were driving forces behind the environmental awareness. The company had chosen a collective solution to producer responsibility. They could not influence the costs of this and consequently had made no attempts to change product design to that effect.