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Case Study in the Norwegian Electrical and Electronic Industry

NTNU
Program for industriell økologi
Rapport nr: 1/2004

Reports and Communications from

Norwegian University of Science and Technology (NTNU)
Industrial Ecology Programme (IndEcol)

Report no.1/2004
ISSN 1501-6153
ISBN 82-7948-028-5 (trykt)
ISBN 82-7948-029-3(pdf)

Editor:
Professor Edgar Hertwich, Programme Leader (IndEcol)

Design and layout:
Elin Mathiassen, Coordinator (IndEcol)

Reports and Communications may be ordered from:

Industrial Ecology Programme (IndEcol)
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Acknowledgement

The work of this paper is part of the project under the RAMBU[1] programme entitled "Pathways to Sustainability: Policy Instruments and Dynamic Efficiency," coordinated by the Fridtjof Nansen Institute at Lysaker. Among the five case studies of the project, research fellow Kjetil Røine from the Industrial Ecology Programme (IndEcol), NTNU, is responsible for Case B: "Product- and waste policies stimulating dynamic efficiency", which aims to understand the effects of extended producer responsibility (EPR) on stimulating technological change. We hereby acknowledge the financial sponsorship of the Norwegian Research Council through the RAMBU programme and the fruitful cooperation with our colleagues at FNI: Atle Christer Christiansen, Jon Birger Skjærseth, Jørund Buen, Jørgen Wettestad and Lars Guldbransen.

The content of this paper is to a large extent empirical, and thus, there are many people who we have to express our gratitude to. They brought inspiration, information and other types of assistance to smoothen our research process. Here are some names of persons and institutions that we'd like to mention in particular: Brage Rønningen, Ole Viggo Svendsen and Thor Chrstian W Svendsen from producer responsibility organizations; Rune Opheim, Morten Helle and Olav Skogesal from SFT; Torgrim Asphjell from the Ministry of Environment; Dag Ausen, Trond Lamvik and Runde Magne from SINTEF; Torbjørn Iversen, John Wrobel and Rune Henden from Osram AS; Yngve Fahre from Elektronikkgjenvinning AS; Thor Endre from ABB AS; Frank Mathilas from WEEE Recycling AS, and professor Ab Stevels from Delft University of Technology. In addition, we'd like to thank those who participated in our web-based survey and those who spent time answering our phone calls and e-mails.

Last but not least, we are grateful to our colleagues at IndEcol and our family members for their continuous support, which is, without doubt, essential to the birth of this paper.

[1] RAMBU stands for "Rammebetingelser, styringsmuligheter og virkemidler for en bærekraftig utvikling." It is a programme sponsored by the Norwegian Research Council.

Abstract

Environmental policies are said to have an important role to play in driving environmentally-friendly technological changes. Among various types of environmental policies, extended producer responsibility (EPR) is a relatively new and market-oriented approach. When resources are drawn from the upstream actors, i.e. the producers, to the downstream waste management activities, there exists potential for innovation to occur at both sides. As one of the first countries in the world, some EPR instruments have been implemented for the electrical and electronic (EE) sector in Norway since 1999. The EU Directive on waste electrical and electronic equipment (the WEEE Directive) and the EU Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (the RoHS Directive) came into influence some years later. This paper presents the empirical data including a web-based survey and three in-depth company cases in order to understand how EPR has stimulated technological changes and innovation in the Norwegian EE industry.

Executive Summary

Technology plays an essential role in all industrial activities. When different technologies bring comfort and convenience to our lives, the rapid material consumption also results in various forms of environmental deterioration. Gradually, it is realized that pushing technological development in an environmentally-friendly direction is an important task, and public policy is one of the major driving forces.

Among various types of environmental policies, extended producer responsibility (EPR) is a relatively new and market-oriented approach. OECD (2001) defines it as "*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 product's life cycle*". When resources are drawn from the upstream actors, i.e. the producers, to the downstream waste management activities, there exists potential for innovation to occur at both sides. The producers may make product changes in order to reduce their cost, and the waste managers receive more support, either financial subsidies or an enlarged market for example, to have their job done.

In this paper, we aim to look for empirical evidence regarding how EPR stimulates technological changes. In Norway, some EPR policy instruments have come into force for the electrical and electronic (EE) industry since 1999: the EE Regulation and the EE Covenant. To fulfill their obligations accordingly, the Norwegian producers have collectively set up a national return system for their end-of-life products and pay a fee when introducing new products in the market to producer responsibility organizations (PROs), who then take over the physical responsibility to coordinate the collection and treatment of scrapped EE products. At the moment, there are three major PROs in the Norwegian EE industry.

At the EU level, two directives regarding EE products were promulgated in October 2002: the Directive on waste electrical and electronic equipment (the WEEE Directive) and the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (the RoHS Directive). The former requires producers to take back and recycle their waste, while the latter basically demands that new EE products should not contain six hazardous substances.

The above-mentioned domestic and international policy instruments, together with some others, bind on the Norwegian EE industry. It is then of our research interest to find out whether these EPR instruments have driven technological change among actors in the sector. A web-based survey entitled *"Green" technological changes in the Norwegian EE sector* was conducted. 71% answered "yes" when asked whether there have been technological changes in the products or processes during the last 10 years to deal with environmental problems. Based on those who answered yes, the driving forces were identified as: "environmental regulations in EU" (68%), "environmental awareness and commitment in the organization" (59%), "environmental regulations in Norway" (55%), and "market demand" (50%).

In spite of the survey results, interviews with staff from PROs and industry associations revealed that the upstream actors in the Norwegian EE industry are not yet very active in carrying out environmentally-friendly product changes. Reasons to this can be that, first, Norway is only a small market with no big producers, and second, there is no clear mechanism to stimulate "green products" in the pricing structure of the collective scheme. However, the implementation of the RoHS Directive drew rather high attention and participation from the producers to remove focal substances from their products.

Though the Norwegian national EPR scheme does not bring out much of the upstream actors, the resources that are collected and flow into waste management motivate the downstream actors. To date, several EE waste treatment plants can be found national-wide. They are preoccupied to find technological solutions to process tricky EE products and increase their process efficiency.

Three company cases were selected to be closely examined, in order to see the mechanism of policy influence. In Osram AS, lead was removed from their production of incandescent lamps, and the RoHS Directive was the main cause. Research activities in the mother company even started some years before the directive was finally promulgated. WEEE Recycling AS put together "the most modern recycling plant in the world" for EE waste, and Elektronikkgjenvinning AS possessed "the world's first facility capable of processing SF_6" from some sealed-for-life electrical switch gears. For these process changes, the Norwegian EPR regulations have everything to say.

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Abbreviations

BFR	Brominated fire retardant
EE	Electrical and electronic
EEE	Electrical and electronic equipment
EPR	Extended Producer Responsibility
EU	European Union
MoE	(Norwegian) Ministry of Environment
PRO	Producer Responsibility Organization
RoHS	(The Directive on) the restriction of the use of certain hazardous substances in electrical and electronic equipment
SF_6	Sulfur hexafluoride
SFT	Norwegian Pollution Control Authority
WEEE	Waste electrical and electronic equipment

1. Introduction

Our lives in this modern era are highly technology-dependent. Technologies bring comfort and convenience to our lives. However, without having the environment and sustainability considered in the first place, the rapid advancement of different technologies in many ways contributed to the deterioration of the environment, for example, by speeding up the material consumption and causing problematic waste. Nevertheless, technological changes which are environmentally friendly have a key role to play in diverting the situation. And it is recognized among different literature references that environmental policies have effects on the development and spread of such technological changes (Jaffe & Stavins, 1995; Norberg-Bohm, 1999; Cleff & Rennings, 1999; Kemp, 2000; Christiansen, 2001; Jaffe, et.al, 2002).

Along the move of time, environmental policy makers started to shift their perspectives: from strict command-and-control regulations to more market-based measures, from downstream waste management towards the upstream producers of products. In this paper, our particular policy focus falls on *extended producer responsibility* (EPR), a relatively new, market-oriented approach. OECD (2001) defines it as "*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 product's life cycle*". To date, EPR can be found implemented through different policy instruments, on both regulatory and voluntary basis. The EPR instruments are often designed for a certain type of products or product groups. When the producers are required to take responsibilities for their end-of-life products, more resources will flow into the downstream activities of collecting, sorting, dismantling and recycling. At the same time, producers may respond to EPR by making changes in their product, particularly if there are incentives to do so. Therefore, the mechanism of EPR gives potential driving force to both downstream process innovation and upstream product innovation.

In the Norwegian Report no. 44 (1991-1992) to the Storting[2], it was stated that "*different instruments may be used to make producers and distributors responsible for handling the waste generated by their products, and to motivate them to reduce or change their use of waste-generating product.*" (p.29). From then on, this statement has gradually been realized along with the implementation of several EPR programmes, among which, in 1998, both a regulation and a voluntary agreement were established for electrical and electronic (EE) products. As one of the first in the world, Norway started to run a return system for end-of-life EE-products in 1999. It is financed by the manufacturers and importers, i.e. the producers, of the products and organized by a number of producer responsibility organizations (PROs). A few years after, in October 2002, two related directives were finalized in the European Union (EU) for EE-products: the WEEE Directive and the RoHS Directive, demanding producer's effort to reduce the environmental impact of their products.

With the above introduction being stated, the purpose of this work paper is to provide better empirical understanding of the importance of environmental policies, particularly various EPR instruments, to the technological change and innovation in

[2] Storting is the Norwegian parliament. Report no. 44 (1991-1992) to the Storting: Relating to Measures to Reduce Waste, Increase Recycling and Ensure Environmentally Sound Waste Management.

the focal industrial sector. It is thus of our research interest to answer the following question:

> ***How does extended producer responsibility (EPR) contribute to stimulating technological changes and innovation in the Norwegian EE industry?***

In other words, what kinds of environmentally-friendly technological changes in the Norwegian EE industry have been stimulated, among both upstream and downstream actors? What kind of influences have different EPR instruments made in these changes, and through what mechanisms?

To answer the research questions, we examine the empirical conditions on both sector and company level. On the sector level, a web-based survey was conducted with the attempt to grasp the situation of the general trend and development in addition to interviews with staff from various industry organizations. To get more insights in the change mechanism, we carried out a number of case studies on company level with interviews of actors involved. All in all, this is a qualitative study based on the collection of primary data such as on-site interviews, phone interviews and e-mail correspondence; and secondary data such as various official reports, company publications, academic journals and internet sources. The main purpose of this work paper is to present these empirical findings.

2. Theoretical Perspectives and Analytical Framework

In this chapter, we first sum up the theoretical perspectives in two key areas which are relevant to this research: 1) technological change and innovation, and 2) public policy and policy instruments. Then, the concept of "extended producer responsibility" and its presence in policy implementation will be briefly introduced. Finally, the analytical framework for this paper is laid out and the methodology presented.

2.1 Technological changes and the environment

The development of new technologies has always been central in industrial activities. Some describe technology as a double-edged sword. "On the one hand, it can generate negative environmental externalities, and, on the other hand, technological innovation can generate positive economic externalities" (Fukasaku, 2000, p.18). However, it is realized that in the course towards sustainable development, technologies also has an indispensable role to play. Radical changes are required in the products and services that are produced, as well as the way that they are produced, in order to mitigate the deterioration of environment.

Technology is said to be both socially constructed and society shaping. Its development has a lot to do with the dynamics of the society in which it is embodied, and the adoption and diffusion of the technology, in turn, inject change factors to the society. The formation process of technological changes is on one hand *rational*, *goal-oriented*, or *optima*l, and on the other hand *adaptive*, *cumulative* and *evolutionary* (Christiansen, 2001)[3].

In the 1940's, Schumpeter proposed a three-stage process of technological change: *invention* constitutes the first development of a scientifically or technically new product or process; *innovation* is accomplished when a new product or process is first commercialized or made available on the market; and finally, in the *diffusion* stage, a successful innovation becomes widely available (Jaffe, et al. 2002). Grübler (1999) gave the process of technological change a more life-cycle-like six-stage typology: invention, innovation, niche market commercialization (adoption), pervasive diffusion (diffusion), saturation and senescence. For a technological change to occur, each of these stages is unique, and yet inter-linked. A technological change is the cumulative impact arising from all stages.

Some distinctions can be found among the technological changes and innovations. *Incremental* or *minor* innovations "underpin the cumulative and adaptive character of technological changes, emphasizing the learning effects connected with routine activities and modifications upon existing technologies and knowledge"; and *radical* or *major* innovations "points to the intrusion of radically new elements that fundamentally alter the way in which technologies are perceived" (Chrstiansen, 2001, p.7). The differences lie in the magnitude of change. For long-term technological advancement, both are important.

Another commonly seen distinction is between process and product innovations. "A *technological product innovation* is the implementation/commercialization of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. A *technological process innovation* is the implementation/adoption of new

[3] Christiansen (2001) has done a good literature summary in the related field. Here we quote his work directly when suited.

or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these" (OECD/Eurostat, 1997). Some argue that these alone may not be sufficient to obtain significant environmental improvements in the long run. It requires *system innovations* that go beyond the existing device concepts or infrastructures.

When it comes to environmental innovations, all innovations that contribute to environmental improvements via de-materialization, de-toxification and de-energization (or de-carbonization) may be counted. Some people use the term "eco-innovation" particularly to distinguish it from the generic innovations which take place on a day-to-day basis in different industrial activities. It may range "from technological changes that are embodied in tangible equipment to organizational and systemic innovations" (Fukasaku, 2000, p.18). And environmental innovations, like any other type of innovation, "must meet a variety of goals: they should be expendable; it should be possible to fit them into existing processes; and, in the case of products, they should meet user requirements in terms of performance characteristics" (Kemp, 2000, p.36).

Factors that drive or trigger off technological changes have been widely discussed academically. The *technology push* theory is based on the available knowledge and technology, i.e. the existing technological and scientific development pushes for more of that to happen. The *demand pull* or *market pull* theory states that technological changes are triggered by market opportunities derived from social needs. Gradually, researchers tend to agree that both are relevant. These driving forces co-exist in a "neither simple nor linear" model. Both push and pull are acknowledged as necessary, but not sufficient for technological change to occur. "Push has a greater impact on the early phases of the technology life cycle while the influence of demand-pull is seen more strongly in the later stages" (Christiansen, 2001, p.10). In addition, *feedback mechanism and learning* has an important promoting role in this complex model.

Some might wonder why technology development does not always tend to happen in a faster or preferred way. "Technologies are selected not only on the basis of technical or economic performance measures, but also by prevailing socio-political and cultural norms, rules and preferences" (Christiansen, 2001, p.11). Technological changes are as well constrained by various kinds of barriers and inertia. The birth of one technology requires numerous sub-technologies or supporting infrastructures. This *technological inter-relatedness* may result in *network effects*, "requiring new technologies to adapt to existing system." Yet, the more adopted one technology is, the more experiences and resources are poured into improving it. This mechanism continues to increase the preference for this technology against other competing potentials. Such *path dependency* may also hinder the up-rising of environmentally-favoured technological changes, or make the coming changes more incremental than radical. Radical changes usually require enormous financial investment which companies, either individually or collectively, are not ready to pay for.

2.2 The role of environmental policies

Most of the time, environmentally-friendly innovations occur within firms in the private sector. However, the benefits of environmental improvement coming from these innovations are largely public. Thus, for most private firms which are mainly profit driven, the signals of making investments for environmental technological changes may not be clear or straightforward. "Because of the externalities involved in their development and diffusion, it is clear that environmental innovations suffer from market failure. Also, because of the complex nature of environmental innovations that require a transdisciplinary and intersectoral approach, they also suffer from systemic failure" (Fukasaku, 2000, p.17).

Therefore, the role of regulations or governmental interference is crucial. Cleff & Rennings (1999) argue that, due to the externality problems of eco-innovations, the conventional discussion of technology push and demand pull should be supplemented by the influence of the regulatory framework, highlighting the regulatory push/pull. "Eco-innovations are, in contrast to such technologies as microelectronics and telecommunications, normally not *self-forcing*" (p.192). Norberg-Bohm (1999) mentioned that the rate and direction of technological innovation can be influenced by a number of key factors such as industry structure, factor prices, technological trajectories and histories, consumer demand, corporate organization and management, societal norms and leadership preferences and aspirations. Public policy is yet another important variable of influence. "Environmental regulation influences technological innovation by changing some of these key factors", such as by providing economic or political incentives or by reducing long-term uncertainties (p.16).

It is already recognized among literatures that environmental policies have effects on the development and spread of new technologies. It is also noticed that different types of policy instruments can have "significantly different effects on the rate and direction of technological changes (Jaffe et al., 2002). Vedung (1998) suggested such classification:

- Regulation ("stick")
- Economic means ("carrots")
- Information ("sermons")

"All of these forms of intervention have the potential for inducing or forcing some amount of technological change, because by their very nature they induce or require firms to do things they would not otherwise do" (Jaffe, et al., 2002, p.50).

Command-and-control measures such as performance-based or technology-based standards are chosen by non-economists and governmental authorities for its effectiveness. However, the *technology forcing* of such measures tends to stifle innovation since there are no incentives for firms to do more or do it differently from a regulated way. "Technology-based standards appear to perform worst in stimulating innovation, since by their very nature they constrain the technological choices available, and may thereby remove all incentives to develop new technologies that are environmentally beneficial" (Jaffe & Stavins, 1995, p.45). In addition, it is not easy for authorities to decide for the most suited standards. "They are either made unambitious, or run the risk of being ultimately unachievable" (Jaffe, et al., 2002).

Command-and-control measures usually require firms to take the same share of responsibility of pollution abation regardless of cost. This low cost-efficiency is often criticized by economists. Market-based instruments such as environmental charges/taxes, subsidies, tradable permits, deposit-refund systems etc., on the other hand, induce, rather than command, behavior changes by providing financial or similar motivations for regulated sources to improve environmental performance. It allows mechanisms which may create *long-term and continuous incentives* for firms to outperform the others. "Market-based instruments have been identified as the environmental policy instruments with the highest dynamic efficiency (innovation efficiency)" (Cleff & Rennings, 1999, p.192).

It is important for policy makers to keep in mind that there is no "common panacea". Oftentimes, a portfolio of instruments or a policy package seems appropriate in order to reap the full benefits of technological and industrial change. "Soft and voluntary environmental policy measures may be sufficient for pioneers. However, hard measures seem to be still necessary for non-innovative firms" (Cleff & Rennings, 1999, p.201). In addition, to deal with environmental problems caused by various products, policy designs ought to cover consequences throughout the entire life-cycle. Taking the product- and waste policies in Germany for example, "eco-labels such as the Blue Angel, which certify a certain environmental product quality, stimulate product innovations, while the Green Dot has innovative effects for recycling activities" (Cleff & Rennings, 1999).

In general, it is observed that there is a shortage of research on the actual influence of environmental policies on technological changes. Nevertheless, Kemp (2000) summarized the effects of different policy instruments on technological development and pointed out that:

1) "The most common responses to regulation are *incremental innovation in processes and products* and *diffusion of existing technology*, particularly in the form of end-of-pipe solutions and non-innovative substitutions of existing substances."
2) "The *stringency* of the regulation is an important determinant of the degree of innovation, with stringent regulations such as product bans being necessary for radical technology responses." The bans of PCBs and CFCs are some good examples. In those cases, even before the regulations were promulgated, the search process for solutions to the problem began in the regulated sector.
3) However, soft instruments also have their role to play. Covenants are a new policy instrument increasing adopted in Europe and USA. "They are attractive because they lower the administrative burden and help to establish a better, more cooperative relationship between government and industries" (p.35).

These findings can be laid as interesting hypotheses before our empirical research.

2.3 Extended Producer Responsibility

The concept of extended producer responsibility (EPR) was introduced in early 1990s and has gradually obtained international attention and adoption. OECD (2001) defines EPR as "*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 product's life cycle*." Another definition describes EPR 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 product's life cycle, and especially to the take-back, recovery and final disposal of the product*" (Lindhqvist, 2000, p154).

The EPR principle is realized in various types of policy instruments. OECD (2001) mentioned the three basic categories: (1) *Take-back requirements.* This may be the purest form of EPR and is often associated with targets of collection and recycling/recovery rate. (2) *Economic instruments.* Some examples are deposit-refund system, advance disposal fees and material taxes. (3) *Performance standards.* For example, restriction on the use of certain material within a product or requirement of a minimum amount of recycled content. It is also possible that the producers bear informative responsibility, such as to inform waste treatment plants on the material content and structure of the discarded products (Tojo, 2001). All in all, the mechanisms of EPR instruments may fall on a continuum from mandatory to fully voluntary, from regulations to voluntary agreements.

EPR programmes, in both international and national arenas, have been found implemented for various *products* or *product groups*, such as packaging, batteries, automobiles, solvents, paper, plastics, tires, carpets, and electrical and electronic products. Mainly, the focus has been put on products that impose pressure on the environment (containing hazardous substances), add volume of waste (high volume) and have low potential for recovery and recycling (difficult to manage) (OECD, 2001).

Besides the overall objective of reducing environmental effects of products in their end-of-life phase, there are two main reasons for government authorities to consider adopting EPR principle (Tojo, 2001):

1) *To reduce financial or physical burden from the waste management authorities:* Traditionally, producers have not been particularly interested in considering the environmental qualities of their products beyond the point of sales or certain point in the use phase, and the task of waste management falls on the society, particularly the local governmental authorities. By asking the producers to take the responsibility, financially and/or physically, for their products at the end-of-life stage, the efficiency and adequacy of waste management may well increase.
2) *To link and thus affect different stages of product life cycle:* When the producers are required to pay attention to the end-of-life management of their products, "a sensible producer" may receive signals or incentives to prevent the waste at source or incorporate environmental considerations into product design. The establishment of this feedback loop from downstream to upstream is the core of EPR principle.

EPR aims primarily at reducing environmental effects from products in end-of-life phase by increasing the recovery of products and materials, and at the same time, upstream effects such as design change are expected. In some cases, such as the Norwegian EPR for EE products, upstream companies, i.e. the producers, are required to take the financial responsibility for their waste and pay a fee to a *producer responsibility organisation* (PRO), who bears the physical responsibility and runs a collective collection and recycling system. The PROs spend their revenues on downstream companies to increase recycling. This mechanism may induce technological improvements and changes along two paths. First, the upstream companies are likely to carry out "product innovation" to reduce the generation of waste, to encourage reuse, and/or to increase product recyclability. Second, the downstream companies can come up with "process innovation" to improve the collection, sorting, dismantling and recycling in the end-of-life phase (see Figure 2-1). Such feature of being both end-of-pipe and preventative makes EPR instruments not just a waste policy, but also a product policy.

Linnanen (2001) assessed three different types of EPR recycling systems for EE products on the basis of economic, technical and ecological criteria. He categorized the Norwegian producer organization model as "system based on a fixed recycling charge" (details see Chapter 3.2), where producers who have made efforts in environment-friendly product design are not treated equitably or rewarded. Despite its drawbacks, such arrangement is suitable for managing multiple product categories and thus of administrative significance.

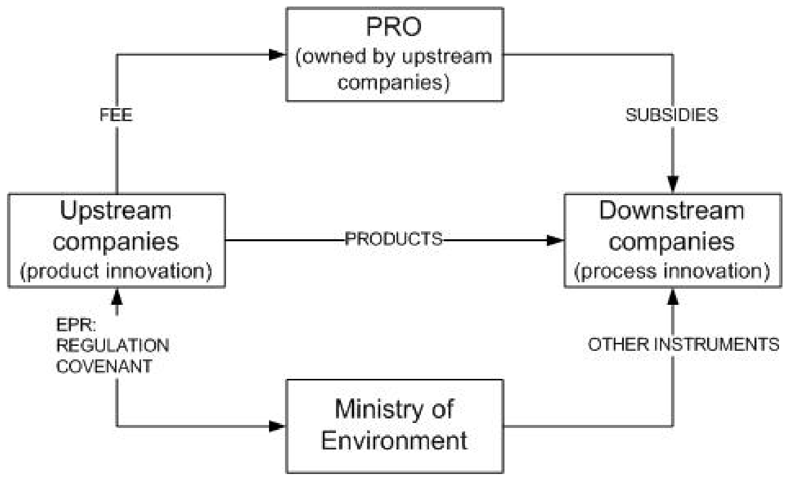

Figure 2-1Product and process innovation in the Norwegian EPR scheme

2.4 Analytical framework

Summing up the theoretical perspectives mentioned in the above two sections, policy instruments may have a dominant role to play in driving environmental innovations and technological changes. The following task of this paper is to examine the importance of EPR instruments and understand their influencing mechanism from empirical evidence.

To fulfil this research task, an analytical framework is adopted (see

Figure 2-2), where "technological change" is regarded as the dependent variable, and "EPR and the portfolio of environmental policy instruments" is our independent variable. *Dynamic efficiency*, hereafter meant as "the degree to which policy instruments are capable of providing continuous (dynamic) incentives for beneficial technological and structural change, at both company and sector level", is employed to express the interplay between EPR and technological change. To closer obverse the mechanism, we may examine the influence of policies in each stage of technological change: *invention, innovation, adoption (in a niche market)*, and *diffusion*. However, the portfolio of environmental policies must not be seen in isolation from other factors that are decisive for the observed technological change and innovation. Factors such as *type of problem* and *industrial and political context* may help explain the observed development.

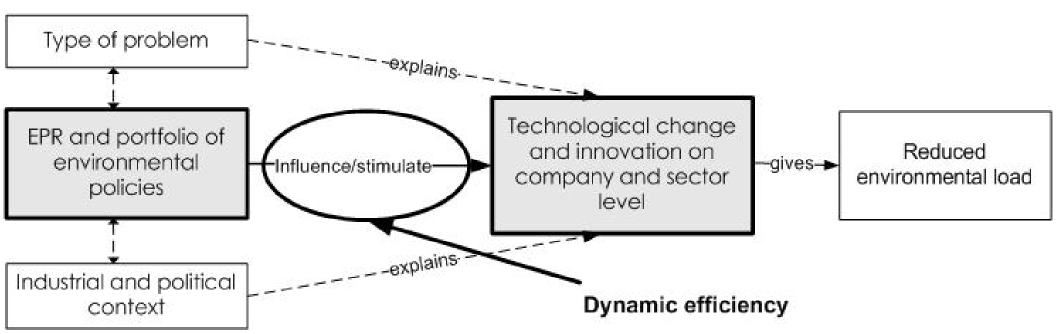

Figure 2-2 Analytical Framework

2.5 Methodology

Case study method is adopted as the research strategy for this paper. According to Yin (1994), the research design of case studies consists of five components: (1) a study's question; (2) its propositions, if any; (3) its unit(s) of analysis; (4) the logic linking the data to the propositions, and (5) the criteria for interpreting the findings. In order to understand the influence of EPR on stimulating technological changes, we select *the Norwegian EE industry* as the unit of analysis. Theoretically, EPR allows the mechanism to drive more active participation and innovation, particularly from the producers' side. The empirical data we collect are supposed to bring us a closer look at the reality.

To achieve the purpose of this research, we examine both the general trend in the sector and some company case studies. On the sector level, we want to get some understanding about the general condition such as: *How many players in the sector are active in making environmentally-friendly technological changes? What kind of technological changes took place already? What are the main driving forces for those changes?* In order to find the answer, we carried out an anonymous web-based survey in autumn 2003, using NTNU's internet capability.

The survey link was sent to a number of actors in the Norwegian EE industry by e-mails. The list of actors was provided by our contacts in some PROs and industry associations. At the end, we received 35 replies to our survey, 31 of which were considered valid and used for further analysis. The complete survey, with both questions and results, is presented in Appendix II. We understand that with such a small number of respondents, it is doubtful whether the result can be generalized to the entire sector. Nevertheless, it gives us some good indications about the current situation. In addition to the survey, we conducted personal interviews with staff from various industry organizations in the sector. With the help of their perceptions and experiences, a clearer picture can be drawn.

Other than the attempt to map out the general condition, we also select three company cases for in-depth study. By going deeper into these cases, we want to get more insights in the process and mechanism of the technological change, and then see the role and relative importance of EPR instruments. In each of these cases, on-site visits and interviews with the key personnel were made.

The collection of empirical data is multiple-sourced, including primary data such as personal interviews, phone interviews and e-mail correspondence; and secondary data such as various official reports, company publications, academic journals and internet sources, during the period of 2003-2004. The presentation and analysis of the empirical data is done in accordance with the research purpose and the analytical framework.

3. Setting the Scene

In this chapter, we set the scene by providing the background for later analysis and discussion. First, we present the major environmental issues and trends in the sector. Then, we introduce the existing conditions of EPR schemes that concern the Norwegian EE industry, both domestically and at EU level.

3.1 Environmental issues and trends in EE sector

By definition of the Norwegian authorities (MoE, 1998), electrical and electronic (EE) products are "*products dependent on electrical current or electromagnetic fields for their correct function, plus equipment for generation, transmission, distribution and metering of said currents and fields, including the components necessary for cooling, heating, protection etc. of the electrical and/or electronic components.*" This makes EE products a highly heterogeneous product group. They can be small as a shaver or big as a wash machine, with life span from 1 to 30 years. Usually, they are built with complicated composition and structure. According to a report in 1996[4], the Norwegian Ministry of Environment (MoE) put EE products into 18 product categories. The estimated sales volumes and waste quantities in Table 3-1 indicate the scale of the Norwegian condition.

Table 3-1 Sales Volume and Waste Quantity in Various EE Product Categories in Norway

No.	Product Category	Estimated lifespan (years)	Sales in Norway (tonn, 1994)	Estimated yearly waste quantity (1996-2000)
1	Automatic dispenser	5-10	612	470
2	White goods	10-20	41953	41340
3	Brown goods	5-15	14455	10810
4	Cables and conductions	20-30	34386	25510
5	Computer equipment	5-10	7840	7790
6	EE toys	5-15	1367	1710
7	Equip. for heating, air-con, and ventilation	15	7681	4080
8	Lighting equipment	1-10	8359	6720
9	Medical equipment	5-10	2461	2710
10	Equipment or instrument for measuring and inspection	5-10	12310	11230
11	Office machines	5-10	3805	3390
12	EE work tools	15-25	27997	12090
13	Telecommunication equipments	5-10	3855	2400
14	Components	10-15	220	50
15	Watches, clocks	5-10	245	300
16	Batteries	1-10	4235	3750

[4] The report was commissioned to and done by the consulting company Hjellnes COWI AS.

17	Alarms, smoke detectors	10	83	190
18	Electrotechnical equipment	> 20	14357	9320
	Total		**186,221**	**143,860**

(Source: Ministry of Environment, 1996)

Like other types of product and waste, EE products result in different environmental problems which growingly gain attention. Stevels & Boks (2002) point out that environmental feature of a product should include the three aspects of *emissions*, *resource consumption* and *potential toxicity*. A life-cycle analysis (LCA) based on the Dutch Ecoindicator 95 method shows the life-cycle impact for electronic products (see Table 3-2) as a reference, though it is claimed that such analysis mainly concentrates on the emission aspect. The figures indicate that energy consumption is the biggest contributor to the environmental impact. Despite this, our paper focuses mainly on changes that reduce environmental burdens at the end-of-life phase.

Table 3-2 Life Cycle Impact for Electronic Products

Life cycle item	Life cycle impact (% of total)
Energy consumption	50-80%
Materials and parts	10-40%
Packaging and transport	approx. 10%
End-of-life/ recycling	max. 5%
Substances, potential toxicity	N.A.

(Source: Stevel & Boks, 2002)

In the European Union, waste from EE products accounts for approximately 4% of municipal waste and has the expected growth rate of 3-5% each year (ETC WMF[5], 2003). But one can say that it is not the magnitude of EE waste which makes one of the major issues, but rather content of it. The main composition of EE waste is estimated to be of 48% ferrous metal, 21% plastics, 13% non-ferrous metal and 5% glass (ETC WMF, 2003), at the same time, it also contains hazardous heavy metals or chemicals like lead, cadmium, mercury, brominated frame retardants (BFRs) and PCBs. Without proper treatment, these hazardous substances may emit to soil, air and water and cause damage to both the environment and human health. Appendix I lists out the applications and known health effects of some hazardous substances.

Particularly, the content of hazardous substances is the concern of the Norwegian authorities. One incidence that aroused public concerns, for example, is the high doses of BFRs found in the fish caught from Mjøsa, the largest inland lake in Norway (MoE, 14 October 2003). To date, the Norwegian authorities claims that out of the 144,000 tonnes of EE waste generated annually, there are 1.6 tonnes of mercury, 61 tonnes of cadmium, 460 tonnes of lead, 9 tonnes of PCBs and 710 tonnes of BFRs[6] (SFT, 2003b; SFT, 14 January 2003).

5 European Topic Centre on Waste and Material Flows

6 The estimation of these figures came from the 1996 report made by Hjellnes COWI AS and has not been updated since. The author thinks that it is important to monitor the quantity variation of total EE waste generated and the toxic content of it. However, our contacts in the authorities revealed that it is a very costly process to do so.

Apart from the need to remove hazardous contents, the end-of-life EE products have good remaining economic value to be recovered via recycling activities. Nevertheless, "complexity of the structure makes it difficult to disassemble, and use of different materials prevents it from efficient recycling" (Tojo, 2001). To deal with this issue, it requires upstream efforts from the producers to make design changes. "Eco-design" has gained increasing attention in the EE industry. However, Stevels (2003) regard this as a challenge in practice since eco-design activities are not very financially rewarding most of the time: "the cost items closely related to environment are modest compared with the functionality value of EE products."

In addition to the problems in the waste stream, people in the EE industry also begin to be aware of the environmental impacts from other phases of the product life cycle. For products with longer lifespan, such as large home appliances, the use phase results in the highest environmental impacts through energy use (and water use for wash machines). Besides, the manufacturing processes of many EE products are often both material- and energy intensive. This may speed up resource depletion. Another issue being discussed is the long supply chain. The complex composition of EE products requires a large amount of actors or stakeholders involved in different manufacturing processes. With the growing trend of production outsourcing, the actors in the supply chains are often found geographically disperse, and this may make necessary environmental communications a rather challenging task.

In the web-based survey we conducted for actors in the Norwegian EE industry, 58% of the 31 respondents considered "increased quantity of waste" to be the major environmental problems of their EE products, 48% answered for emissions of toxic heavy metals and hazardous chemicals from waste treatment. Less than 20% considered "use of scarce metals and minerals (resource depletion)", "emissions of greenhouse gases due to energy consumption in production" and "emissions of greenhouse gases due to energy consumption in use phase" as the major problems (see Appendix II for full result). One respondent who makes electrical cookers points out that the prices of EE products are getting lower, and that consumers make replacement more often than before. Such trend may continue to increase consumption, whether the longevity of products has been improved or not.

3.2 EPR in Norway

When it comes to EE products, Norway is an importing country. In 1994, the sales volume of EE products in Norway amounted to 186,221 tonnes (see Table 3-1), but domestic production is only one-third of this figure. "Domestic production of EE products is about 60,000 tonnes per year. The largest part is cables, 25,000 tonnes per year. Other domestic production includes cookers, instruments for measurement and control, EE work tools, lighting, telecommunication equipment, equipment for heating, air con and ventilation" (MoE, 1996a). Among the production, there is not much for consumer products. One of the main reasons to this is that the domestic market is rather small and does not seem to make to economy of scale. Some larger Norwegian producers design and produce more complicated systems or niche products for professional use, but their main market focus is exporting. In general, the companies in the EE industry are not big. Only a few of them have more than 250 employees (Ausen, 5 June 2002).

In 1998, as one of the first countries in the world, a piece of EPR legislation was promulgated by the Norwegian Ministry of Environment to deal with the problem of scrapped EE products and their toxic content, pursuant to the Pollution Control Act and the Product Control Act: *the Regulations regarding Scrapped Electrical and*

Electronic Products (hereafter called **the EE Regulation**). It came into force on 1 July 1999. The main purpose of it is to reduce the environmental problems of EE waste and to ensure recycling when justified. It specifies the obligations of distributors, municipalities and importers/manufacturers in the collection and treatment of EE waste. Under the EE Regulation, consumers will be able to deliver EE waste free of charge to distributors or delivery points set up by local authorities, while commercial clients may be required to buy replacements from distributors or to pay a fee to local authorities when delivering. Importers and manufacturers are responsible for setting up a nation-wide system for collection and proper treatment of EE waste. In addition, they also have reporting obligation.

To carry out the obligations specified in the EE Regulation, the EE industry, presented by seven national suppliers' organizations, entered into a sectoral agreement with the Ministry of Environment in the same year of 1998: *the Agreement on Reduction, Collection and Treatment of Waste from Electrical and Electronic Products* (hereafter called **the EE Covenant**), in which the suppliers of various EE products should ensure that at least 80% of Norwegian EE waste would be collected by 1 July 2004. However, no recycling target was specified.

According to one of our contacts who represented one of the seven industry signatories, the EE Covenant could be considered as a complement to the EE Regulation, which took the authorities 3 years, from 1995 to 1998, to work out. The Covenant was an initiative from the MoE, and therefore, not completly voluntary. "The EE Regulation sets the pre-condition for an eco-industry, while the Covenant gives implementation details" (Sperstad, 5 March 2004). Some other of our contacts described the EE Covenant as a soft regulation.

In the EE Covenant, mechanisms for a collective system to be run by non-profit third parties were established. The 18 product categories listed in Table 3-1 were grouped into white goods, electronic products and industrial products. Consecutively, three *producer responsibility organizations* (PROs) have been set up by industry associations of different product groups to handle the management of EE waste. *Hvitevareretur AS* takes care of the white goods, and *Elektronikkretur AS* takes care of the brown goods and electronic products. The two companies nowadays operate a joint system called *El-retur*, covering the consumer EE waste. *RENAS AS* is in charge of the commercial EE waste from industrial users.

Being a member of the PROs, manufacturers and importers, i.e. "*the producers*", of different EE products get to fulfil their responsibility of waste management "financially" by paying the fees and transfer the physical responsibility to the PROs. They pay fees in proportion to the products that they introduce to the market. In the El-retur system, the producers pay a fixed fee per certain type of products, e.g. NOK 80 for each washing machine for household use and NOK 8 for different telephones. In RENAS' system, the producers pay a certain percentage of the product value for each certain type of product, e.g. 5% for lighting sources and 1% for most products. This, to some extent, obeys the "polluter pays principle". However, while this simple fee structure may help to achieve higher administrative efficiency, it does not seem to provide incentives for producers to make their products environmentally superior. One RENAS staff agreed that "*there is no clear mechanism to stimulate green products*."

Since these PROs are non-profit companies, the rates of the member fees they collect are only supposed to reflect the actual costs. The PROs then use their revenues to organize the waste management. They sign contracts with collectors, transporters and recyclers to get the job done, without being physically involved directly. One contact in SFT commented that the Norwegian EPR for EE products is more like a privatized tax, organized by private companies instead of government authorities.

However, because of the voluntary nature of the EE Covenant, producers of EE products are not compelled to join the collective system run by the three PROs. They can also choose to establish their own system or join other systems if available. This freedom of choice resulted in problems of "free-riders", i.e. some companies have neither joined a collective system nor established a system of their own. SFT estimated that free-riding caused some 40 million NOK of loss for the waste management revenues. In July 2003, the EE Regulation was revised and strengthened in order to deal with this problem (MoE, 8 July 2003). The obligations of producers and other potential PROs were more clearly defined.

In 2002, about 72,000 tonnes of EE waste has been collected and treated by the three PROs, and this equals to approximately 63 % collection rate and 16 kg of EE waste per citizen. In 2003, the amount of collected EE waste increased to 92,000 tonnes, accounting for 79% of total EE waste[7]. The figure below shows the increase of collection rate since the system was established in 1999 (SFT, 14 July 2004).

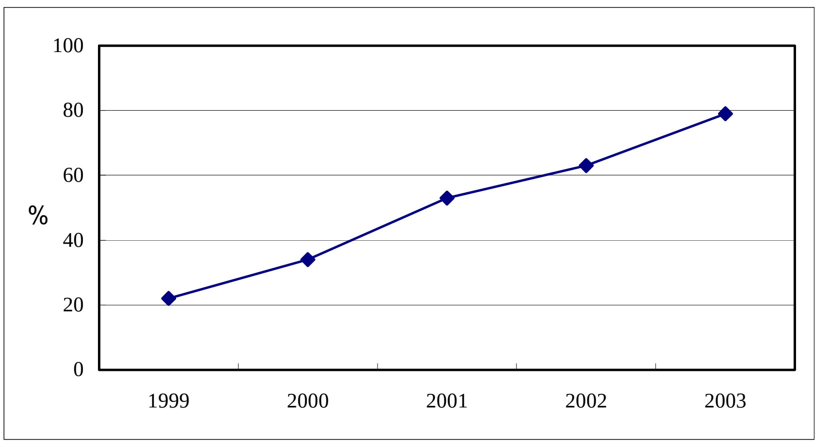

Figure 3-1 Collection Rate for EE Waste (source: SFT)

Under the Norwegian EE Regulation, all EE products are included regardless of their operating voltage range. Such broad coverage paved the way for *the Agreement on Reductions of the SF6 Emissions from Electrical Sector* **(the SF_6 Agreement)**, which was signed in 2002 between the MoE and various parties manufacturing and using high-voltage equipment containing SF_6, a very potent greenhouse gas. RENAS, the PRO for industrial EE waste, was the coordinator. More details of this instrument will be discussed in Chapter 5.3, when a relating case study is presented.

It seems that, in the case of the Norwegian EPR for EE products, though the government takes an initiating and pro-active role, the government-industry relationship can be considered rather consensual. In the case of reducing the SF_6 emissions, one MoE staff stated that "by close cooperation with the industry, the

[7] The estimation of the "total EE waste" has been revised. The collection rate for the period 1999 – 2001 was based on 144.000 tons generated EE waste, while in 2002 this was reduced to 129.000 tons. Nevertheless, the amount of waste collected is increasing year after year.

Norwegian government wants to implement a framework of measures that implies considerable reductions in emissions, while maintaining competitiveness" (Asphjell, 2002). When SFT prepares drafts for regulations, there exist mechanisms to call for opinions from the public or those who may concern. Companies in the Norwegian EE industry organize themselves via a number of industry associations for different product categories. This is an important interface for policy-makers to get their ideas crossed.

3.3 EPR in EU and International

At the EU level, the problems of EE waste have also been in focus. In EU, waste electrical and electronic equipment (WEEE) is considered one of the fastest growing waste streams. If the current growth rate is maintained, the amount of WEEE will be doubled in 12 years (ETC WMF, 2003). Until recently, more than 90% of WEEE ends up being landfilled or incinerated without recovery.

After years of discussions and negotiations, in October 2002, two directives were finalized under European Commission's DG Environmental Directorate*: the EU Directive 2002/96/EC on waste electrical and electronic equipment* **(the WEEE Directive)** and *the EU Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment* **(the RoHS Directive)**. They entered into force in February 2003. "The difference is that, while the WEEE Directive remains based on article 175 of the EU treat, the RoHS Directive is based on article 95. The former is for environmental laws and sets minimum standards, while article 95 is intended to ensure market harmonization" (ENDS, 13 June 2000).

The WEEE Directive covers a wide range of electrical and electronic equipment (EEE) within a limited voltage range, which then includes almost all consumer EE products and some products for professional use. Its purpose is the prevention of WEEE and the promotion of reuse, recycling and other forms of recovery of WEEE. Producers, which are defined as brand-owning manufacturers/sellers/resellers and importers, will be responsible for taking back and recycling WEEE, either collectively or individually[8]. By 31 December 2006, the collection target of 4 kg of WEEE per capita per year from private households has to be met, as well as the targets for recovery and reuse/recycling of products in different categories (see Table 3-3).

Table 3-3 Product Categories and Recovery Targets in the WEEE Directive

	Product category	**Recovery (%)**	**Reuse/recycling (%)**
1	Large household appliances	80	75
2	Small household appliances	70	50
3	IT and telecommunications equipment	75	65
4	Consumer equipment	75	65
5	Lighting equipment	70	50
6	Electrical and electronic tools	70	50
7	Toys, leisure and sports equipment	70	50

[8] Whether to impose individual or collectively financial responsibility on producers has been heavily discussed. "Company-by-company responsibility was essential to foster innovation in environmental design and provide an early legislative boost to integrated product policy" (ENDS, 11 May 2001). At last, the WEEE Directive allows collective financial responsibility for historical waste, and individual responsibility for new products put on market after 13 August 2005, the latter of which is to provide incentives for producers to implement design changes. The take-back systems can be run either individually or collectively (INFORM, 2003).

8	Medical devices	TBD*	TBD
9	Monitoring and control instruments	70	50
10	Automatic dispensers	80	75

* To Be Determined

Though the WEEE Directive "seeks to improve the environmental performance of all operators involved in the life cycle of EEE", some argues that its practice does not provide obvious drivers for product reuse and component recycling (Lamvik, 18 June 2003).

The RoHS Directive is a companion to the WEEE Directive and covers a similar scope of products, adding electric light bulbs and luminaries in households. From 1 July 2006 on, new EEE put on the market should not contain the following six hazardous substances: *lead*, *mercury*, *cadmium*, *hexavalent chromium*, *poly-brominated biphenyls* (PBB) and *poly-brominated diphenyl ethers* (PBDE). A list of exemptions exists, including some uses of mercury in fluorescent bulbs, lead in the glass used in cathode ray tubes (CRTs), lead in solder used in applications such as servers, etc. This is "likely to increase the possibilities and economic profitability of recycling of WEEE and decrease the negative health impact on workers in recycling plants".

The regulation of the RoHS Directive is explicit, and any producer who wishes to sell their products in the EU market has to work on the removal of the listed hazardous substances. One report from the US (INFORM, 2003) points out that after they figure out the solutions for their European customers, it is unlikely for companies in the US to continue using these substances in products sold in US. Thus, the report foresees the impact of the RoHS Directive in product changes to be global, while the influence of the WEEE Directive is more regional.

Some argue that the WEEE and RoHS Directives only focus on some narrow parts of the overall environmental problems caused by EE products and have some operational drawbacks, such as unclear definitions and uncertain gains in terms of eco-efficiency (Stevels and Boks, 2002). To date, the officials from the European Commission's DG Enterprise Directorate are still establishing a more design-focus directive. It started as the draft EEE directive (directive on the impact on the environment of electrical and electronic equipment) in 2001, which was then merged into the draft EuE directive (directive on establishing a framework for eco-design of end use equipment) in late 2002, covering all sorts of energy-driven products. In August 2003, the latest version emerged: **the draft EuP directive** (on establishing a framework for the setting of eco-design requirements for energy-using products). The draft EuP Directive introduces a holistic perspective and addresses the complete life cycle. Compared to its predecessors, it added the requirements for physical and quantitative parameters in environmental analysis. However, the remaining major challenge may lie on how to reward eco-design activities in practice. (Stevels, 2003)

In the meantime, SFT in Norway continues to work on suggestions for domestic implementation of both WEEE and RoHS Directives to the MoE. Though Norway is not an EU member, these directives have binding effects because of the European Economic Area (EEA) agreement. Due to the existence of the Norwegian EPR, the WEEE Directive would not require dramatic further actions in Norway. However, for the pursuance of the RoHS Directive, the Norwegian authorities started to establish more product-oriented (versus waste-oriented) rules.

The following table sums up the existing policy instruments mentioned in the above sections.

Table 3-4 A list of related policy instruments for the Norwegian EE sector

Level	Name of Instrument	Ref. No.	Entry into force	Target group
Norway	The EE Regulation	16 MAR 1998 (T-1224)	1 JUL 1999	EE sector (producers and distributors)
	The EE Covenant	16 MAR 1998		EE sector (producers)
	The SF6 Agreement	19 MAR 2002		EE sector and power industry
EU	The WEEE Directive	2002/96/EC	13 FEB 2003	Member states
	The RoHS Directive	2002/95/EC	13 FEB 2003	Member states
	The draft EuP Directive	Under construction		

4. Trend of technological changes at sector level

After understanding the EPR context for the Norwegian EE industry, we present the findings about the trend of technological changes in this chapter. A web-based survey was conducted, targeting mainly upstream actors in the sector. Also, a number of interviews were made with people from industry associations, PROs and some researchers in the field. We summarize the interviews into changes upstream and downstream, respectively.

4.1 Result from web-based survey

In order to understand the development of technological change in the Norwegian EE industry and the driving forces behind it, we conducted a web-based survey entitled *"Green" technological changes in the Norwegian EE sector*. The survey link was distributed to various actors in the sector. We received 35 replies, 31 of which were considered valid. Around 58% of the valid respondents are producers, either Norwegian or foreign-based, and around 20% are from industry association or PROs. We might not be able to generalize the result to the entire sector, but it definitely leaves us some interesting indications. The complete result is presented in Apendix II.

When it comes to whether environmental issues are important while technological changes are carried out in the products, 68% of the respondents answered "yes, very import", 26% answered "somewhat, but not among the top priorities" (see Figure 4-1).

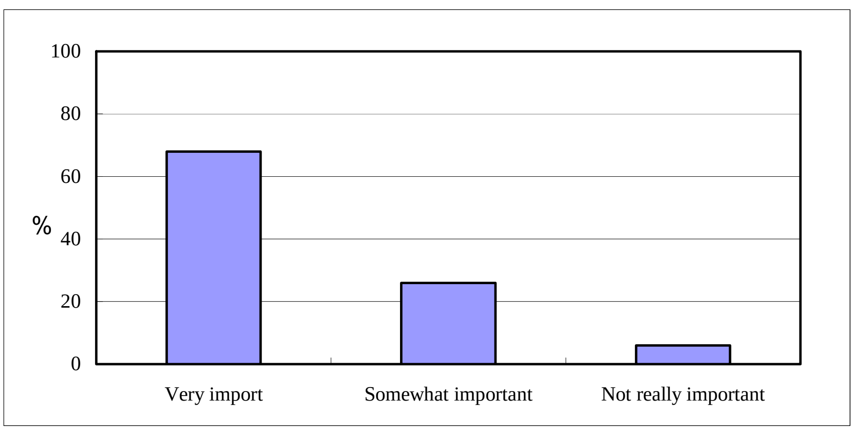

Figure 4-1 "Are environmental issues important when technological changes are carried out?"

71% answered "yes" when asked whether there have been technological changes in the products or processes during the last 10 years to deal with environmental problems. Based on those who answered yes, the changes are: "substitution of substances" (77%), "elimination of substances" (68%), "reduced energy consumption in use phase" (68%), "reduced use of materials" (41%), and "change of product functions" (14%) (see Figure 4-2). 73% of the yes-respondents answered there were "continuous changes on many product types". The intensity of changes in time distribution is spread out rather evenly in the last 10 years, with some increase in the period of 2001-2003. The technological changes were to deal with the problem of "content of hazardous chemicals" (73%), "increase of waste quantity"

(59%), “resource depletion and resource efficiency” (55%), “content of toxic heavy metals” (50%), and “greenhouse gas emissions” (32%).

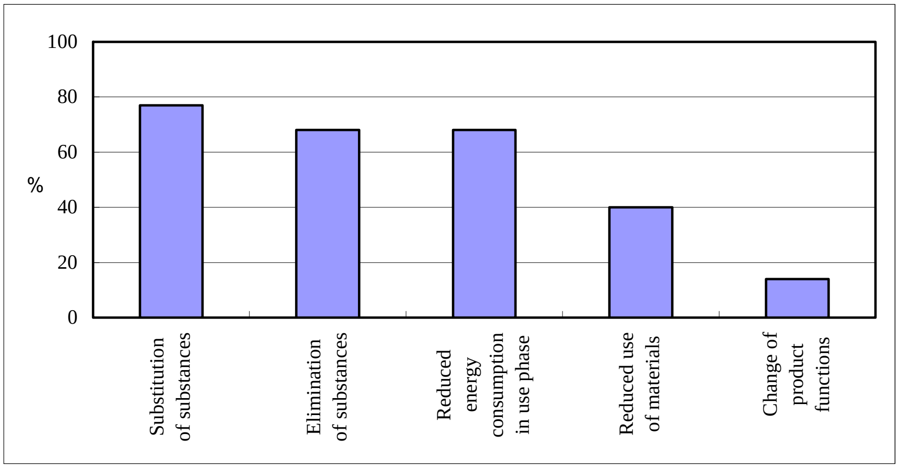

Figure 4-2 "What kind of technological changes have been carried out?"

Furthermore, the driving forces for the changes that occurred were mainly: “environmental regulations in EU” (68%), “environmental awareness and commitment in the organization” (59%), “environmental regulations in Norway” (55%), and “market demand” (50%) (see Figure 4-3). Here, effect of the environmental awareness is ranked higher than market demand. Some respondents mentioned their company policy and the environmental management system (EMS) ISO14001 as the drivers.

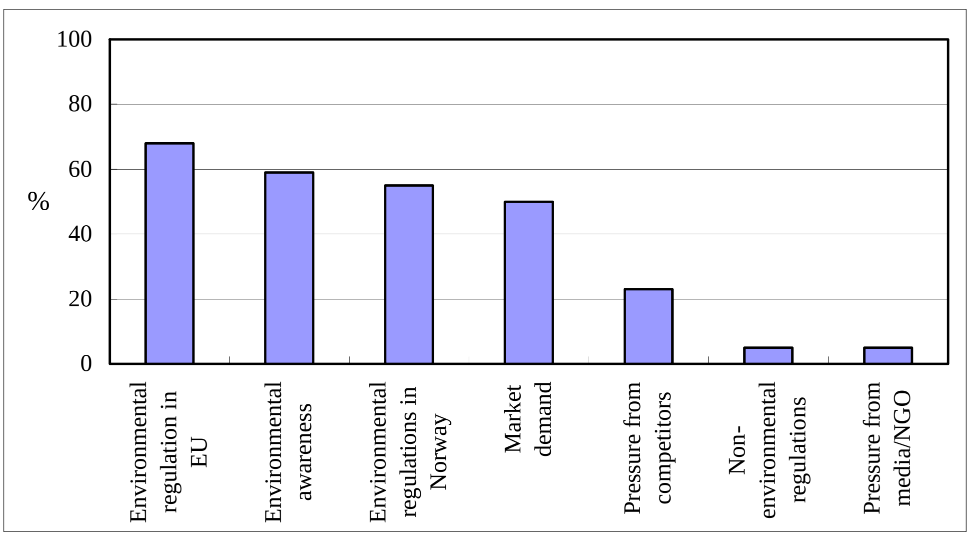

Figure 4-3 "What were the main driving force(s) for the technological changes?"

The main reasons for technological change not to occur were pointed out as the lack of pressure for green products from governmental regulations (29%), the lack of market demand for green products (29%), and the high development cost (26%). For more changes to start occurring, the effective driving forces are recognized as “environmental regulations in EU” (87%), “market demand” (77%), “environmental regulations in Norway” (45%), “pressure from competitors or value chain” (39%), “environmental awareness and commitment in organization” (32%), and “pressure from media or NGO” (19%) (see Figure 4-4). Here, market demand is regarded an important trigger. However, while one respondent thinks that market forces and pressure along the value chain are more important than regulations, another reflects that it is hard to persuade the customer to pay more for a substitute product to get the same functionality.

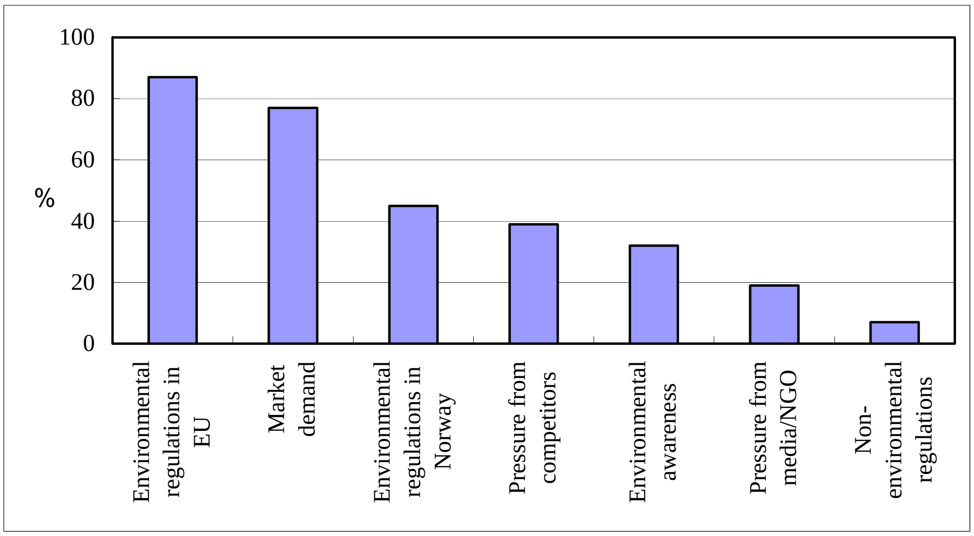

Figure 4-4 "What will be the main driving force(s) for companies to start making green technological changes?"

The survey result shows that the changes in the sector were rather toxicity and waste oriented. The change intensity increased during the period of 2001-2003, following the Norwegian EPR implementation in 1999 and the political discussion for the EU Directives. Regulation, particularly those at EU level, has been regarded by the respondents as the most important driving force for both changes that occurred and changes to come, while the Norwegian regulations accounts for obviously less significance. The environmental feature of the EE products is not the key focus of the market as yet, but market demand is pointed out as a potential driver. This may say that when the authorities push the producers for making environmentally-friendly technological changes, substantial efforts should be diverted to stimulate the demand of eco-products as well.

4.2 Summary from interviews

The way in which the Norwegian EPR scheme for EE products functions is to get financing from the upstream actors (the producers) in order to support the waste managing activities in the downstream actors. Such mechanism can supposedly drive technological change from both ends: the producers make product changes to reduce the cost of waste management fees, and the recycling industry and other downstream companies get more resources to improve their process and efficiency. In the below sections, we summarize our findings from different interviews for changes upstream and downstream respectively.

4.2.1 Changes in upstream companies

While 71% of respondents answered yes to the occurrence of technological change, some of our interviewees revealed a less optimistic perspective. They think environmental issues are not yet big among the Norwegian EE producers, despite that they followed the EE Regulation and established a take-back system accordingly. Concepts like green products or eco-design have started to be promoted by industrial organizations and some PRO, but so far, the response is not keen. One contact in Hvitevareretur expresses that, usually, big companies such as major European suppliers care more about environmental product development. Norwegian producers are not in the forefront and seem to have a "sit-and-wait" mentality.

Industrial networks such as ITTF (IT- industriens teknologiforum) and Abelia Innovasjon have been established in the sector for the producers to jointly explore technological possibilities, since EE products are in their nature highly technology-intensive. However, so far, the environmentally-related projects are more of "observation" quality than of "execution" quality (Ausen, 25 September 2003). Companies want to get themselves prepared for coming regulations and trends, but only few results have been carried out into product change. Environmental projects at ITTF focus very much on the removal of hazardous substances, such as lead and different BFRs.

Companies who were more active since the early stage took the initiatives due to their environmental commitment rather than regulations. It is observed by one contact from SINTEF that those with ISO14001 certification tend to be more environmentally aware and active.

From the interviews, two reasons may be concluded to explain why only limited product changes occurred among Norwegian producers. First, Norway is only a small market with no big producers, and second, there is no clear mechanism to stimulate "green products" in the pricing structure of the collective scheme. In general, collective responsibility tends to provide less driving forces for individual producers to make more radical changes, as discussed in the debate for the WEEE Directive. The Norwegian take-back scheme charges producers by the *quantity* of products they introduce to the market, but not by the *quality* of it. Thus, it gives no incentives for producers to make product changes such as removing the hazardous content. At the same time, one interviewee from an industry association points out that it is not an easy task to establish a qualitative standard to differentiate EE products. Setting industry-wide *standards* is a key issue in some European organizations, and there is often a trade-off between environment features and security features.

With the implementation of the EU RoHS Directive, things start to be different. "The industry is heavily occupied and motivated with activities to get rid of hazardous component," says the interviewee (Sperstad, 5 March 2004). In the following chapter, one of the company cases- the Osram case, will provides a good example of such influence.

4.2.2 Changes in downstream actors

Without doubt, the EPR in Norway has brought in resources to foster activities in the end-of-life phase. The take-back scheme is running, and according to many interviewees, running very well. When the system just started in 1999, only few EE waste management facilities existed, and the operations were rather low-end. To-date, several treatment plants can be found national-wide. The major concern in waste treatment for EE waste was the content of mercury and some other hazardous substances, particularly in the industrial waste. RENAS started to educate the downstream actors with the hazardous composition in various products and tried to survey on the existing recycling technologies in Europe and America (Mathilas, 11 November 2003). Years after the EE Regulation coming into force and the EE Covenant signed, the recycling industry has evolved, and a number of technological changes undergo, for example, for removing SF_6 from electrical switches and for cutting CRT (cathode-ray tube).

Another main focus of recyclers is to increase their operating efficiency, since the three PROs, as the major market regulators of EE waste management, continue to push for increasing efficiency of their systems. The main process to dismantle various EE products is still manual, and this means high costs in a country like Norway. Both domestically and internationally, there is a trend to work out some automotive solutions. In autumn 2003, the automatic facilities at WEEE Recycling AS were established and claimed to be one the most modern EE-waste dismantling and shredding process in the world.

When downstream actors were asked about the practise of “design for recycling” from the producers’ end, in their opinion, not much has happened. At least, no producers have initiated conversation with them regarding the criteria which would make their recycling tasks easier. To improve the life-cycle environmental performance of EE products, communications between upstream and downstream actors can be crucial.

In the following chapter, two company cases from the downstream actors were selected for presentation: the WEEE Recycling case and the SF_6 case.

5. Case studies at company level

During our interviews with people from the industry associations and PROs, we tried to identify some technological changes that have occurred for in-depth case studies. Doing so may allow us to take a closer look at the influencing mechanism and relative importance of EPR instruments. The selection of changes covers both product and process changes, in both upstream and downstream sides of the Norwegian EE industry.

5.1 Lead-free production in Osram AS

5.1.1 Change description

In autumn 2003, Osram AS in Norway planed to start the production of lead-free incandescent lamps, removing lead in both the glass and the solder.

Osram is one of the leading producers of lightings in the world. One of its 53 worldwide production plants is located in Drammen, Norway. Each year, Osram AS in Drammen produces approximately 35 millions incandescent lamps[9], only 15-20% of which are exported. In Norway, about 55 million incandescent lamps are sold in the market per year. According to the production personnel, there are averagely 2 grams of lead in each incandescent lamp, in both the glass for flare and exhaust and the solders. This means that the production in Osram AS will account for nearly 70 tonnes of lead use every year. Incandescent lamps are small, diffusely-spread, short in lifespan[10], and thus difficult to collect after use. With the current low recycling rate of less than 1%, basically all of the lead content ends up in disposal without proper recovery (Rønningen, 5 August 2003).

Lead-free glass for flare and exhaust tubes is already in the market and quite normal in use. The development of lead-free glass for lamps happened more than ten years ago. Main drivers, according to Osram's Belgian glass supplier (Armand, 20 August 2003), were the high cost of lead and its environmental concern.

To find lead-free solutions in soldering is a more challenging task. Since about two years ago, Osram's German headquarter began to look into lead-free alternatives in soldering. From the corporate research center in Germany, the personnel in Drammen received recommendations about possible options of lead-free solders. Then, they had to work on process modifications themselves in order to incorporate this new material in the production process. Though not the first to use lead-free glass, Osram AS is the first factory in the Osram group to apply lead-free solder in the production of incandescent lamps.

5.1.2 Reasons of change and policy influence

In Norway, incandescent lamps are covered by the Norwegian EE Regulation, and their end-of-life treatment falls under RENAS' responsibility. To fulfil their obligations, Osram AS chose to become a member of RENAS'. At the moment, they pay 5% of the product value to RENAS to take care of the end-of-life treatment. *The*

[9] Incandescent lamps are also known as filament lamps. Among all the lamp types, incandescent lamps are by far the least energy efficient. Generally speaking, only about 5% of energy consumed is used for generating light, and the remaining releases as heat.

[10] In general, the life span of incandescent lamps is 1000 hours. Osram in Norway produces lamps with longer life span of 2500 hours.

rate is the same for all lighting products. Such fee structure does not differentiate lamp types according to their environmental features. Doing so may reduce administrative difficulties, but it does not seem to provide incentives for producers to make more radical changes in their products. Thus, we may say that the domestic policy setting in Norway did not contribute much in focal product change of lead removal.

The EU WEEE Directive does not cover the filament bulbs or incandescent lamps. The RoHS Directive, though, requires that from 1 July 2006 on, the new incandescent lamps should not contain lead. This was the main reasons why Osram in Germany started to make R&D efforts in finding lead-free soldering solutions. Such actions started even when the directive was still at its emerging stage, almost two years before final promulgation.

Why did Osram AS in Norway take the initiative to be the first one in the Osram group for lead-free soldering? According to the personnel (26 June 2003), it is due to the implementation of the environmental management system ISO 14001. They identified lead content in their products as the significant environmental aspect which they aim to improve. Compared to other affiliates, the organization of Osram AS is rather small. This facilitates the process for decision making and priority setting. The end-users or the consumers of the incandescent lamps had almost no role to play in driving this product change. One main reason for this may be the lack of awareness: the lead content is not marked on the packaging of the products or on the products themselves.

Still, one may raise questions such as, "does the replacement have better performance?" or "would the industry eventually find the solutions anyway?" It seems reasonable to say that if it were not for the RoHS Directive, the lead content is most likely to remain present. This is due to the existing technological trajectory. The industry found lead solder easier to use, and they tend to stick to it. Incandescent lamps are not among the list of rising-star products with new, advanced technologies, though they are still popular in use. For a product that is already well accepted and yet being gradually replaced due to its low energy efficiency, it does not attract investment to make changes that do not lead to cost reduction or higher revenue. Even if the replacing technology may result in better performance, it does not justify the trade-off.

We may look at this change in two parts. In lead-free glass, Osram in Drammen is in the *diffusion* phase of the technological change. Lead-free glass is already a mature product in the market. In lead-free soldering, however, Osram AS play a key role in *adoption*, i.e. being the first in the Osram group to apply lead-free solder in production. Osram Germany was the main actor in the *innovation* phase, trying to find right combination of solder. However, they are not the ones that invented the solders themselves.

The RoHS Directive played an important role in many stages of this change: from identifying possible substitutions of the hazardous substances (innovation), adopting the substitutions into products (adoption), to pushing the modified products into wide acceptance (diffusion). In the Osram case, the ROHS Directive was the main driver for Osram in Germany to begin its R&D efforts in finding a proper solder solution. It was one of the reasons why Osram AS took the initiative to put it into production. It is also to be expected that the deadline approaches, RoHS will eventually help to ensure and speed up the diffusion of substituting solutions for lead-free incandescent lamps. This seems to echo with the findings in the survey, saying that regulations from EU are more influential than those at Norwegian national level.

5.2 WEEE Recycling AS

5.2.1 Change description

On 14 October 2003, the environmental minister of Norway attended the opening of WEEE Recycling AS, who claimed to possess "the most modern recycling plant in the world" for EE waste.

The process includes dismantling and shredding of EE waste and is to a large extent done by automatic machine, except some manual removal of mercury-containing units and some sorting. There are two lines at the plant: the CFC lines for refrigerators and the EE lines for other EE products. In their automatic facility, "dismantling chain is used instead of knives, nitrogen gas is used to avoid explosion, and vibration units and magnets are used to sort different materials out from each other" (MoE, 14 October 2003). To start with, WEEE Recycling did some screening of existing technological options. They ended up with two suppliers, one in Germany and one in Sweden. To the date of interview, there are 4 other CFC lines and 2 other EE lines in Europe, but WEEE Recycling is the only one combing the two.

WEEE Recycling mainly takes in and processes consumer electronic products, including white goods, brown goods and other EE waste collected by retailers and municipalities. The total treatment capacity is about 250,000 tonnes per year. Their main customer is the Norwegian El-retur system, with market territory covering mid-Norway and northern Norway (Mathilas, 11 November 2003).

5.2.2 Reasons of change and policy influence

The owners of WEEE Recycling are both private companies and municipal waste companies, some of which have been dealing with EE waste treatment since the national collection system started in 1999. The main objective for some of the owners to set up WEEE Recycling is to secure the waste treatment contact from El-retur in the future. The waste treatment companies are required by the El-retur system to work with increasing efficiency and lowering cost. The automation of the treatment can bring up the efficiency manyfold.

Therefore, the managing director of WEEE Recycling concluded during the interview, "If there had not been the Norwegian EE Regulation, the plant would not have been built. The regulation is the reason."

In this technological change, WEEE Recycling is one of the early adopters of a new technology. Their machinery supplier in Germany was the innovator who spent 3-4 years in putting up the engineering ideas. At the moment, both WEEE Recycling and their German supplier are thinking about expanding. "There is absolutely a good future for this technology" (Mathilas, 11 November 2003), in light of the coming WEEE implementation in various EU countries.

Thanks to the Norwegian EE Regulation and EE Covenant, the national collection system of EE waste was built up, and the market for "digesting" the EE waste thus emerged. Today, waste treatment plants can be found in different parts of Norway. The regulation in Norway drove WEEE Recycling into *adoption* of a modern technology. It can be expected that the WEEE Directive will further contribute to its *diffusion*.

5.3 SF_6-treatment facility in Elektronikkgjenvinning AS

5.3.1 Change description

In RENAS' environmental report 2001, it is stated, "*the world's first facility capable of processing SF_6 has been set up in Tønsberg*" (p.11). Elektronikkgjenvinning AS (now merged into NorskMetallretur AS) in Tønsberg was the company who built the first facility to remove SF_6 from end-of-life SF_6-containing equipment outside the manufacturers and users of such equipment (Fahre, 8 August 2003). Recently, this facility has gained some international attention.

Sulfur hexafluoride (SF_6) is a man-made gas. It is colorless, odorless, non-flammable and chemically stable. SF_6 also possesses a number of unique features such as high dielectric strength and arc-quenching capability. These features help SF_6 to gain its firm status for the high and medium voltage application in different electrical power equipment, including substations, transformers and switchgears. The main advantage of SF_6 in this application is that it makes possible to build compact equipment that are safe and long-lasting. The sealed-for-life units require little maintenance throughout its service for 30-50 years.

"The use of SF_6 has been debated, first regarding safety (its decomposition at 200°C can be toxic), and now because of its high global warming potential (GWP)" (CAPIEL 2003). SF_6 is one of the six green house gases (GHGs) listed in the Kyoto Protocol. It has the highest known GWP among all the greenhouse gases. One tonne of SF_6 is equivalent to almost 25,000 tonnes of CO_2 in 100 years (Nordic Council of Ministers, 1995). Despite its extremely high GWP, its total emissions from the electrical sector only accounts for less than 0.1% of man-made green house effect (Knobloch, et al., 2002). In Norway, the emissions from the electrical power equipment accounts for approximately 10% of the total SF_6 emissons (SFT, 2002). To-date, there are about 275 tonnes of SF_6 banked in the existing electrical power equipment in the country (Runde, 2001). Without organized recycling, the SF_6 banked in the equipment may become losses in the air after service.

In August 2001, the opening of the SF_6-removing facility in Tønsberg took place. There were a number of partners involved: one machinery supplier in Babenhausen, Germany was the most important partner who provided the expertise in draining SF_6 from high voltage equipment; SINTEF in Trondheim provided some engineering assistance; and ABB in Skien, the only producer of SF_6 switchgears in Norway, also played an important role.

It did not take long for Elektronikkgjenvinning to come up with this technical solution, nor would people in the electrical power industry consider this as a major technological breakthrough. The in-coming switchgears to be processed are mostly under 24kV and can be divided into two types: those that are completely sealed without opening and those that are built with a fitting for valve. The most innovative element in the facility is the emptying device for the sealed type (Fahre, 19 June 2002). Technologically, it is a fairly simple solution. However, managerially, it brings much more value, such as "extending the managers' horizon from the factory gate to recycling stations" (Endre, 18 July 2003).

5.3.2 Reasons of change and policy influence

Elektronikkgjenvinning has been in the business of handling EE waste since 1997 and is a contractor of RENAS' for the treatment of EE waste. Under the scope of EE Regulation and the EE Covenant, RENAS is the recipient and manager of the end-of-life SF_6-containing switchgears, if the manufacturers and importers pay the membership fee for their products. When RENAS realized that SF_6 was problematic due to its high GWP, RENAS turned to Elektronikkgjenvinning for help, asking them to find out how to remove SF_6 from the SF_6-containing equipment.

In this technological change in the end-of-life process of electrical switchgears, the *innovation* and *adoption* was carried out by Elektronikkgjenvinning upon RENAS' request, with the contributions from a number of partners. "The Norwegian regulation has everything to say" (Fahre, 19 Jun 2003).

In addition to this technological change, other efforts in reducing SF_6 emissions were also made in Norway. Norway ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 and the Kyoto Protocol in 2002, and efforts in reducing the emissions of GHGs have been on-going accordingly. "The most important policy instrument in Norway is currently the CO_2 tax, which now applies to about 64 per cent of all CO_2 emissions." (SFT, 2002) Adopting the same logic, the authorities once considered to introduce a tax on SF_6 to increase the cost of its use and thus reduce its emissions. However, due to its high GWP, the tax rate for SF_6 will be extremely high and thus threaten the Norwegian electrical industries with "distortion of competition" (Runde, 2001).

Using results from some life cycle assessments (LCAs), the electrical industry argues that SF_6 is environmentally superior to its existing rival technologies. The only drawback is in the aspect of global warming potential. Besides, some producers claimed that "there are no good alternatives to SF_6" in certain applications, which makes the heavy taxation or out-phasing of SF_6 unrealistic (Endre, 2002). Eventually, instead of introducing the eco-tax on SF_6, the *Agreement on Reductions of the SF_6 Emissions from Electrical Sector* (**the SF_6 Agreement**), was signed in 2002 between the Ministry of Environment and various industrial parties: the importers and manufacturers of the equipments and the utilities who use the equipment. This agreement covers all relevant phases of the life cycle and includes both stationary large units and stand-alone switchgears. The agreement is the only one of its kind in Europe, if not in the world. Collectively, the electrical industry is obliged to reduce 13% of their SF_6 emissions by 2005 and 30% by 2010, while in a business-as-usual scenario, an increase of 7% in the emissions is expected from 2000 to 2010 (Asphjell, 2002). According to SFT (13 July 2004), the first yearly report shows that the sector has already managed to reduce 60% of SF_6, which is equal to 0.11% of total Norwegian GHG emissions.

When the SF_6 Agreement was signed, the SF_6-removing facility in Elektronikkgjenvinning was already in operation. The owner of the facility thinks that his facility can be used as "the alibi of the power industry" (Fahre, 21 July 2003). However, in the opinions of one producer's, though it was convenient to use the facility in their argumentation, the agreement would have been signed even without it and then the signatories would be responsible to provide a satisfactory end-of-life solution (Endre, 18 July 2003). Nevertheless, the signature of the SF_6 Agreement may help the *diffusion* of the SF_6-removing technology. "Substitution of SF_6 with other gases or technical solutions is only considered to be realistic in the longer term" (Asphjell, 2002). It is then interesting to observe whether the development of SF_6 substitutions will slow down due to the signature of the SF_6 Agreement and the diffusion of the SF_6-removing technology.

6. Conclusions

From our empirical findings above, we can summarize the influence of different EPR instruments on the Norwegian EE industry as follows:

For the downstream actors, the EE Regulation and EE Covenant have brought in financial resources from manufacturers and importers and administrative supervision from several producer responsibility organizations (PROs). The Norwegian EPR has made structural and operational changes to the sector. Since 1999, the amount of collected and recycled end-of-life EE products has been increasing every year. An active recycling industry evolved. This has also resulted in a number of *process innovations* which would not have occurred, if not for the regulation's sake. Many people in the sector would agree that the EE Regulation and EE Covenant together make up a fairly good *waste policy* for EE products. Now when the EU WEEE Directive is in force, the Norwegians have relatively little to do in order to meet the requirements.

For the upstream actors, particularly the producers, the effect of the Norwegian EE Regulation and EE Covenant is far from of equal significance when it comes to stimulating *product innovations*. The main explanation for this is the lack of incentives. The fees that producers have to pay for introducing new EE products in the Norwegian market do not differentiate the environmental quality of the products, but only the quantity of them. Therefore, the Norwegian EPR for EE products is not yet to be categorized as a *product policy*.

It is the coming implementation of the EU RoHS Directive that started to drive product changes among some Norwegian producers to remove of certain hazardous materials. This leaves us something to discuss. The requirement of the RoHS Directive is specific and rather stringent. According to Kemp (see Chapter 2.2), stringent regulations such as product bans are more ready to arouse radical technology responses. We can observe such tendency in the Osram case, when research actions occurred even before the directive was promulgated. However, in the global trade arena, a policy instrument like the RoHS Directive would not work as well if it were initiated and implemented within a country like Norway. Due to globalization, products and services move regardless of national boundaries. It is not easy for individual countries, particularly those with only a small market and a few producers, to set their own product standards. It demands a high degree of international joint effort. Only when the focal market is enlarged and harmonized, will the signals sent to the producers then be strong enough.

Regarding the types of technological change and innovation that we observed in the Norwegian EE industry, they are mostly of incremental nature and fall within diffusion or early adoption of existing technology. For downstream actors, this might be due to the limited amount of available capitals and the cost efficiency demanded by the PROs. For the producers, one major reason can be that environmental properties are usually not as financially rewarding as functionalities of the products. We do not see the consumers of EE products asking for superb environmental features, but some new, innovative functions.

Regulations can be identified as the main driving force for environmental innovation in the Norwegian EE industry. It is particularly so for the downstream actors. Though a stringent regulation like the RoHS Directive is effective to stimulate actions among producers, its environmental gain covers only a small part of the entire picture. To get the producers more involved, it is important for policy makers to take their market and profit into consideration. Policy instruments can be more simulating if there are incentives for producers to make a difference in their products.

Finally, to conclude this research paper, we make the following suggestions for those who are concerned:

1) The Norwegian EPR instruments for EE industry gave birth to a well-functioning national return system for end-of-life EE products. However, its pricing structure does not seem to provide incentives for producers to make technological change and innovation in their products. This is what the policy makers and the PROs should aim to improve, in order to achieve better environmental effectiveness for the system.
2) The different PROs are in the best position to organize some dialogues between their upstream members and the downstream waste managers. Understanding the concerns of downstream actors may help the producers when they are trying to improve the "design for recycling" properties of their EE products.
3) EPR has the potential to be both waste policy and product policy. The case study in the Norwegian EE industry tells us that the aspect of waste policy can be to a large extent achieved domestically, while the aspect of product policy may require high level of international cooperation, especially for products that travel across borders. In the recent years, EU has been working out several instruments. Such efforts can only be continued and expanded.

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Appendix I: Applications and known health effects of certain hazardous substances in EE products

Type of hazardous substance	Application	Known health effect
Lead	Certain types of cabling (the sheathing for electric conductors) and solders	Damage to brain and nervous system; behavioural changes and personality problems in children
Cadmium	Ni-Cd batteries and rechargeable electric tools; plastic cabling	Kidney and bone damage, lung cancer if breathed in; seldom acute, but pneumonia, vomiting and diarrhoea possible
Mercury	Level switches, relays, gauges and meters	Neurological damage, foetal deformities, various types of mental problems
BFRs (PBB, PBDE)	Plastic sheathing on cables and wires, and in plastic used as other shell of many electric appliances	Similar in many way to PCBs, though only limited knowledge on actual effects
PCB	Capacitors in many electrical installations such as lighting fixtures, and as additives in transformer oils and insulation material for electrical conductors in walls (use in new products banned in Norway in 1980s)	Endocrine disrupters and genetic damages; hermaphrodism among polar bears; carcinogens

(Source: RENAS, 2002)

Appendix II: Result of the web-based survey

Survey name: **"Green" Technological Changes in the Norwegian EE Sector**

Survey period: 20 October – 11 November 2003

Survey link: https://www.its-learning.com/main.aspx?ProjectID=595

No. of respondent: 35 (31 considered valid)

1	**Your organization is**	
	a Norwegian producer or sub-contractor	35.5 %
	a foreign-based producer or an importer	22.6 %
	an industry association or other related organization (such as Producer Responsibility Organization like RENAS)	19.4 %
	a recycler	6.5 %
	a research institute	3.2 %
	others	12.9 %
2	**What type of EE products is your organization involved with?**	
	Consumer or household products	29.0 %
	Products for industrial use	22.6 %
	Both of the above	48.4 %
3	**What are the major environmental problem(s) caused by your EE products during the last 10 years? (more than one option allowed)** **(Remark: If you are not a producer nor an importer, please answer the questions for EE products in general.)**	
	Increased quantity of waste	58.1 %
	Emissions of toxic heavy metals from waste treatment	48.4 %
	Emissions of hazardous chemicals from waste treatment	48.4 %
	Use of scarce metals and minerals (resource depletion)	16.1 %
	Emissions of greenhouse gases due to energy consumption in production	12.9 %
	Emissions of greenhouse gases due to energy consumption in use phase	19.4 %
	Others	3.2 %
4	**If possible, please specify your answer of question 3:**	
	- Product life time is shorter in EU/ Norway. Volumes high and wastestream of WEEE have to be handle correctly - Just increase of EE waste. No heavy toxic metals nor chemicals used. - EE-waste that is not collected and treated the right way, may let out PCB's and other harmful chemicals from putting it to landfills or in shredders - Lead pollution (lead glass, lead based solder), to soil from discarded lamps - We are producing electrical cookers. Prices of such products is lower than before and the consumers change more often than before - Products contain SF6 which need to be reclaimed. Products utilise copper. - We aim at longevity and low energy use for all our products. These factors have improved significantly over the last 10 years. - I think that all the issues in questions 3 are relevant, difficult to say what is the most important	

	- The changing of old products with new products are rapidly increasing. - For the reason of contents of electrical components as printcards etc. - Plastics, metals, printed circuit boards (incl. lead), packaging - It is a general problem. More products are being produced. Several are categorized as EE products. Both scarce resource use during product design and manufacturing and problems at EOL treatment are present. In addition, these products consume energy during use. Still the majority of energy production is based on non-renewable resources.	
5	**Are environmental issues important when technological changes are carried out in your EE products?**	
	Yes, very important	67.7 %
	Somewhat important, but not among the top priorities	25.8 %
	Not really important	6.5 %
6	**During the last 10 years, have there been any technological changes in your EE products or in the production process to deal with environmental problems?**	
	Yes	71.0 %
	No (please jump to questions no. 15-17)	29.0 %
7	**What kind of technological changes have been carried out? (more than one option allowed)**	(out of Yes in Q6)
	Elimination of substances	68.2 %
	Substitution of substances	77.3 %
	Reduced energy consumption in use phase	68.2 %
	Reduced use of materials (dematerialization)	40.9 %
	Change of product functions	13.6 %
	Others	4.5 %
8	**If possible, please specify the technological changes in question 7:**	
	- Just look at the ICT technology taken place - Simplification of mechanical design lead to lighter products. Pushing subcontractors to not use ozone deploying agents. Complete list of inventory established for recycling firms at EOL - Removal/substitution of lead in glass and solder. Use of "short neck" bulbs Smaller glass components - New factory means less energy consumption and substitution of substances. - Sustainable design, better use of design tools and new techniques enable better differentiation, i.e. use less raw materials and elimination of (part)-processes not favourable to the environment - Some toxic substance are banned from use in new products (Hg, Pb, BFRs etc.) Some of these have been replaced by substitutions - Detection controlled function - Makes machines that require less energy when used. Uses recyclable materials in our production - Try to avoid PVC and lower energy consumption	
9	**What was the frequency of the technological changes?**	(out of Yes in Q6)
	One-time change on one product type	4.5 %
	One-time change on many product types	13.6 %
	Continuous changes on one product type	4.5 %
	Continuous changes on many product types	72.7 %
10	**When did the technological changes mainly take place?**	(out of Yes in

		Q6)
	before 1994	13.6 %
	1995 - 1997	13.6 %
	1998 - 2000	13.6 %
	2001 - 2003	22.7 %
	I am not able to specify.	36.4 %
11	**What kind of environmental problems did the technological changes try to reduce? (more than one option allowed)**	(out of Yes in Q6)
	Increase of waste quantity	59.1 %
	Content of toxic heavy metals	50.0 %
	Content of hazardous chemicals	72.7 %
	Resource depleption and resource efficiency	54.5 %
	Greenhouse gas emissions	31.8 %
	Others	4.5 %
12	**If possible, please specify your answer of question 11:**	
	- Less glass, less waste, lead removal - Introduction of closed loop process for surface treatment of components, substitution of production processes not producing hazardous waste or unproportionally contributing to GW	
13	**What were the main driving force(s) for the technological changes? (more than one option allowed)**	(out of Yes in Q6)
	Environmental regulatioins in Norway	54.5 %
	Environmental regulations in EU	68.2 %
	Non-environmental reguations/ public policies	4.5 %
	Market demand	50.0 %
	Pressure from competitors/ value chain	22.7 %
	Environmental awareness and commitment in the organization	59.1 %
	Pressure from media/ NGOs	4.5 %
	Others	9.1 %
14	**If possible, please specify and describe shortly the main driving forces for the technological changes:**	
	- ICT - Intensive EHS program implemented over the last 5 years from corporate level. Elements aimed to take care of employees, facilities and products. - General policy of mother company for "green" products. ISO 14001 - Hazardous waste management was according to company policy (ISO14001) also perceived benefit from "green" good will. However one must not forget anticipated impact from legislation - Investors	
15	**What are the main reason(s) that no technological change has occurred? (more than one option allowed)**	
	The cost of development is too high.	25.8 %
	There is no pressure for environmentally-friendly products from governmental regulations	29.0 %
	There is no market demand for environmentally-friendly products	29.0 %
	All the other companies in the sector produce the same thing. We don't feel the need to be different.	9.7 %

	Others	12.9 %
	Not answered	35.5 %
16	**What will be the main driving force(s) for companies to start making technological changes to deal with environmental problems? (more than one option allowed)**	
	Environmental regulations in Norway	45.2 %
	Environmental regulations in EU	87.1 %
	Non-environmental regulations/ public policies	6.5 %
	Market demand	77.4 %
	Pressure from competitors/ value chain	38.7 %
	Environmental awareness and commitment in the organization	32.3 %
	Pressure from media/ NGOs	19.4 %
	Others	0.0 %
	Not answered	3.2 %
17	**If possible, please specify your answers in questions 15 and 16:**	
	- 15: Technological changes did occur. 16: Main reason for change comes from own organization, but govt regulations will also have to be dealt with. Norway will likely follow Europe in new EHS regulations - In general there is no market for a substitute product as long as the customer has to pay more to get the same functionality. Also one must bear in mind that a product's environmental load must be related to its environment, to the system it belongs. There is always a danger for suboptimalization, i.e. What would happen to a car if a new env. friendly engine was 10 times more heavy? - The awareness among consumers are low, and it's not a significant focus to development of products. Banning of substances is an effective way to make it better. If we also could have regulations than obliged producers to make their products if they contain eco-toxins over a certain level, the consumer would have a possibility to choose the more eco-friendly product (if for instance light-tubes containing more than 10 mg Hg had to be marked, and others not) - Most important: environment not emphasized by management - Market forces and pressure along the value chain are more important than regulations	
18	**Thank you very much for your kind contribution. If you have other comments about this issue or this survey, please tell us here or send us an e-mail.**	
	- I believe that the electronic industry should combine the EHS efforts aimed at people, facilities, the environment and EE products. Today it seems like these activities are not fully coordinated. - As a distributor to the industry, many of the questions were not really applicable. Our current sitation is simple and yet extremely complex: customers get what they are requesting –suppliers push what they have. This includes the products, but also the liabilities. The "pressure" we experienced is mainly from customers and international legislation. - It is a paradox that the wages in Norway prevent recycling companies from separating waste designed to be recycled. Thermoplastic components are labelled for the purpose, still it is incinerated in Norway and reclaimed in China. - We are very depending on use of standard electrical components manufactured by other companies. It is therefore important to start the process there.	

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ISSN 1501-6153
ISBN 82-7948-028-5 (trykt)
ISBN 82-7948-029-3 (pdf)