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The case of plastic packaging in Norway

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ABSTRACT

The purpose of this thesis is to identify key conditions for successful industrial implementation of collective extended producer responsibility (EPR) programmes in the Norwegian plastic packaging system, according to an industrial ecology perspective. 'Key condition' is defined as those factors, both drivers and barriers, which are critical for the outcome of industrial implementation of EPR. As we have seen there are several key conditions to be identified. We have studied this by first developing a theoretical framework based on the industrial ecology perspective and combined with a modified understanding on categories for EPR policy instruments we have developed an analytical framework which combines a material flow approach and an actor approach. Based on this we have carried out a case study of the Norwegian EPR system for plastic packaging, organised by the producer responsibility organisation Plastretur. We have shown the complexity of this system by doing analysis on various levels, both with respect to material flows and to actors. Our conclusions are primarily valid for this system only, but we have shown how our results correspond to existing literature, both theoretically and in practice.

The overall conclusion from this case study is that the Plastretur EPR scheme has proven to be successful with respect to recycling ratios and costs, while it has been less successful concerning dematerialisation and design for recycling. This conclusion is contrary to what is considered to be the strength of EPR policies, but it provides empirical evidence for the arguments put forth by for instance Veerman (2004) on the Dutch system, claiming that EPR has mainly effects downstream. We argue that one of the reasons to this controversial result is that previous studies have not to a sufficient extent taken into account the need for identifying the causality between EPR policy instruments and the observed effects. We have provided this through a detailed case study on various analytical levels.

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Doing research of this kind is indeed an introspective activity depending almost entirely on your own, internal motivation. Luckily, a number of colleagues and friends have made this journey less lonely than it might otherwise have been. Starting at the same time and finishing so too, Arne Eik has been close during work and leisure. Thanks for providing early-morning coffee and discussions, and for reintroducing me to the joy of being a midfielder on the football ground. The young and multidisciplinary group of research fellows at IndEcol has constantly provided inspiring feed to my own project, and Hilde, Lars Brede, Margit, Martina, Rolf, Frank, Klaus, Jan Tore, Håvard S, Stig and Øivind have all contributed to bits and pieces of this thesis and to the joy of going to work every day. In addition, to the train-Tuftees Torgeir and Jørund for joyful talks and friendship and to Rene for numerous and humorous days in Trondheim and Leiden.

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Bærums Verk, February 2006

Kjetil Røine

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1. INTRODUCTION

This thesis examines extended producer responsibility (EPR) and how this policy principle has been implemented in the Norwegian plastic packaging industry since 1995. Today, more than 10 years later, the 30 % material recycling target has still not been reached. How can we explain this, and what can we learn from these experiences?

1.1 Background

On 14th of September 1995, closing a long negotiating process, four agreements between the Norwegian Ministry of Environment (NMoE) and industrial sectors of packaging in Norway were signed (NMoE 1995a,b,c,d). The overall environmental intention of these agreements, or covenants as they are denoted, was to counteract increasing amounts of generated waste and increasing amount of waste ending up at landfills. The covenants, being preferred to a more traditional environmental tax paid by industry to government, challenged industry to itself decide how to reduce the amounts of waste in the most cost-efficient way in order to reach certain targets defined in the covenants. These targets were related to the rate of collection, the rate of material recycling and the rate of energy recovery, in addition to a non-quantified waste reduction objective.

This Norwegian example is representative for the development of environmental public policy related to products. As has been realised to an ever-greater extent during the last decades, the environmental impact of a product comes from its entire life cycle, and not only during production. Strategies and actions carried out by the upstream companies, 'the producers', are thus decisive for the environmental impact later in the life cycle. This new understanding has paved the way for public policies where upstream companies to a larger extent have become obligated and responsible for the environmental impacts from their products beyond the production phase and particularly for the end-of-life (EoL) phase of the products. This relatively new policy principle is today known as EPR. EPR has been applied in several OECD countries such as Japan, Australia, EU-countries and US (OECD 1998a), and is today a frequently used approach for reducing environmental effects from products.

EPR is defined as a policy principle (Davis 1998, Lindhqvist 2000, Tojo 2004): "Extended producer responsibility (EPR) is a policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product". The underlying premise in this definition is that the policy principle does not in itself have the power to induce changes on market actors, and that the extension of the producers' responsibilities is thus implemented through tangible EPR policy instruments. Indeed, implementation of EPR in national contexts varies along a number of dimensions, for instance type of environmental problem to be solved, type of product, type of responsibility, type of sectors involved, and consequently type of policy instruments (OECD 2001). These dimensions will be discussed in Chapter 3.

The research on EPR has mainly been on the policy design level (OECD 2001), on design, implementation and evaluation of EPR schemes (free-riders, monopoly of Producer Responsible Organisations (PRO), ownership etc) (OECD 1998a), on institutional issues and challenges (Tojo et al. 2001) and on goal attainment (Tojo 2001, OECD 2004). These analyses are, generally speaking, on an aggregated level leaving the intermediate processes and mechanisms as part of the industrial implementation of EPR fairly unknown to the policy makers. For simply knowing whether the target is reached or not, measuring the outcome, e.g. the actual recycling rate compared to the target set, is sufficient. This approach however, does not provide any knowledge on why the outcome is the way it is. In order to improve policy design, to evaluate the potential for improvements within the existing policy regime, or to understand how various actors that are exposed to the policy instrument actually behave, both in relation to the policy instrument and in relation to each other, in-depth case studies on the industrial implementation of EPR are needed.

OECD notes that "the primary purpose of EPR is to provide incentives to producers to redesign products to make them more environmentally sound" (OECD 1998a, p 11). To what extent are EPR policy instruments actually designed to fulfil this objective? Thomas Lindhqvist states that "EPR is a vehicle for innovation in the design of products and product systems" (Lindhqvist 2000, p. 155). Theoretically and conceptually it might be valid, but is it also true in reality? To what extent do EPR policy instruments actually influence decision-making processes within upstream companies? This thesis aims at diminishing this knowledge gap.

Changes on a product and company level provide, however, only the *potential* for getting the products recycled in a proper way. The organisation of the recycling system to take care of waste flows has been analysed by many (OECD 1998a, OECD 2001), but the *role* of the PROs as well as the *means and instruments* at hand for them to execute their targets, have only been studied to a limited extent. Where are the potential for improvements for reaching the targets? How do the PROs interact with market actors in order to reach the objectives?

Although various EPR schemes exist, depending on country, material- and product group (OECD 2001), the basic intention for all EPR take-back programmes remains the same – to move towards closed loops by transforming linear flows into circular flows by placing enhanced responsibility on the producers. EPR is hence an interesting case from an industrial ecology perspective. As a matter of coincidence, by the time

Germany introduced their Packaging Law, which is regarded as the first operational EPR programme, Frosch and Gallapagous (1989) employed the term 'industrial ecosystem' in their seminal article "Strategies for manufacturing" in the monthly *Scientific American*. This article was the birth of the term 'industrial ecology' (IE).

There are clearly connecting points between industrial ecology and EPR. First, several have argued, theoretically, that EPR is an important strategy within industrial ecology (Ehrenfeld 1995, Lifset & Graedel 2002). Second, the industrial ecology concept with a focus on systems perspective, on closing loops, on technological change and innovation, and on preventive strategies for reducing the environmental changes due to human activities, is to a large extent compatible to the EPR focus on recycling and the role of upstream producers. Third, industrial ecology is regarded as a promising way of thinking for making environmental improvements in the future, while EPR is held to be a policy instrument for the next generation (Powers and Chertow 1997). Even though industrial ecology and EPR have emerged in the same period of time, they have developed more or less independently. EPR in Norway has been implemented without any observed connection or relevance to industrial ecology field of academics (Rensvik 1998). Fifth, both industrial ecology and EPR rely, to a greater or lesser degree, on market mechanisms.

Starting from the industrial ecology perspective, the case of EPR is in fact an example of how industrial ecology ideas might be put into practice through concrete public policies. It is though interesting to study how well such a public policy works in practice. From this stand point, we regard EPR as a policy principle for implementing some of the ideas that are contained in the industrial ecology way of thinking. Moreover, and most importantly, industrial ecology will serve as the conceptual and analytical basis for this study.

Industrial ecology has not to date significantly influenced policy making, although some examples can be found on substance policy (Lifset 2005). However, the obvious common features of industrial ecology and extended producer responsibility make it interesting to study their connections and coherences. Industrial ecology seems to be a wider concept than EPR because it includes more perspectives, larger systems and a more total picture of the environmental challenge, such as improved metabolism and more sustainable energy patterns. Given the premise that an industrial ecology practice will provide more sustainable patterns, it is interesting to study the power and influence of EPR to implement industrial ecology principles. It is also interesting to study whether EPR programmes influence and implement *other* industrial ecology practices than those which are inherent in the EPR principles. Has EPR the power to induce changes within organisations and industries towards an overall industrial ecology way of thinking.

During the last decade a large number of papers have been published on industrial ecology and EPR. Theoretical papers, conceptual papers and more empirical and practical papers are found on both issues. Industrial ecology and EPR are to some extent discussed in the same paper, but these simply state (theoretically) that EPR is a significant policy within the industrial ecology concept (Ehrenfeld 1995, Lifset and Graedel 2002). There are, as far as the author can see, no papers discussing the empirical relationship between industrial ecology and EPR which can test and discuss these statements.

Rather than spreading the empirical investigation over a number of EPR schemes, which would have made it more complicated to control for all the variables, this study closely investigates one case. We have selected the case of plastic packaging in Norway. There are several reasons for this. First, a voluntary agreement between industry and national authorities is the regulatory basis for the industrial implementation of EPR in the plastic packaging sector in Norway. This voluntary agreement is from an industrial ecology point of view interesting to consider as it provides an alternative to traditional command-and-control policies. Second, take-back schemes are considered as the purest form of EPR (Gertsakis et al. 2003). Third, the link between industrial ecology and EPR is particularly evident in the take-back schemes since these deals with loop closing and transition into circular flows which is a key characteristic of industrial ecology. Forth, although studies show that voluntary agreements are not effective within energy- and production process-related settings (OECD 2003), there are few studies on the effects of voluntary agreements on products for instance related to loop-closing and dematerialisation.

It is argued from political and administrative actors that Norwegian EPR systems are successful (Berntsen 2005, Brende 2003). Through the covenant the targets are set and it is up to the industry to find the means and solutions to reach these targets. But the targets for plastic packaging have not been reached. This thesis looks into the internal mechanisms within this system to explain why. Hence, the Norwegian case represents an illustrative example as well because Norway is a relatively transparent country, making it easier to explain the performance of this system and the challenges related to achieving the targets.

1.2 Aim of the study and research question

Despite the increasing interest in EPR as a policy for improving material flows, few in-depth studies on the industrial implementation of EPR have been carried out. Understanding the processes, dynamics and mechanisms within the EPR system is important to understand its outcome. The purpose of this research is therefore to better understand – based on an industrial ecology perspective – the industrial implementation of collective EPR programmes based on voluntary agreements. The methodological objective is to develop an analytical framework for studying industrial implementation of EPR based on an industrial ecology perspective. The empirical objective is to synthesise the achievements and lessons learned from implementation of EPR in order to provide knowledge to decision-makers, on how to improve the political and industrial implementation of EPR.

The main research question is this:

> *What are the key conditions for successful industrial implementation of collective EPR programmes in the Norwegian plastic packaging system, according to an industrial ecology perspective?*

In addition to defining EPR, we need to look into the terms 'industrial implementation', 'an industrial ecology perspective', 'key conditions' and 'successful'. These terms will be discussed in more detail in Chapter 2-4, but will briefly be commented upon here.

'Industrial implementation' describes the processes within the industrial sector and companies that occur as a consequence of EPR policy instruments. More on this will be provided in Chapter 3.

By 'key conditions' we mean the factors, both drivers and barriers, which appear to be critical for the outcome of the industrial implementation of EPR. There are obviously a number of potential 'key conditions', and in this thesis we will employ industrial ecology and Giddens' structuration theory (Giddens 1979, 1984) as basis theories for what these 'key conditions' can be and where to look for them.

The term 'successful' is used to express that the objective is to generate knowledge on how EPR systems might be improved in order to achieve targets at the lowest possible cost. That said, we are not aiming to analyse at which point the EPR system is successful, but rather pointing to drivers and barriers for the direction and speed of the observed changes. Hence, this thesis studies the industrial implementation of a certain policy to learn more about its successes and failures.

The final term raised here is 'an industrial ecology perspective'. The industrial ecology perspective is chosen because it deals with many of the issues that EPR is concerned with, that this way of thinking is potentially fruitful for moving towards a more sustainable society, and that it provides an analytical basis for studying EPR systems.

In order to make it easier for the reader to follow the arguments, we disclose the conclusion already here. The key factors found in this study to be significant for successful industrial implementation of EPR are:

1. Proper sorting by waste generator
2. PRO must find a balancing role in influencing the market

3. Explicit incentives directed towards the producers for obtaining changes upstream
4. Producers see the link between their own waste generation and the EPR recycling system
5. A mix of EPR-based policy instruments that create pressure along the entire value chain must be employed.

The remaining of the thesis will provide explanation to justify this conclusion.

1.3 EPR-system for plastic packaging in Norway – an overview

Although companies for some time had prepared themselves for the implementation of EPR, it can, for simplicity reasons, be said that the EPR implementation at sector level started with the signing of the covenant in September 1995. According to the agreement, the role of the government was reduced to set the boundary conditions and targets only, while the role of the industrial sector was to comply with them. This chapter will briefly present the system that the industrial sector itself established as a consequence of the covenant.

Simply stated, Plastretur is established by those who have signed the covenant with Norwegian Ministry of Environment (NMoE) to collectively comply with the targets of 30 % material recycling and 50 % energy recovery of the plastic packaging consumption per year, see Figure 1.1 below. In addition there are particular targets for expanded polystyrene (EPS); 50 % material recycling and 10 % energy recovery. Plastretur is owned by the producers, packers & fillers, retailers and importers in the plastic packaging chain ('producers'), and finances its activities through the licence fee paid by these producers.

The horizontal 'central line' in Figure 1.1 above, from 'upstream sector' to 'secondary use companies', illustrates the material flows of plastic packaging in a life cycle perspective. Plastic packaging flows from producers to consumers and waste generators, and further as plastic packaging waste to the waste management sector. We collectively denote all these on the central line as 'direct actors' because these actors are those who actually process the plastic packaging forward in the life cycle.

Given the overall objective of reaching the targets in the covenant and the income from the licence fees, the key role of Plastretur is to spend the income as efficiently as possible so that the targets are met. The operational objective of Plastretur is then to design and implement systems, strategies and means (e.g. contracts, subsidies and information) towards the direct actors and primarily the waste management sector. However, strategies and means influencing the upstream sectors to design for environment, the consumers and waste generators to sort and source separate correctly and the secondary use companies to employ recycled material, might also be significant for achieving an effective system. The full and dotted lines from the box 'Plastretur' to the direct actors illustrate this.

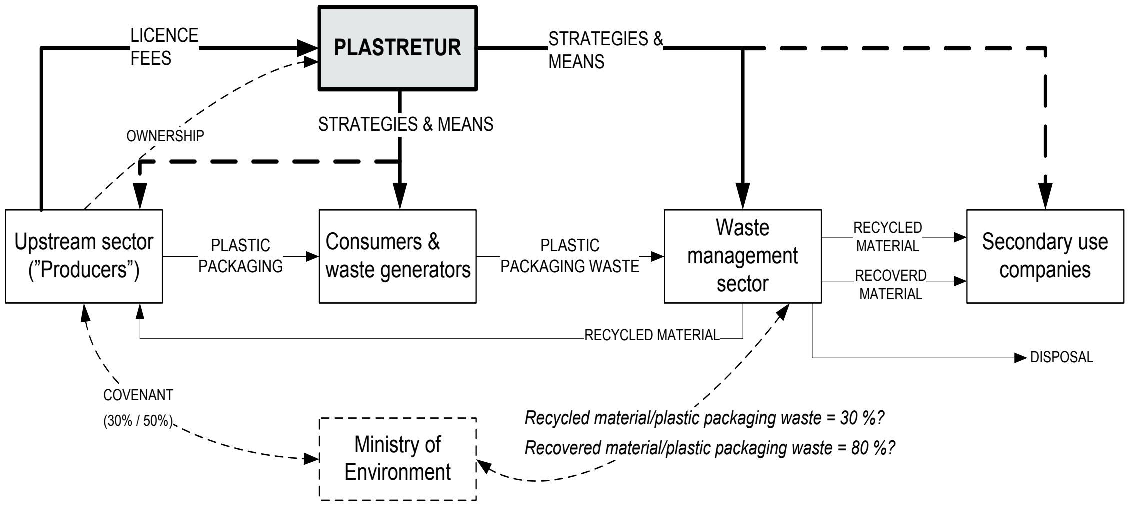


Figure 1.1: A schematic presentation of the Plastretur system.

Plastretur, NMoE and other actors that influence the flows of plastic packaging without being in physical contact with or claiming ownership to the plastic packaging, are here called 'indirect actors'. The balancing interaction between the direct and indirect actors makes this a market-driven EPR-system. Plastretur is a catalyst for directing the cash, and thereby the material and product flows, in a wanted direction, and with the direct actors competing on a regular basis to make money. It is a collective system since the targets to be met are for plastic packaging as a group and not for single plastic packaging products.

The term 'Plastretur EPR system' is here used for grasping all material flows, activities, structures and actors that are, in one way or another, influencing the fulfilment of the covenant. The purpose of the system is to fulfil the targets, consistent with the EPR principles discussed in Chapter 3. The EPR system for plastic packaging does, thus, not only include the Plastretur organisation and its activities, although this is perhaps the most significant part of the entire system.

The Plastretur EPR system for plastic packaging is based on some key principles. First, the objectives shall be achieved by stimulating existing, direct (market) actors and hence, the existing waste management industry to collect, sort and recycle the material, and to employ various strategies and means in order to comply with the covenant. Plastretur shall not develop a parallel collection and recycling system like in Germany (OECD 1998b). Second, Plastretur should focus, due to economical reasons as stated in the covenant, to get the 'cheapest' tons first. This proved to be within agriculture and commerce and industry.

Third, from the very beginning in 1996, the strategy has been to 'plan from behind'. This was important since Plastretur is guaranteeing collectors that there will always be recyclers available to receive the collected plastics. Experiences from previous plastic recycle efforts in Norway and Germany showed that collecting plastics without having a viable recycling industry was not successful both from an economical and environmental point of view (Muenk 1998, OECD 1998b). Forth, Plastretur sign contracts with collectors, typical traditional waste management companies, by guaranteeing a minimum price for the collected and baled plastic packaging and delivered to the recyclers that Plastretur have contracted. The principle is that Plastretur shall cover the deficit the waste management companies have when collecting, sorting and material recycling instead of energy recovery, combustion or land filling. However, the collectors are obliged to receive plastic packaging from any waste generator free of cost for the waste generator. However, they can get paid for the transport from waste generator to their recycling sites. The recycler gets paid for the actual amount sold.

Table 1.1 Generation of plastic packaging waste in Norway in 2004.Sources: (a) Plastretur (2005), (b) Eik (2005), number from 2003, and (c) Syversen 2005

Organisation	Type of product	Consumption a year [tons]	% of total
Plastretur	Normal plastic packaging	119100 [a]	90.5
Plastretur	EPS	4800 [a]	3.6
Plastretur	Hazardous waste	5000 [a]	3.8
Resirk	One-way beverage PET-bottles	1700 [b]	1.3
Others	Some very toxic and explosive hazardous products	1000 [c]	0.8

Plastretur is running a collective system where there is no direct connection between the fee payer and the product(s) that is recycled. However, Plastretur is not responsible for plastic packaging that is subject to governmental taxes, that is one-way beverage bottles, which is the responsible of Resirk. The total amount of plastic packaging under the responsibility of Resirk is 1,700 tons (Eik 2005). Hence, the Plastretur system, with its 119,100 tons of general plastic packaging in 2004, 4,800 tons of EPS and 5,000 tons of plastic packaging defined as hazardous waste deals with 97.9 % of the total plastic packaging consumption in Norway.

We will in Chapter 7 return to a more detailed description of the EPR system.

1.4 Scope and limitations

The case study is limited to the plastic packaging sector in Norway, and the first type of product shown in Table 1.1 above. The study does neither include poly-ethylene terephthalate (PET) beverage bottles as this fraction is covered by another regulation (see Eik 2005), plastic packaging of EPS nor plastic packaging with hazardous content. Moreover, the study looks at one of several variants of EPR schemes, namely that of product take-back regulated by a negotiated agreement. That said, the thesis does not cover any entirely voluntary schemes initiated by industry without any kind of intentional governmental interference.

The study does not explicitly look at individual EPR systems, but is limited to collective EPR systems. Moreover, we do not intend to assess the level of the targets in the covenants, whether these are 'correct' or not, but rather use these targets as a starting point for the analysis. It is the processes during the industrial implementation that reveal the key conditions.

We are not performing an environmental assessment of the recycling targets set or recycling ratios obtained. Rather, the intention is to understand the industrial implementation of EPR, leaving the assessment of the targets to others. Moreover, although a material flow approach will be used for studying the EPR system, we do not intend to develop an improved methodology for material flow analysis (MFA).

1.5 Research method

This is a case study that combines various methods for empirical investigation and analysis. The study consists of one main case study covering the entire plastic packaging sector (the 'Plastretur EPR system') and of several smaller cases on a company level along the entire life cycle. We employ a material flow approach for studying the EPR system on the sector level and typical case study tools such as in-depth interviews, active participation, document research as well as quantitative analysis of economic and environmental parameters on company level. The idea is to look deeply into this single case by studying all major actors along the entire life cycle, on different levels. Since a number of actors are involved, and not only one company (as is normal in case studies), this represents a complex case. However, the results are primarily relevant to the boundary conditions that are valid for this case. The results will be subject to analytical generalisation by comparing with existing literature from other EPR systems (Yin 1994).

1.6 Research context

This research started in 1998 and has been financed by the Norwegian Research Council. The working environment has been at the Industrial Ecology Programme at the Norwegian University of Science and Technology (NTNU), Trondheim. During the research period the author has been involved in a number of research projects such as 'Productivity 2005 - Industrial Ecology', and co-editor of a new graduate level textbook within industrial ecology. For the period 2003 – 2005 the author was a guest researcher at Fridtjof Nansens Institute in Oslo, and since 2002 he has also worked as a consultant for various Norwegian and European EPR systems.

1.7 Outline of the thesis

The structure of the thesis is as follows:

Chapter 1. Introduction This is the present chapter that provides a background leading up to the aims for the study as well as the research question.

Chapter 2. Industrial Ecology – a theoretical perspective. This chapter starts with a presentation of the concept of industrial ecology based on literature in the field. A theoretical framework for industrial ecology is presented, based on three dimensions i) resource perspective, ii) networks of actors' perspective and iii) systems perspective. This will be the structural framework for carrying out the studies on this thesis.

Chapter 3. Extended producer responsibility – a policy principle. Here we focus on EPR as a new policy principle and how it fits with the more traditional policy instruments. Further, the distinction between political and industrial implementation of EPR is elaborated.

Chapter 4. Analytical framework and research methodology. The aim of this chapter is to provide the analytical framework that will be applied for studying the research questions. We start by introducing a general analytical approach based on the industrial ecology perspective, and develop thereafter the particular analytical framework to be employed for this study. Then we present the research design, including the various methods for collecting and treating the empirical evidence needed for studying the research questions. A multiple range of methods have been used: MFA, case study based on interviews, surveys, data collection, observed participation, active participation, literature survey, secondary literature studies (annual reports, board documents, etc) This is a case study of one system and contains in-depth studies of an upstream company (Tine Norske Meierier (Tine)) and of Plastretur as the PROs.

Chapter 5. Policy implementation of EPR in Norway. This chapter presents data from the policy implementation of EPR in plastic packaging in Norway.

Chapter 6. Dematerialisation and loop closing in selected EPR systems The intention here is to gain a picture of the dematerialisation and loop closing within plastic packaging in Norway. This chapter takes an overall view of the systems studied by looking at the major inflows and outflows to and from national EPR systems.

Chapter 7. Industrial implementation of EPR on plastic packaging in Norway – sector level. This chapter focuses on the actual EPR-system. Important empirical information is gained by looking at the flows of materials, cash and information throughout the system, and by presenting the various actors and their overall roles in the system, and, in particular, studying Plastretur and its role and the challenges it faces.

Chapter 8. Industrial implementation of EPR on plastic packaging in Norway – company level. In this chapter, a web survey on 'technological change and innovation' is first presented. Then we elaborate on particular companies throughout the life cycle of plastic packaging by looking into the processes and decisions that are relevant for EPR. The aim is to find evidence for the effects of EPR on a corporate level. The main focus will be on Tine Norske Meierier (Tine), the largest Norwegian dairy company.

Chapter 9. Key conditions for successful implementation of EPR. In this chapter we employ the empirical information from Part II to discuss the research questions stated in chapter 1. Moreover, we will discuss the implications for EPR system for plastic packaging to discussing the generalisation of these results, both related to theory, methodology and empirically interested people.

Chapter 10. Conclusions, scientific contributions and recommendations for further studies. Here we draw the conclusions and recommendations for further studies.

2. INDUSTRIAL ECOLOGY – A THEORETICAL PERSPECTIVE

The objective of this chapter is to develop the *theoretical framework* needed for analysing the industrial implementation of extended producer responsibility in an industrial ecology perspective. We will start with a discussion of the most relevant indusial ecology literature for this thesis. Next, due to limitations in existing theoretical frameworks, a three-dimensional structure of the field is developed and discussed in 2.2 – 2.4. This structure is constituted by i) the resource perspective, ii) the networks of actors' perspective and iii) the systems perspective.

2.1 A discussion of most relevant industrial ecology literature

Industrial ecology has emerged as a unifying term during the last 16 years. The field has grown considerably within academia throughout the world[1]. Ehrenfeld (2004) argues that industrial ecology is being institutionalised. The growing body of academic literature on industrial ecology brings about a variety of approaches, definitions and operationalisations[2]. For instance, *Journal of Industrial Ecology* (1997) provides some key words considered to be significant within the field: 'industrial metabolism', 'dematerialisation and decarbonisation', 'life cycle planning, design and assessment', 'design for environment', 'extended producer responsibility', 'eco-industrial parks', 'product-oriented environmental policy' and 'eco-efficiency'. This diversity demonstrates the breadth of the field and its interdisciplinary character, but also the potential vagueness of what the field is actually about (Lindhqvist 2002, Johansson 2003).

Industrial ecology is suggested as a new way of thinking for reducing the environmental impact from human activities (Ehrenfeld 1995). It is spoken of as a concept, a paradigm, a strategy, a tool and a method, depending on the actor or the professional field one is based in, and the motives the actors have[3]. But in the heart of industrial ecology thinking is the ecological metaphor where ecological systems are viewed *as models* for designing and improving industrial systems (Graedel 1994, Socolow 1994, Ehrenfeld 1995, 2000a, Levine 2003,). The underlying hypothesis is that *if* the human society adopts principles in natural systems, *then* our society will become more sustainable[4].

Frosch and Gallapagous (1989) were the first to use the term 'industrial ecosystem', and also employed the metaphor as a commercial argument. If industrial activities were interconnected as industrial ecosystems in the same way as found in Nature, this would be beneficial both for the company and for society. Hence, extending the system boundaries, making production waste useful as inflows for other processes, is a key characteristic of the field. This extended system perspective is evident in the first textbook in the field, where industrial ecology is defined as

> *"…the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural and technological evolution. The concept requires that an industrial system be viewed not in isolation from its surrounding systems, but in concert with them. It is a systems view in which one seeks to optimize the total materials cycle from virgin material, to finished material, to component, to product, to obsolete product, and to ultimate disposal. Factors to be optimized include resources, energy, and capital." (Graedel and Allenby, 1995, p. 9)*[5].

The definition emphasises the system perspective, material flows, life cycle perspective and optimisation. Engineers have always been concerned with optimising industrial processes, and industrial ecologists bring in costs and material flows that previously have been overlooked due to a narrow system analytical perspective. The definition also points to the fact that understanding material and energy stocks and flows within society (industrial metabolism) and between society and nature is a basic premise for dealing with environmental problems. We consider environmental problems as changes in environmental conditions that eventually might cause *human* problems, or reduced ability to, according to Ehrenfeld (2000a, p232) "flourish forever".

It has been argued that industrial metabolism is a cornerstone within industrial ecology (Ayres 1989, Erkman 1997) [6]. The selection of topics and texts in *A Handbook of Industrial Ecology* (Ayres and Ayres 2002) confirms this strong focus, both methodologically and empirically. Thinking in terms of *industrial* metabolism does not, however, explicitly take the interrelation between the environment and society into account as it only looks at what happens *within* the society.

Similar to all academic fields, industrial ecology is also recognised by the analytical approaches and methods employed for studying the topics of interest. The *methods and tools* employed to study the stocks and flows of material and energy into, within and out of industrial systems (technosphere), provide a more practical aspect of industrial ecology. Wrisberg *et al.* (2002), Finnveden and Moberg (2005) and Brattebø et al. (2006) provide overviews of available methods. Life cycle assessments (LCA) and material flow analysis (MFA) are two methods frequently referred to as being at the core of the industrial ecology concept. This is underlined by the fact that more than half of all articles published in *Journal of Industrial Ecology* are on LCA and/or MFA.

The industrial ecology systems analytical methods are characterised by being system-oriented, building on the law of mass conservation, and having a product and life cycle focus. The intention is to provide as precise and reliable information as possible on the actual flows and environmental and human impacts for decision-making, expressed either in monetary or physical metrics. The latest methodological developments are on combining methods, for instance MFA-LCA (van der Voet et al. 2004) and LCA-IOA (Hybrid-LCA) (Strømman 2005), and the tendency is to a greater extent develop mathematical expressions based on matrixes.

Lifset and Graedel (2002) provide a broader understanding than what is covered through the industrial metabolism. They present six core elements characterising industrial ecology: i) the biological analogy, ii) the use of systems perspectives, iii) the role of technological change, iv) the role of companies, v) dematerialization and eco-efficiency and vi) forward-looking research and practice (p 4). They go beyond industrial metabolism by recognising the role of companies as key actors essential to bring about technological changes.

Moreover, they put emphasis on the prescriptive and prospective character inherent in the concept, indicating like several other authors (Ehrenfeld 2000a, Boons and Rooms 2000), that the metaphor points out ideas, potential solutions or directions towards a sustainable condition, bringing it further than the pure descriptive nature of industrial metabolism. They consider the ecological part of the industrial ecology term to be understood in at least two different senses; "industrial ecology looks to non-human "natural" ecosystems as models for industrial activity" and "industrial ecology places human activity […] in the context of the larger ecosystems that support it" (p. 4). They put less emphasis on explaining why these six elements are chosen to characterise the field and how these are interrelated.

Several scholars have paid attention to the shortcomings of industrial metabolism's ability to grasp the interrelation between nature and the environment. For instance, Kay (2002) defines industrial ecology as "the field of integrating/adapting production consumption systems into the limited ability of natural ecosystems to provide energy and absorb waste". Based on this, Kay proposes four industrial ecology design principles, by stating that the design of production-consumption systems should be such that:

1. the interface between societal systems and natural ecosystems reflects the limited ability of natural ecosystems to provide energy and absorb waste before their survival potential is significantly altered, and that the survival potential of natural ecosystems must be maintained. This is referred to as the problem of interfacing.

2. the behaviour and structure of large-scale social systems should be as similar as possible to those exhibited by natural ecosystems. This is referred to […] as the principle of bionics (in the IE literature it is often referred to as mimicry).

3. whenever feasible, the function of a component of a societal system should be carried out by a subsystem of the natural biosphere. This is referred to as using appropriate biotechnology.

4. non-renewable resources are used only as capital expenditures to bring renewable resources on line.

A somewhat similar radical understanding of industrial ecology is put forth by Ehrenfeld (1995). He operationalises industrial ecology, building on the work by Tibbs (1992), by classifying the main elements of industrial ecology into two main groups: *i) "Critical technologies and infrastructure"* and *ii) "The design of new roles and new rules"*. This is illustrated in Figure 2.1 where we have illustrated the need for balanced approaches by placing the two groups of elements on each side of a pair of scales.

The first group contains elements that industrial systems should head for in order to become more similar to natural ecosystems. The second group contains regulatory and institutional elements in order to identify new roles and new rules for the actors. A balance between these two groups is needed as designing social institutions and framing conditions which contribute to improve environmental situation is just as important as designing technical products and production systems. This again emphasizes the importance of an interdisciplinary approach to industrial ecology (Røine 2000). However, the academic focus has so far been mostly on the left side of the figure (Korhonen et al. 2004).

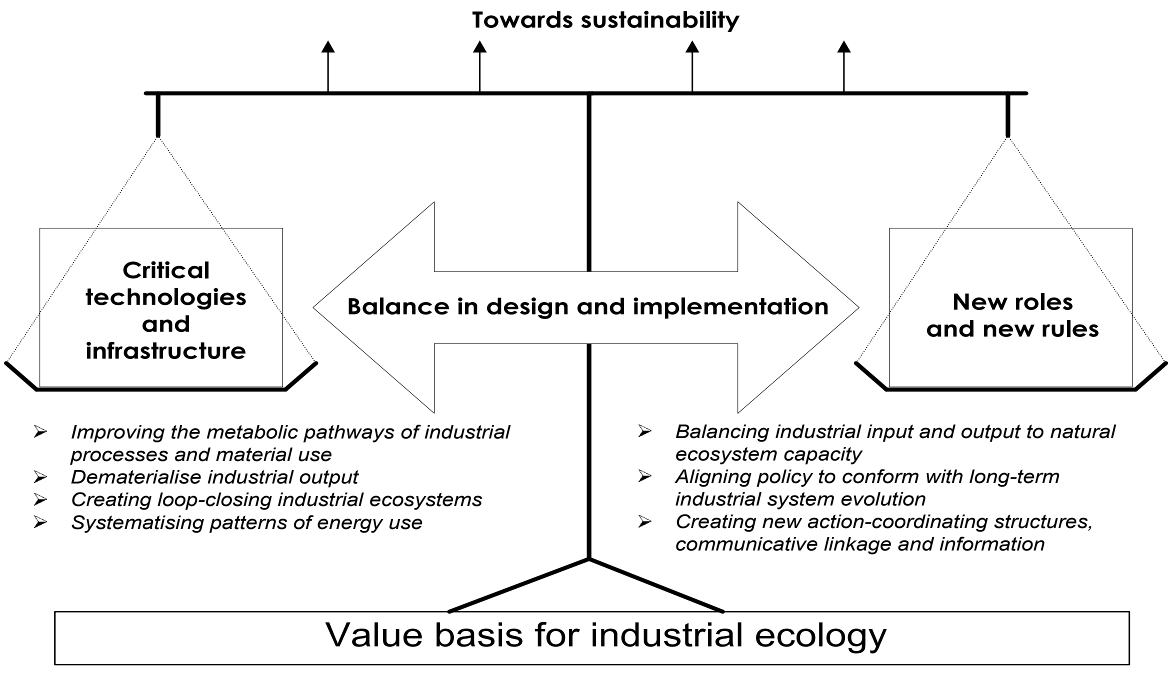


Figure 2.1 Balance between technological and institutional improvement

This categorisation invites to the discussion whether industrial ecology is normative or descriptive. Ehrenfeld (2000a) argues that it is both, and gets support on this view from Andrews 2000, Boons and Rooms 2000, Opoku 2004, Brattebø et al. 2006, to mention a few. The field is occupied with developing methods for analysing stocks and flows of materials and energy in products, process and infrastructure in order to reduce the environmental burden from these in a life cycle perspective. Ehrenfeld (2000) categorises this as the descriptive-analytical aspect of industrial ecology since it aims at bringing knowledge about past, present and future stocks and flows.

The normative part of industrial ecology is the ecological metaphor that offers *models and strategies* for carrying out needed changes, besides indicating direction of the changes. Industrial ecology is driven by the concern for the environmental impacts from human activities (Lifset and Graedel 2002). Ayres (1999) points to this direction when arguing that a future stable state may exist in which material resources are consumed and recycled efficiently and completely as in stable natural ecosystems, with exergy obtained from the only renewable source, namely the sun. A closed 'industrial ecosystem' will eliminate material wastes or convert them into raw materials and deliver immaterial services to final consumers.

van der Voet et al. (2001) understand the metaphor as basically a source for ideas, but not for normative 'shoulds' when arguing that "the metaphor can, in a technical sense, teach us useful lessons on how to arrange the processes most efficiently, how to prevent losses from cycle, what the usefulness is of certain policy measures in terms of the problems they intend to solve, how to spot problem shifting to other areas, to other environmental problems or to other time periods" (p. 2), but warns industrial ecologist to "arrange society or at least the processes related to production, consumption and waste management, based on inherent notions of a right or wrong way to do, as there is no morality in Nature" (p 2). Moreover, Isenmann (2003), Ehrenfeld (2003), Allenby (1999), Boons and Roome (2000), Johansson (2002) and Spiegelman (2003) all contribute further to this discussion on metaphors and the normative-descriptive character of industrial ecology[7].

The main focus within the field of industrial ecology has been on describing and mapping the actual, historical material flows and environmental impacts by using the methods explained above. Given that industrial ecology also is a normative guide for understanding technical systems as part of a larger industrialised society, it is an implicit consequence that transitions from current to a more sustainable state are needed. An important question in industrial ecology literature is: How do we get there? Dealing with social systems also involves the powers and factors of interacting humans, which involves an entirely new field of knowledge, namely the social sciences. Erkman (1997, p. 1) interprets the idea of industrial ecology as

> *"first to understand how industrial system works, how it is regulated, and its interaction with the biosphere; then, on the basis of what we know about ecosystems, to determine how it could be restructured to make it compatible with the way natural ecosystems function"*

Like Erkman, White (1994) indicates the need for understanding how these flows can be changed and redirected when he defines industrial ecology as

> *"the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows to the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources".*

First, White does not limit his definition to the core activities of industrial companies, but includes consumer activities as well as part of the industrial ecology system. Second, in order to comply with the prescriptive objective of transforming material flows towards an improved industrial metabolism, White explicitly goes beyond 'industrial metabolism' by including the need for understanding the *factors* that actually influence stocks and flow. How can we for instance understand the internal business mechanisms that induce environmental improvements, and the role of public policy in stimulating business to improve products and processes? White's focus on factors is implicitly supported by Ehrenfeld when he, conceptually, argues for the need for "new roles and new rules" (Ehrenfeld 1995). Thus, we might find both conceptual and empirical papers on this as well as articles on company level and sector/national level.

If you look at relevant journals, for instance *Journal of Industrial Ecology* and *Journal of Cleaner Production*, you see that there are very few articles that deal with influencing factors, both conceptually and empirically. On the conceptual side, some papers discuss, ex ante, innovation and design for environment on corporate level and EPR on the national/societal level. Empirical studies concerning influencing factors are rare, although Røine and Lee (2006) provide an empirical ex-post study that look at how EPR induce technological change and innovation on both corporate and national level, and King and Lenox (2001) provide an empirical study on the causality between financial and environmental performance.

Moreover, van der Voet et al. (1994, 1996) provide studies that employ Substance Flow Analysis (SFA) for mapping the stocks and flow of various substances (cadmium and nitrogen) and then discuss the implications for policy design and changes. These are, however, studies on aggregated national levels, and do not incorporate company studies and the (potential) policy effects on these actors. Most important is to get empirical knowledge on how various factors influence actual material flows as "macro level analysis of materials and energy flows tell us little about how to improve the efficiency of the industrial ecosystem" (Andrews 2000, p38).

Going through journals on for instance environmental policy, innovation and management reveal the fact that articles cover relevant factors but seldom connect these factors directly to industrial ecology topics such as material flows, life cycle improvements, dematerialisation and loop closing. Apparently, there is a missing link, illustrated also by the fact that *A Handbook of industrial ecology* (Ayres and Ayres 2002) includes some non-metabolic aspects of industrial ecology, without actually providing a systematic presentation of the actors and factors that influence material flows (Bohne et al. 2004).

Moreover, studies on both internal and external drivers for companies to implement industrial ecology are rare. The discrepancy between the ambitions of the field is most evident when we look at how changes and implementation in practice actually occur. Peck (2003) points out that empirical knowledge on the effects of policy instruments, both on company and national level, is imperative to avoid being naive regarding the complexity of social change processes.

Some have argued for extending the focus *from factors to actors* since actors constantly make conscious and unconscious decisions that are decisive for the actual material flows (Andrews 2000, Brattebø et al. 1999, Røine and Opoku 2000, Eik 2005). The actors, be it individuals, firms and/or governmental agencies, all have, first and foremost, their own self-interests that they seek to maximise. Thus, "[I]ndividuals are fundamentally interesting units of analysis as well as being building blocks for aggregate agents like firms and nations" (Andrews 2000, p 36). Despite this, only a few industrial ecologists have asked "what species are present and what are their roles and distinguishing feature" (ff). Moreover, recalling Ehrenfeld (1995), there is a need for *empirical knowledge* to be able to actually design new roles and rules. On the contrary, Jackson and Clift (1998) argues that "[w]ithout such theory [of agency], we will be at a loss to determine which actors should take which steps and whether the incentives are in place to encourage them to act appropriately" (p. 3).

In summing up, the literature on industrial ecology is to a large extent dominated by methodological and empirical studies on industrial metabolism, as well as on conceptual papers regarding the ecological metaphor and efforts to define the field. Less attention has been given to factors that influence this metabolism, although some studies have been done on corporate level particularly related to design for environment and on national level on the influence of policy instruments (van der Voet et al. 1994). However, these have to be complemented by empirical studies, particularly on corporate level, in order to understand the mechanisms that induce technological changes and innovation. So far, industrial ecology does not appear as a separate, established science, but rather as a young and 'immature' concept that has not entirely developed into a discipline. No strong common agreement of terminology and definitions exist, no authoritative epistemology and theory of science (Lifset and Graedel 2002). It appears rather as a collection of concepts, perspectives, strategies and tools.

2.2 Structuring industrial ecology – a three-dimensional approach

Like other scientific fields, industrial ecology is through theories, models, methods and analysis producing knowledge to better understand the real world (Boons and Rooms 2000). The actors and structures in the real world represent forces and factors influencing the paths of the materials and energy through design and implementation of policies (authorities) and strategies (firms and consumers). Industrial ecology provides ideas and inspiration to improve industrial practice related to sustainability. Figure 2.2 below illustrates these two realms[8].

There are, however, still deficiencies in the existing theoretical frameworks that can be applied for developing the analytical framework for studying the 'real world' in this thesis (ref. Figure 2.2). The main problem is the limited focus on how to carry out changes, what actors might be significant in this (Andrews 2000) and the apparent distance between the ambitions of the field and the actual results (O'Rourke et al. 1997). To cope with this, we propose a 3-dimensional structure of the field: i) resource perspective, ii) networks of actors' perspective and iii) systems perspective.

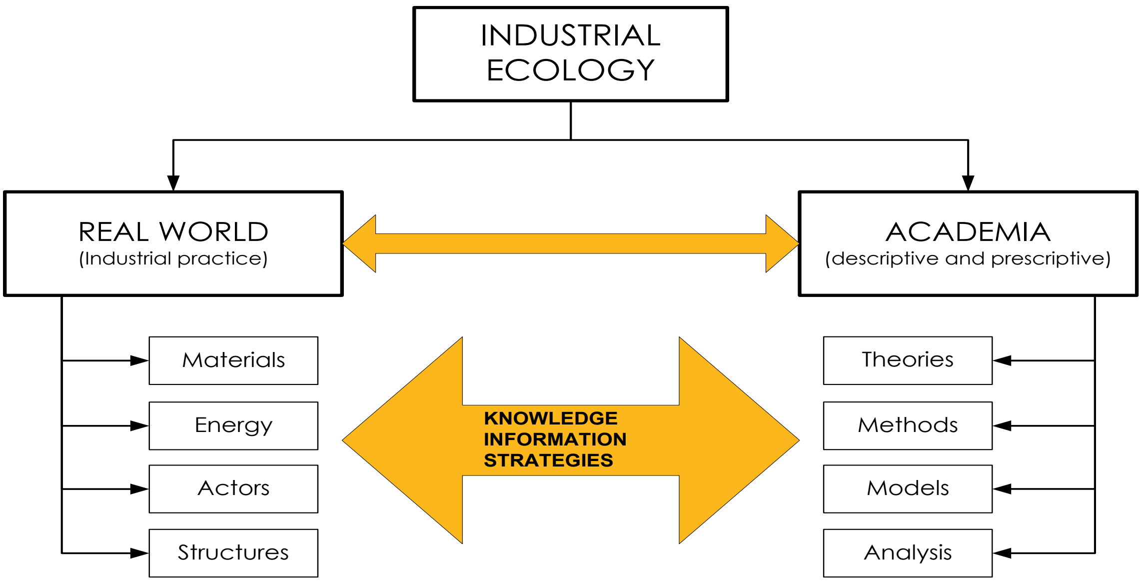


Figure 2.2 Two realms of industrial ecology

First, understanding the stocks and flows of material and energy is a core element of industrial ecology. This might not be limited to flows within society, but should preferably also include the flows of material and energy from nature to society and back again. Moreover, the role of the industrial ecology metaphor is not yet precisely understood and investigated. Based on Lifset and Graedel (2002), Kay (2002) and Ehrenfeld (1995, 2004), among others, we develop the *resource perspective* as fundamental within industrial ecology. This perspective distinguishes between the interface aspect and the mimicry aspect.

Second, studies on material flows and environmental impacts usually leave the actors as 'black boxes'. The processes within the black box remain unknown. As pointed out by Andrews (2000) and Jackson and Clift (1998) it is the individuals (as private individuals or as representing firms, governmental institutions etc.) that actually make decisions. Similar to ecological systems, there are networks of actors within industrial systems that are interconnected in webs of interests and dependencies (Ehrenfeld 2004). In order to understand the underlying mechanisms that cause the actual material flows, we propose the *networks of actors' perspective* to be a significant dimension of industrial ecology. In order to understand the mechanisms of change, we need to look into the single actors and their networks. We also need to look into both internal and external factors (drivers and barriers) for the companies, which influence the 'space of action' for the actors.

Third, the *systems perspective* is argued to be a core characteristic of industrial ecology and appears as both a physical and an analytical extension of systems boundaries (Brattebø 1995, van der Voet 1996, Erkman 1997). Firstly, the systems perspective is materialised through physical interconnecting solutions for material and energy flows that go beyond the traditional processing plant towards industrial eco-parks such as Kalundborg (Frosch and Gallapagous 1989, Ehrenfeld and Gertler 1997, Ehrenfeld and Chertow 2001). This physical dimension of the systems perspective is covered by the resource perspective. Secondly, the systems perspective has an analytical dimension by extending the systems boundaries in time and space as well as in relation to the number of actors and factors included in the analyses. We will now look into these three perspectives.

2.3 The resource perspective

As seen in Figure 2.1, Ehrenfeld's four elements within the category 'Critical technologies and infrastructure' raise some questions: How do these elements actually relate to each other and can each of them, for instance dematerialisation, be deduced from the metaphor? In order to grasp the content of the resource perspective, we distinguish between the interface aspect and the mimicry aspect.

2.3.1 The interface aspect

There are continuous interactions between the environment and industrial economic systems[9] due to the fact that human activities are inevitably based on use and consumption of natural resources[10]. Industrial economic systems are subsystems to ecological systems.

Natural resources are extracted from the environment, brought into the industrial economic systems, processed into useful qualities and concentrations, ending up as products or energy carriers. As illustrated in Figure 2.3, the inflows are currently larger than the outflows, giving accumulation of materials in society. Moreover, the stocks and throughput in the industrial economic systems have increased considerably over the centuries and particularly the last decades. According to the law of mass conservation[11], however, the historical input must sooner or later leave the global economic systems and enter the environment again, and larger outflows are thus expected in the future, see Figure 2.4. The flow of materials from the environment to the industrial economic systems and back to nature again can be regarded as the 'big loop'.

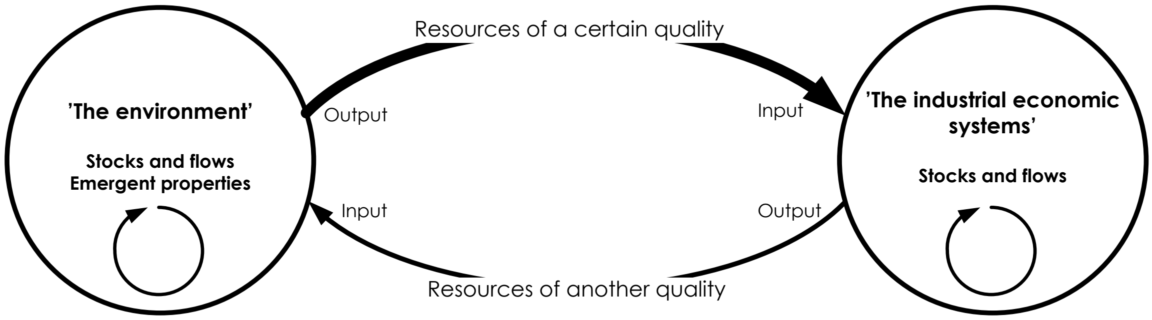


Figure 2.3 Relation between environment and the industrial economic systems.

Figure 2.4 shows three situations ('past', 'now' and 'future') all with larger inflows than outflows, which provide addition to stocks (accumulation). If inflows equal outflows there is a steady state situation. Estimating future outflows provides knowledge for designing public policies to cope with these[12].

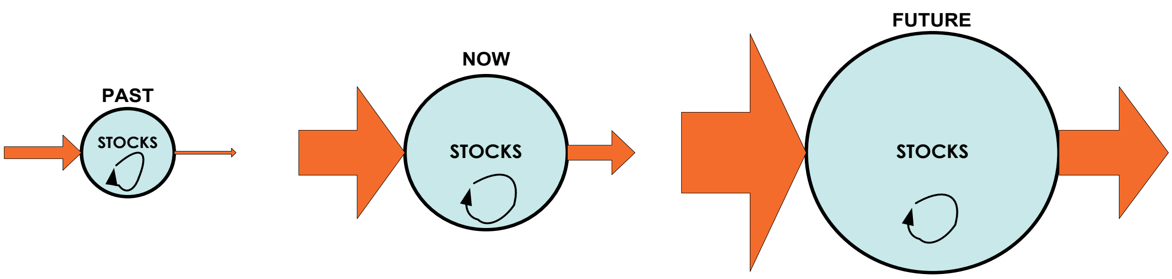


Figure 2.4 Size of inflows, stocks and outflows from industrial economic systems in a historic perspective

The environmental consequences of human activities depend to a large extent on type and quantity of resources used, and in what quantity and quality the materials re-enter the environment. We distinguish between three different types of resources:

1. *The renewable resources that are input to society.* Examples of renewable resources are the sun, wind, forests and fish. Renewable resources are those that can repeat themselves, reproduce or propagate. Proper management of these resources means that the consumption must not exceed the interests of nature capital in the actual region.

2. *The non-renewable resources that are input to society.* Examples of these are fossil fuels and inorganic material[13]. Good management of these resources means that the consumption must be evaluated in relation to the total amount available and the degree of substitution of renewable resources covering the same function.

3. *The emergent properties in Nature that are influenced by extraction to and emissions from society.* Local and global eco-systems are examples of these resources. Good management of these means that extractions (e.g. deforestation in the Amazons) and emissions should be on a level that eco-systems can handle within their buffering capacities so that their emergent properties are not permanently disturbed. The buffering capacity is that systems can sustain external influences up to a certain point, and if this point is exceeded, the system will change dramatically or even collapse[14].

Based on this categorisation of resources and keeping in mind that there are physical limits to the possible growth in industrial economies (Boulding 1966, Georgescu-Rougen 1971, Daly 1991), the environmental consequences of the interactions can be reduced by looking at i) the resource input to society and ii) the harm of the outflows from society.

Reduced resource input may have three primary effects; i) less disturbance to the eco-systems, ii) less material throughput requires less energy and iii) reduced inputs result in reduced outputs. As for the outflows, these might cause harm primarily because of two reasons. First, industrial economic systems manufacture artificial compounds that are not present in Nature (e.g. certain petrochemicals, chlor fluorine carbones (CFCs)), and with no decomposition properties these will accumulate and eventually disturb eco-systems and their emergent properties. Second, society emits compounds that are present in Nature (for instance CO_2) but in such a large quantity that these will disturb the natural processes[15].

As noted by Lifset and Graedel (2002), the 'ecology'-part of industrial ecology may have two meanings. Their point on industrial economic systems being subsystems to the ecological systems is covered above and we denote it the *interface aspect*. Two groups constitute the interface aspect: i) reducing resource input and ii) changing towards less harmful flows. Reducing resource input in material terms is about dematerialisation, while in energy terms this is about energy conservation and conversion efficiency.

Changing towards less harmful flows is correspondingly about transmaterialisation and decarbonisation. Table 2.1 below summarises this. We will here only discuss the issues relevant for this thesis, and hence, we will not discuss the energy issues.

Table 2.1 The interface aspect

	Material	**Energy**
Reducing resource input	Dematerialisation	Energy conservation and conversion efficiency
Changing towards less harmful flows	Transmaterialisation	Decarbonisation

2.3.1.1 Reduce resource inputs

Dematerialisation is a key element in the industrial ecology concept and has been a continuous topic in the literature[16]. Dematerialisation is primarily measured on the input side to an industrial system, and is a quantitative measure of the material flows, not taking into account the environmental impacts of these flows[17]. Dematerialisation is defined as "the absolute and relative reduction in the quantity of materials used and/or the quantity of waste generated in the production of an economic unit" (Cleveland and Ruth 1998, p. 16).

Dematerialisation can be explained on different levels and scales. For illustrative purposes we employ national level and company level in order to distinguish between the level of common goods (national) and private goods (company). This distinction is important for understanding the different roles of the actors and consequently the different strategies they accomplish. Further, we distinguish between absolute scale and specific scale. On the absolute scale we measure the total material input to for instance a company, a country or the Earth, during a certain period of time, for instance a year. On the contrary, in the specific scale the material flow is not only related to the time period but also to the economic performance or the product specification. Table 2.2 sums up different indicators that can be employed for measuring dematerialisation along the lines of scale and level.

On national level total material requirement (TMR) is the overall quantitative indicator. TMR is the total domestic extraction and import into the system (e.g. a nation) as well as the hidden flows, and is measured on a weight-basis [kg/yr]. It should be noted that indicators on absolute scale is the basis for developing indicators on specific scale. MFA is the collective term for the tools available for measuring the material flows at absolute scale (Brunner and Rechberger 2003).

On the specific scale, the numbers from the absolute scale are employed for relating this to, for instance, economic performance or number of products. A number of indicators can be developed based on this, depending on what kind of information that is requested.

A common quantitative indicator on national level is *decoupling*, which expresses the relation between the environmental and the economic performance, e.g. material input and the gross domestic product (GDP). Measuring this during several years will provide a picture of the material requirements for the actual level of economic activity. If a de-coupling can be observed, this is an indication of relative improvement in environmental performance. If GDP is measured per capita, the indicator can be compared with other nations.

Table 2.2 Dematerialisation along various levels and scales

	Absolute scale	**Specific scale**
National level	Total material requirement [kg/yr]	De-coupling [€/kg], material poductivity [GDP/TMR] or material intensity [kg/€]
Company level	Total resource use [kg/yr]	Material Input pr Service [kg/€] or Eco-efficiency [€/kg]

Eco-efficiency is a frequently employed term, both as a strategy and as an indicator, for expressing the relation between the value creation and the corresponding environmental influence[18]. It expresses the same on the company and product level as de-coupling does on the national level. As an indicator, eco-efficiency can only be measured on the specific scale. This is frequently raised as a criticism of eco-efficiency (Ehrenfeld 1997a, 2000). The purpose of eco-efficiency is very simple – to maximise value creation and minimise environmental burdens.

Business strategies for obtaining dematerialisation include reducing the weight of products, which provides reduced extraction of materials and reduced energy consumption during transportation from final producer to wholesalers.

Further, increased use of recycled material will reduce the gross extraction of virgin material. Whether the net extraction of virgin material will also be reduced depends on the material consumption for carrying out the recycling processes. Redesign of the products and restructuring of the market for these products, for instance leasing instead of selling, are suggested as promising strategies for dematerialisation (Stahel 1994). There is, however, a lack of empirical evidence that such dematerialisation actually takes place.

2.3.1.2 Change towards less harmful outflows

The industrial society manufactures compounds that are not present in nature. The ecosystems do not have natural processes to take care of the emissions of these compounds which may cause harm to both environmental and human health. CFCs and dioxins are examples of such compounds. In this context, transmaterialisation is an important concept as "industries continually replace old materials with newer, technologically more advanced material" (Labys 2002, p. 204). This is the familiar path of industrial innovation, but from the environmental point of view, the demand to be fulfilled is not only related to functionality in use phase, but also the environmental impact throughout the life cycle. A general trend for instance, is the relative increase in plastics consumption as compared to other materials such as steel.

There are thousands of *types of materials* employed in the society with different characteristics. The field of industrial ecology contributes to find balanced choices between a dematerialisation strategy and a transmaterialisation strategy. Dematerialization implies that a reduction of the environmental pressure should be accomplished by a reduction of the flow of materials on weight basis. An improvement might also be accomplished by a transmaterialisation, a substitution of materials with less environmental burden for harmful and/or scarce materials, for instance aluminium substituting for copper.

2.3.2 The mimicry aspect of industrial ecology

Lifset and Graedel's (2002) second point, that ecological systems are models for industrial economic systems, is about the industrial ecology analogy and metaphor. We will call it the *mimicry aspect*. The mimicry aspect helps to identify similarities and differences between industrial and natural systems, which might stimulate new ideas for how to improve industrial economic systems.

The similarities, for instance the fact that there are stocks and flows of energy and material in both ecological systems and industrial systems, constitute the *ecological analogy*. The differences clear the way for developing the *ecological metaphor* (Ehrenfeld 2003). The current differences between practice in industrial systems and what is found in natural systems, for example loop closing, use of renewable energy, design of robust systems with resilience, become inspirations for actors to head towards.

The mimicry aspect does not take into account the size of the actual material flows, the environmental consequences of these, the physical limits of the Earth to support human activities nor the sink-capacities of the eco-systems, and is thus decoupled from the actual interactions in real world. The mimicry aspect is a realm of *potential* solutions that must be scrutinized in a real world context. Several scholars argue that this aspect is very powerful for achieving sustainability (Ehrenfeld 2004). The interface aspect, however, takes these actual connections and mutuality between the society and the environment into account and represents to a large extent what Ehrenfeld (2000a) calls "descriptive and analytic", while the mimicry aspect is "paradigmatic, normative and metaphorical" (p. 229)[19]. There are several elements within the present industrial ecology concept that cannot be explained through this metaphoric and analogical perspective.

For example, dematerialisation is indeed part of the industrial ecology perspective, but it cannot be derived from natural ecological systems. Dematerialisation does not exist in natural systems. On the contrary, industrial systems' dematerialisation can exist also in absolute terms. Less material can be extracted from the environment to the technosphere, making this a dematerialised system. The reason is that industrial economic systems are subsystems to the ecological systems.

A number of properties and characteristics of ecological systems might stimulate actors within industrial economic systems to be creative and come up with ideas and solutions for how to improve the environmental performance. For instance, as noted by Ehrenfeld: 'I believe that the power of the concept of industrial ecology lies in its normative context and in its potential to shape paradigmatic thinking. It is normative in the sense that the above-mentioned three features of the ecological metaphor – community, connectedness, and cooperation – are characteristics we should strive for in designing our worlds. We ought to become more like an ecological community.' (Ehrenfeld 2000, p. 238)

Exploring the metaphorical power within the mimicry aspect is important to bring the field forward. For instance, employing renewable energy resources is part of this mimicry aspect as natural systems are entirely driven by this type of energy source. We will here however, limit ourselves to present the characteristic of ecological systems that are frequently mentioned in the field and that are relevant in this thesis; degradable waste and closed cycles.

2.3.2.1 Degradable waste and closed cycles

There are two types of loops which are important to look at: i) process loops and ii) product loops. A product loop can be closed in basically two ways, by using recycled material or components in the same product system (closed loop recycling) or by using recycled material or components in another product system (open loop recycling). A process loop can be closed if waste flows from production are integrated into the same production or if the waste flow is utilised as input to another production process, as in Kalundborg (Ehrenfeld and Gertler 1997). The basic idea of a loop is that the material is not emitted to the environment and hence being unavailable for future use.

A completely closed production system, with respect to both matter and energy, is impossible, due to physical and chemical laws. This opens for a new type of closed process loop strategy, namely so-called industrial eco-parks, clusters and industrial symbiosis networks and clusters. The key point here is that matter and energy that inevitably becomes waste in one production plant might be useful for other companies/production plants; either geographically close by or far away.

The main difference between closing the process loops in *one* production plant and closing process loops in an eco-park, is that the latter consists of more units, usually several legally independent firms, and that it is geographically more extended. The industrial symbiosis in Kalundborg Municipality in Denmark is a frequently quoted example of an eco-park where waste flows of matter and energy are exchanged between firms instead of emitting these resources directly into the air, water or soil. This feature, the interconnectedness of flows, is a fundamental characteristic of ecological systems, and should therefore be encouraged in other industrial systems as well. There is obviously a close connection between different companies in value chains, but what is more uncommon is the interconnection between firms that are not in the same value chain, but that nevertheless can potentially interchange process waste.

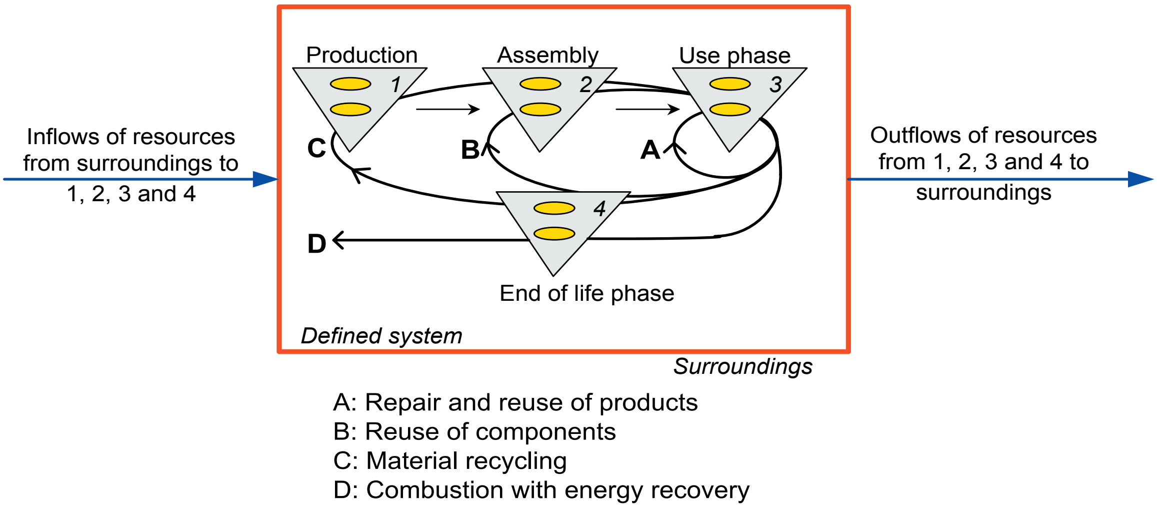


Figure 2.5 Recovery options for closing the product loop

A product's life cycle consists of several processes and moving towards product loop closing means that one sequence is added at the end-of-life (EoL) phase, so that the material is processed instead of emitted into the environment. This process, like every other process, demands energy, and there is always a trade-off between the gains of carrying out the recycling process and the loss due to actual input of energy. Talking about actually closing the product loop means focus on the end-of-life phase.

There are several strategies that can be employed for obtaining this. Figure 2.5 identifies four options: reuse of products and repair; reuse of components; material recycling and energy recovery. In the given consecutive way, this is referred to as the waste hierarchy. In reality, there is a mix of these options. All these strategies show that it is possible to utilise the materials and resources once extracted from the Earth and imported to the industrial economic systems.

Waste prevention is also an option to reduce the environmental impact from the EoL phase. Although the actual closing of the product loop happens in post-use phase, actions can be taken earlier in the product's life cycle to prepare for recycling and recovery. Through design for recovery, including for instance choice of material, packaging solutions, dismantling and transportation method, upstream companies can make it easier for those companies actually carrying out the recovery in post-use phase. Differently from closing process loops, however, the companies may not have the incentives for doing this (Frosch 1994). Extended producer responsibility is a policy that provides better incentives for these recovery options for closing the product loop.

If recycled plastic packaging waste in Norway is employed in other types of products, there is an open loop and the material is transferred to another product system. If employed within the same product system there is a closed loop. The differences between process loops, product loops and product systems loops are shown in Figure 2.6.

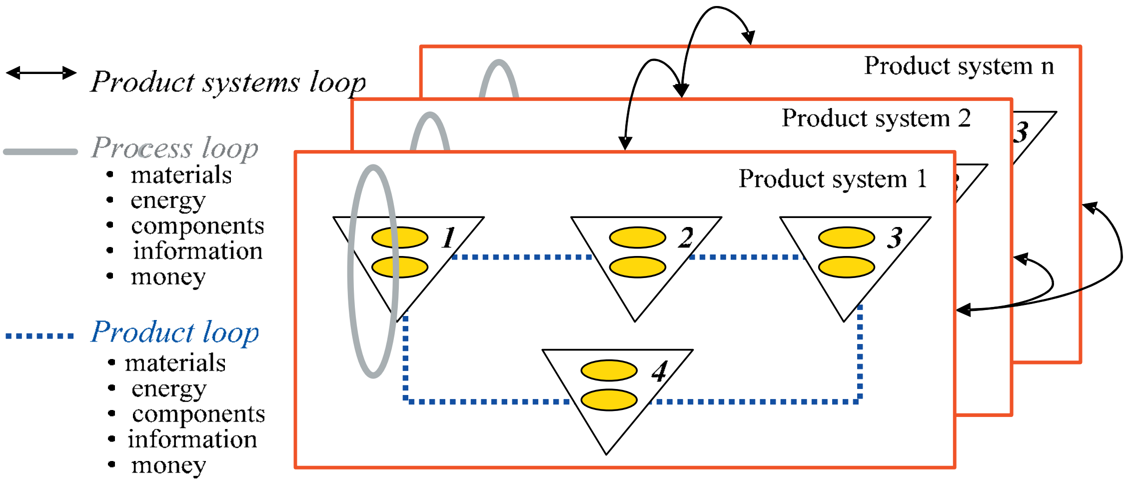


Figure 2.6 The interconnections within and between different product systems

Loop closing is about utilising the resources as much as possible once they are imported to the economy. Keeping the materials available within the system as long as possible is both energy- and material-demanding, and hence there is again, also a trade-off between the gain of keeping the material within the system and the cost of using energy and resources to do this.

Reuse, recycling, and energy recovery avoid materials and products to end directly at disposal sites and minimise loss of materials to environment. As for recycling, this has both a quantitative and qualitative aspect. The quantitative efficiency expresses the relation between material input to and output from the waste management system. The qualitative aspect has two characteristics; the actual quality of the recycled material (for instance compared to virgin material) and the material quality requirements in the product it is used.

2.4 The networks of actors' perspective

The promising ideas of industrial ecology must be translated into daily practice in society, in politics, in industrial strategies and practice and in consumer behaviour, if noticeable changes and improvements are to actually come about. In this process, the industrial sector has a significant role to play, as the term itself indicates. The reason is mainly twofold: companies contribute considerably to the environmental impact and at the same time they have the knowledge, capacity and power to come up with new, more efficient and improved *technical* solutions for environmental improvement. However, a firm's ability to make improvements depends also on other actors and boundary conditions. Thus, the key question still remains: Does industrial ecology bring any substantial new solutions for reducing the 'concerns about human impact on the biophysical environment' (Lifset and Graedel 2002, p 10)?

The normative and goal-oriented aspects of industrial ecology as presented above, imply that studying and understanding social and industrial transformation and change on macro level, as well as how the single actors are involved in the flows on micro level must be an explicit part of the field (Andrews 2000, Jackson and Clift 1998). The metaphor provides inspiration on *what* to implement, but less on *how* to implement it and *who* should be responsible for and involved in the implementation. Once accepting that industrial ecology has a normative aspect, the field, thus, turns to be not merely a descriptive-analytical exercise (Ehrenfeld 2000a). This includes knowledge on innovation, on product, process, product system and national levels, on consumption patterns and consumer behaviours, on dynamics of public policies and industrial behaviour, on how various actors actually act within various political regimes, and on how to design robust political frameworks that promote industrial ecology practice within the networks of actors. The individual actors (or companies as group of individuals) make decisions that might (or might not) alter the structures. By taking actors as starting point and elaborating on their actions and the structures (factors) they consequently constitute, we denote this part of the industrial ecology concept as the *networks of actors' perspective*. This derives from the interconnectedness found in Nature between different actors (Ehrenfeld 2000a).

We will employ Giddens structuration theory (Giddens 1979, 1984) as the theoretical basis for understanding how actors influence and are influenced by external and internal structures such as for instance public policies and organisational culture. Giddens combines a subjective and objective approach saying that structure is the basis for individual actions and that individual agents confirm existing structures or produce new ones through action[20]. Structure and action are thus, two integrated notions contributing to dynamics and changes. Giddens does not look at structures as given, external, over-individual and physical facts that determine human action. Giddens shows that apparently fixed structures are continuously produced and reproduced through human actions, and at the same time these structures are the starting point for further action. Thus, structures are both the medium for and the result of action[21].

The structuration theory recognizes that human actions are enabled and constrained by structures and that these structures are the cumulative history of previous actions. The structure is either reproduced (stays unchanged) or produced (altered) through action. "Structuration theory focuses on the dynamics by which structures are reproduced or altered" (Barley and Tolbert 1997, p. 112). According to Giddens, the structuration consists of three structural dimensions; signification, domination and legitimation. These three dimensions are always present, but the *content* of them will change as a result of action. To these areas belong so-called modalities, which one can describe as the means of interactions. This can be seen from Figure 2.7 below.

Dimension	Signification	Domination	Legitimation
Modality	Interpretive scheme	Facilities	Norms
Action	Communication	Power	Sanctions

Figure 2.7 Giddens' structuration theory

'Signification' relates to knowledge and shared cognitive understanding of an individual, company or society. It is concerned about *what* we understand as important and includes our basic values and beliefs. The modality is interpretative schemes, and the process of human interaction is communication. 'Domination' represents facilities like authoritative and allocative resources. Authorative resources are extended over people, while allocative resources are extended over objects or material phenomena. The actors are able to deploy power due to these resources. Finally, 'legitimation' concerns the norms and rules that individuals draw on in justifying their own actions and that of others. Summing up, structural properties of a social system consist of rules and resources that actors draw on in their everyday interaction.

Giddens strongly emphasises the reflexive and knowledgeable actors and that their interactions are results of their reflexive processes. Reflexivity is based on the properties of the human being(s) in question and its inner will, values and basic assumptions, captured in 'signification'. As noted by Ehrenfeld (2000b) 'Giddens theorises that such visions and values create the tools and power relationships that in turn reinforce and further embed those visions and values in the cultural underpinnings of routine actions'(p. 200) For instance, the concept of industrial ecology might influence the actors' organisation culture at various levels as illustrated in Figure 2.8 below, and the underlying understanding on abstract level is decisive for what happens on the practical level[22]

Giddens is criticized for putting too much emphasis on the knowledgeable actor, and less on the significance of external, slow and causal functioning structures (Guneriussen 1999). The criticism is based on the fact that the actor does not have full information on the consequences of their actions. This is particularly relevant in an environmental perspective where the consequences of a human activity often are unintended. Moreover, although knowledgeable, the actors' space of action is also limited by the structures.

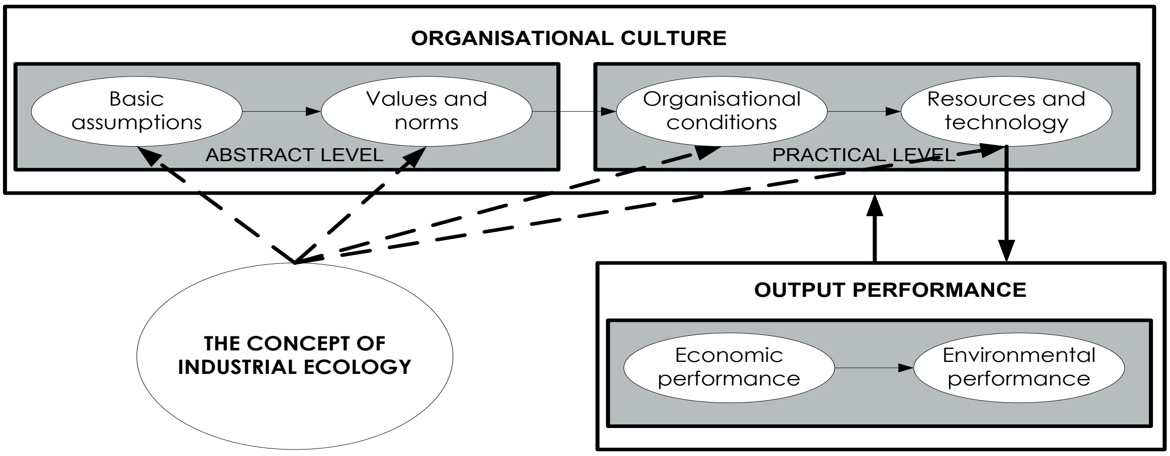


Figure 2.8 Different analytical levels in a random organisational culture as seen from an industrial ecology perspective

Why is Giddens' structuration theory selected as the one applied in studying industrial ecology systems? First, Giddens incorporates the dynamics on how systems change in the structuration theory. Second, combining actors and structures emphasises the dualism of structure, which seems particularly relevant for EPR since this is typical (political) structure acting towards companies (actors), who must relate and reflect on how this structure should be taken into account in their own business strategies. Finally, the structuration theory is combining a positivistic and a hermeneutic approach, or a natural science and a social science approach, which is valuable as seen from the concept of industrial ecology.

This networks of actors' perspective enhance the third element of White's definition (White 1994) by strongly emphasising the role and self-interest of single actors and organisations and the mutual interaction and interdependence between various actors. The networks of actors' perspective also indicates that the solutions to obtain good results lie in the cooperation with others. That said, we take as a premise that individuals and companies are acting to optimise their self-interests, and that altruism is non-existent. However, they are indeed bound to take into account the present structures and boundary conditions. We therefore develop this perspective further by looking into the actual actors present in industrial systems, and their intentions, visions, potential for improvements and roles.

2.4.1 The actors

We distinguish between four different types of actors: authorities, industry, consumers and civil society, as shown in Figure 2.9 below[23]. The authorities and civil society are primarily suppliers of premises, while the interactions between and within 'consumers' and 'industry' primarily constitute the market. According to Giddens' structuration theory, the decisions and actions taken by the actors are to a large extent determined by the dynamics between the actors and their own preferences and resources.

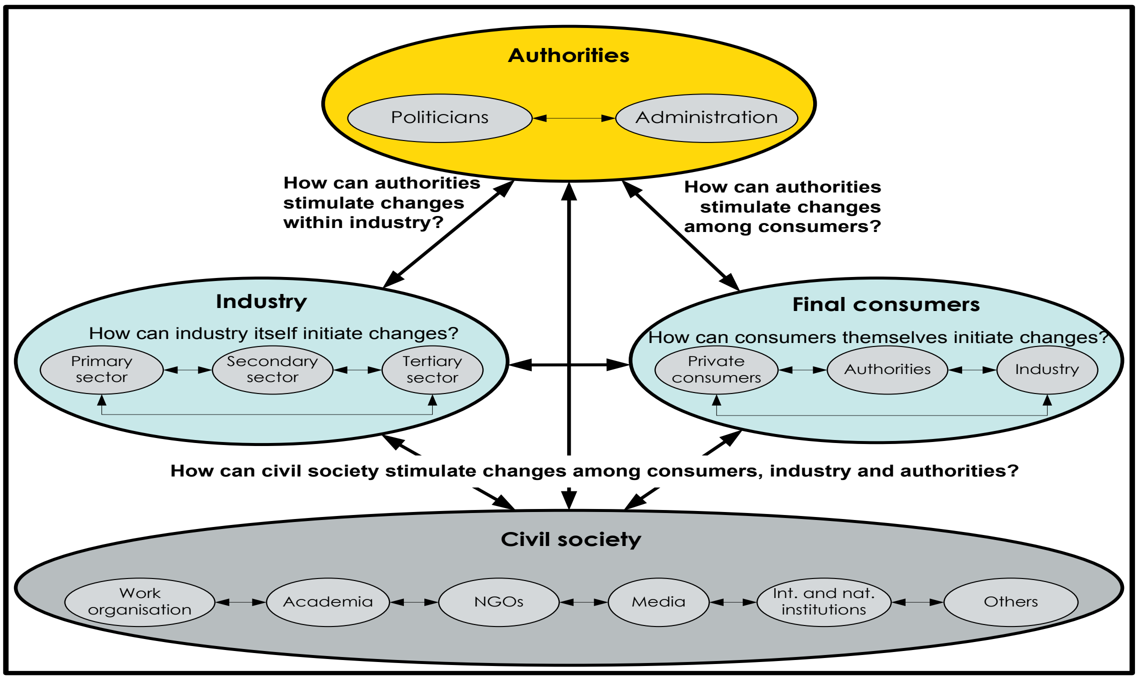


Figure 2.9 Interaction between various groups of actors

We will characterise these actors through the role or type of (self-) interest they actually have, and through the measures, instruments and power they possess in order to fulfil their role and ensure their interests.

2.4.1.1 The authorities

The role of the authorities is to ensure that the resources and values in society are sustained and developed to the best for its citizens (Vedung 1998). The measures are a large body of strategies and instruments ranging from local to regional, national and international arena and from regulatory to economic and informative instruments in order to stimulate technological innovation, behaviour changes and actual reduction in emissions. Moreover, the policy style may alter between countries. For instance, Japanese and European policy makers are more likely to sign 'negotiated agreements' with industry associations and or individual firms, under which the industry agrees to meet certain negotiated environmental goals with the expectation that if the goals are met then legislative requirements will not be imposed. "Public policy instruments are the set of techniques by which governmental authorities wield their power in attempting to ensure support and effect social change" (Vedung 1998, p. 3)

Policies are most commonly designed so that actors only have one commitment in one phase of the life cycle, see upper left box in Figure 2.10. This is the case with for instance emission permits from production plants. Some EPR policies however, include more than one commitment in several phases of the life cycle. For instance voluntary agreements on packaging in Norway have quantitative targets on both material recycling and energy recovery in the end-of-life phase, as well as a non-quantified commitment in the production phase related to waste reduction.

Moreover, the EU Directives (EU 2003a, b) for electrical and electronic (EE) products illustrate a third group of policies where an actor has several commitments (ban of certain substances and recycling commitments) in several phases (production phase and EoL-phase) constituted by several policies ('Restrictions of the Use of Certain Hazardous Substances' (RoHS) and 'Waste electrical and electronic equipment' (WEEE)). Finally, the actors inevitably face commitments from a portfolio of policies in the life cycle phase they are operating within, for instance both environmental and non-environmental regulations.

	One policy	**Portfolio of policies**
One phase	One commitment in one phase	Several commitments in one phase
Multiple phases	Commitment in several phases	Several commitments in several phases

Figure 2.10 Relation between policies and phases

The authorities in Figure 2.9 are separated into two sub-groups; politicians and administration. Ideally, the politicians are passing laws, setting taxes and regulations, while the administration is preparing for these actions as well as doing follow-up work. Moreover, further disaggregation might be done between various departments of authorities, for instance Ministry of Environment, Ministry of Finance and Ministry of Commerce and Trade. These ministries all have various interests and objectives to take into account, which is implemented through their measures and policies. In total, a firm or a consumer is influenced by all these policies constituting a portfolio of policies (Christiansen 2002, Vedung 1998). Within industrial ecology this can be considered as integrated product policy. Authorities might design policies that aim at stimulating consumers (the markets) and the industry (the supply). Thus, on this level as well there are networks of actors.

Within industrial ecology literature, several argue that extended producer responsibility is a key policy, particularly because it creates loop closing mechanisms. Economic instruments might be equally well suited for inducing industrial ecology practice, for instance recycling and loop closing. Hence, there is no particular industrial ecology policy, but rather policies that to a greater or smaller extent contribute to implement industrial ecology thinking as presented in the resource perspective. Evaluating the effectiveness of an EPR policy however, requires a broader understanding of the causal mechanisms that actually provide the observable outcome. Inevitably, other policies than EPR constitute the total package of policy instruments influence and the outcome as well, in addition to non-policy factors such as market competition and consumer behaviour.

Given the ambitious normative objectives inherent in the industrial ecology concept and that public policies constitute a significant factor for meeting these objectives, it is important to be aware of the fact that solutions to environmental problems cannot be more radical than the boundary conditions allow. Radical innovation requires radical policy frameworks. National and international regulatory bodies are occupied with establishing environmental regimes that, on an absolute level, produce desired results, for instance certain recycling ratios. Obviously, these regulatory bodies are just frameworks and the actual changes have to appear as a result of changes and improvements within companies, consumers and so on.

2.4.1.2 The industry

Industrial actors have great power to influence both the environmental properties of a product and consumer patterns in society[24]. 'The industry' captures all commercial firms that produce goods, materials, products and services for industrial and private consumers. We distinguish between primary, secondary and tertiary sectors between which there are interactions, and changes in supply and demand within each sector will affect the other sectors as well.

The primary objective of firms is to survive in a long-term perspective by making profit for their owners. There are a number of strategies to achieve this, depending on the sector, product and other framing conditions in question. The requirements for profits and competitive power are decisive for company choices, making it difficult to implement technological solutions that directly conflict with financial considerations. Socio-economic and environmentally advantageous solutions frequently are not realized because they are not sufficiently interesting when it comes to commercial interests. However, investments with environmental improvements may also be financially profitable in the short term (the win-win situation) (Porter and van der Linde 1995, Brattebø 1995, Hagen et al. 1998). Moreover, companies may prioritise long-term competitive power with environmental aspects as one competitive factor.

In the prolongation of this argument, we might distinguish between those companies whose product or function in itself contributes to environmental improvements (e.g. windmill energy producers) and those companies being within environmentally unfriendly sectors (e.g. oil industry) but that improve their processes to reduce emissions and environmental impacts thereof. Being green might be profitable for companies in both categories (King and Lenox 2001). "Empirical research shows that superior environmental performance and superior financial performance are positively intertwined" (Lyon and Maxwell 2004) Voluntary environmental protection appears to make good business sense.

Independent of which category the company is within, technological change, innovation and business development are central premises for improving their competitiveness and consequently environmental performance. The point of entry for most businesses is not primarily environmental concerns, but rather opportunities for making profits. Knowledgeable business actors know however, that low resource productivity increases their costs, while poor environmental performance may affect their reputation. For instance, the waste hierarchy as a national strategy are less important than financial arguments when companies are to make decisions whether to recycle or deposit. In order to capture these elements in the decision making process, the regulatory frameworks, the innovation environment and the tax system, to mention just some, have to stimulate decisions in line with industrial ecology thinking. Hence, authorities (through legislation and regulation), consumers (through being the market) and civil society (through persuading the market) are all influencing the industry. This emphases the significance of 'the networks of actors'.

Technological change is the outcome of an innovation process providing different ways of fulfilling existing or new functions or needs in society. It has been suggested that the overall innovation process is constituted by four interwoven and dynamically interplaying sections (Grübler 1998; Christiansen 2002). This applies to both product innovation and process innovation. During *invention* and *innovation* the key task is to go from an idea (invention) to the realisation of a product or process (innovation). In these two sections, the innovators face mainly technological and financial challenges, and for instance Design for environment (DfE) might be employed as a methodological approach to the innovation phase.

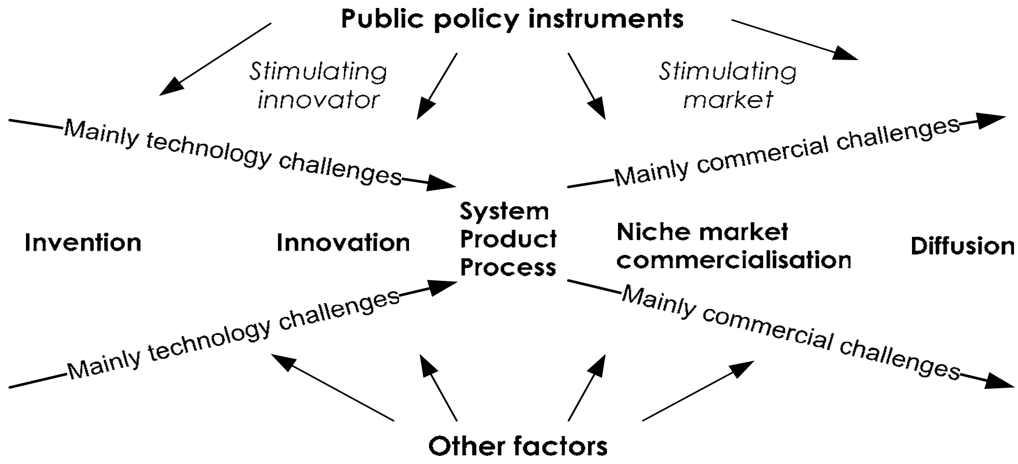


Figure 2.11 Innovation process and stimulating factors in various innovation phases

However, in order to actually reduce emissions on aggregate (national) level, these improvements must penetrate the market. Thus, equally important as product improvement and design for environment, is the extent of diffusion of new technology. Therefore, *niche market commercialisation* and *diffusion* are important to spread new technologies to the market, making these two sections mainly a business and marketing challenge. As argued by Smith (2004), what matters most for successful innovation is not so much the link with basic science, big public laboratories and universities, but close interaction with users (demand), suppliers and competitors.

Hence, it is not the development of technology that is the problem concerning environmental issues, but the implementation and diffusion of it. As shown in Figure 2.11, policy instruments must be directed towards all the four phases of the innovation process, usually through consumers to stimulate market pull and consequently diffusion, and directly towards companies to stimulate invention and innovation. The technological knowledge on how to design and construct a windmill is only one side of the coin. Knowing how to implement this, what is commercially, politically and socially possible, is equally important. That said, as noted by Fagerhaug et al. (2004), 'to understand innovation dynamics it is not sufficient to focus on interaction with external partners, the resources available, innovation output etc. It is also necessary to take into account what goes on within firms, such as strategic choices, the extent to which it manages to benefit from new ideas ('openness'), what it does to encourage the development of new ideas etc.' Getting into the internal company-specific processes is, thus, equally important for understanding the effects of various factors, for instance public policies.

However, although diffusion appears in the market, the potential of environmental improvements depends on the type of innovation. Figure 2.12, a modification of Stevels (1999), shows that the incremental changes and redesign of products do not have the greatest potential to contribute to significant environmental improvement, while functional innovation and system innovation do have the potential to do so. It should be noted that the figure is just illustrative and the scales are not reflecting a real situation.

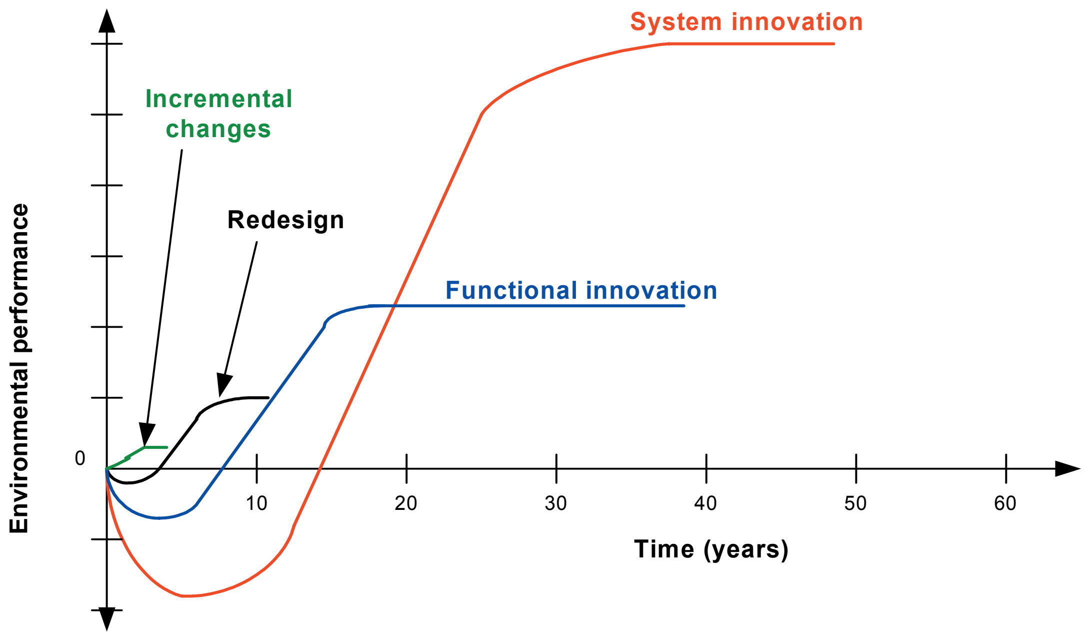


Figure 2.12 Technological innovation on different levels

Incremental changes in product and process design may provide immediate improvements (as indicated by not having any initial negative environmental improvement in Figure 2.12), but may not be sufficient to obtain significant environmental improvements in the long run. This calls for more fundamental changes through system innovation. Given that Figure 2.12 depicts a long-term perspective, for example 40 years, we see that total environmental improvements are definitely greater with system innovation, even with severe negative environmental impact during the first years. The challenge is to encourage long-term thinking and action so that the pro-active investments *are* taken in year 0, and by this means remove the infrastructural lock-ins that impede major environmental improvements[25].

Technological change and innovation are commercially motivated by the expectations of lower production costs (lower purchase cost and lower taxes and fees) or higher income (increased sales), in short and long term perspectives (Hagen et al., 1998). These improvements may also have positive environmental consequences, but this is usually secondary as to why improvements are made. The interests of the market are also the interests of business, and industry's motivation is to position itself in the (future) market. This has led to a transition from an authority-driven to a market-driven environmental policy (Socolow, 1994). If the firm has an 'over-compliance behaviour', this might be a kind of environmental risk management; in relation to consumers and the reputation (shadow of the market), to authorities (shadow of the law) and to competitors (competition on environmental quality).

However, the paradox is that even though the last ten years have shown an increased environmental focus, increased systems approaches and increased interest on the part of industry, the most important indicators of the state of the environment show that the situation is deteriorating (EEA 2005). This points to how inadequate it is to focus only on a micro level, and that the field of industrial ecology captures more than an industrial strategy to attain increased competitive power.

2.4.1.3 Consumers and civil society

Furthermore, the traditional supply and demand fraction characterises the relation between the industry and consumers. The ellipse 'consumer' contains both private consumers (end-users) and 'industry' and 'authorities' who are substantial consumers of both final products and commodities. These represent the demand side of the market. The pattern of consumption is yet an understudied area within industrial ecology, although progress has been made (Journal of Industrial Ecology 2005). The primary issue here is that consumers have a certain amount of money to spend, and consumption is most usually based on functional or psychological needs. Consumers are influenced by authorities through taxes, regulations, bans and information, by industry through product attractiveness and commercials and by civil society in terms in information.

The final ellipse is the 'civil society' which includes all the actors representing particular interests and perspectives and that influence the choices made by consumers, industry and authorities. In Figure 2.9 above, we have identified some of these actors, e.g. work organisations, academia, NGOs, media, international and national institutions such us UN, OECD and WTO, and all of these represent a potentially influencing power to the three other groups of actors.

2.4.2 Relating actors to the resource perspective

Authorities, industry, consumers and civil society are all interacting in various networks of actors, making decisions on strategies and policies that might alter the structures and boundary conditions that everybody relates to. Our particular concern is how these actors and their strategies and policies actually influence the metabolism, and in particular towards loop closing. Or in other terms, how do networks of actors' perspective and the resource perspective relate? Obviously, the crucial analysing units within the resource perspective is the physical flows of materials, products and energy, while the actors, their strategies and how they interact are the main focus within the networks of actor's perspective. In order to carry out fruitful analysis on industrial ecology systems, we distinguish between direct actors and indirect actors. The direct actors are those who actually bring the materials, products and energy forward in the life cycle.

On the other hand, the indirect actors are not in physical contact nor own the materials, they do not have direct power over these, but through their resources (authorative or allocative), strategies and means, they influence the stocks and flows of materials and products. Simply stated, we may say that indirect actors lay the premises and the framework for the direct actors to act efficiently. By making this distinction, we are able to distinguish the significant actors from the less significant. When integrating we find the technological change and innovation within an environmental aspect. Figure 2.13 below illustrates this. It shows key actors, material flows, cash flows and types of innovation for EPR on packaging in Norway.

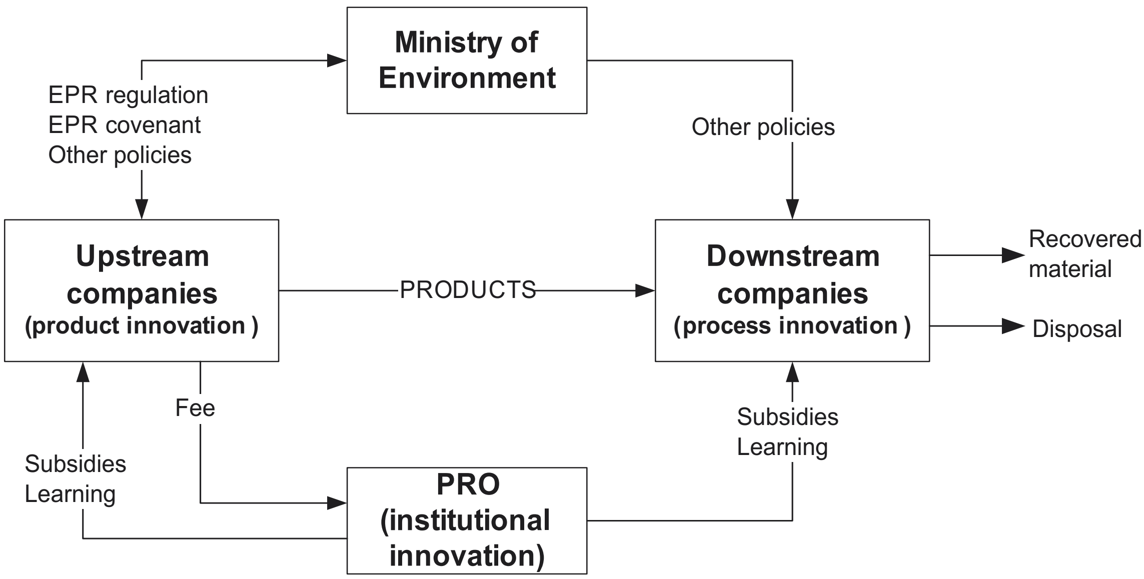


Figure 2.13 Key actors, material flows, cash flows and types of innovation in a collective EPR scheme.

'Technological change and innovation' (TCI) in a life cycle perspective occurs mainly in two phases, upstream and downstream. By upstream is meant all activities from extraction of natural resources to the point of sale to industrial or household consumers, while downstream is from the point where a product becomes waste to the point the material or component is recycled, recovered or disposed. In life cycle terminology this corresponds to 'production phase' and 'end-of-life phase', respectively. Technological change and innovation upstream is denoted product innovation. It reflects a preventive strategy by designing and producing the product with less material so that the amount of waste downstream is reduced (dematerialisation, see e.g. van der Voet et al (2004) for more) or by employing materials and components that are easier to treat in end-of-life phase. Hence, although the environmental problem in focus is downstream, the solutions to them may be upstream.

The second type of innovation appears among downstream companies operating in the end-of-life phase and involves strategies for improving collection, sorting, dismantling and recycling, denoted process innovation in Figure 2.13. Process innovation often requires industrial product innovation, resulting in improved collection/sorting/recycling processes and reduced costs of these operations, all contributing to higher efficiency and eventually improved quantity and quality of the recycled materials.

In collective EPR systems, the upstream companies pay a fee to a PRO that spends this money mainly downstream to increase collection and recycling. The formation of PROs and EPR supporting policy instruments can be considered as an institutional innovation. Institutional innovation is considered as a potential driver for technological change and innovation through subsidies and learning, as well as generally creating arenas for cooperation and focus on these issues.

2.5 The systems perspective

The third dimension of the industrial ecology concept, the systems perspective, deals with approaching complex problems analytically by extending the systems boundaries and including more factors in the analysis. The main argument for employing a system perspective in environmental analysis and decision-making is to avoid partial analysis and problem shifting (van der Voet 1996, Wrisberg *et al.* 2000). By extending the system borders unintended side-effects may be avoided (Lifset and Graedel 2002). Second, the environmental challenges have in a historic perspective expanded in time, place and complexity. They are now regarded as more global than before (e.g. greenhouse gas emissions that influence the global ecosystem), the environmental impacts of human actions are now, since the effects is more on global than local ecosystems, far less visible because the delay times are much longer, and the complexity of the environmental problems has increased, making causal chains less easy to discover. (Karlsson 1997).

On the other hand, Ehrenfeld (2000a) argues that extending the system borders do not necessarily solve any problems, if the problem is the system itself: "Many of my colleagues see industrial ecology as an analytical system, but with broader boundaries than those defined in other technical areas in science and engineering. These academics seek a way to become more holistic and more precise in describing the complexity of the world." (Ehrenfeld 2000a, p. 238) Ehrenfeld argues that more emphasis might be put on the metaphoric aspect of industrial ecology, conf. mimicry aspect of the resource perspective, in order to restructure our institutions, establishing coordinating actors (Ehrenfeld 1995, Boons and Baas 1997) and increase the connectedness, cooperation and community characteristics of the industrial society. There will, in our opinion, nevertheless be a demand for systematically analysing the ideas and potential solutions inspired by the metaphor to be implemented in the real world. The systems perspective is because of this a crucial part of industrial ecology.

There are some well-known practical examples of a systems perspective. The eco-park in Kalundborg, Denmark, evolved without any guidance from neither industrial ecology concept (Erkman 1997) nor a master plan (Ehrenfeld and Gertler 1997 Ehrenfeld and Chertow 2002), but rather as consecutive solutions to emerging local environmental problems. Through extending the system boundaries by redirecting production waste into useful inflows for other processes, different companies and households in a limited geographical region became integrated in terms of material and energy flows. This type of optimisation is based on precisely the same principles as for 'traditional' processing plants. The only difference is that in Kalundborg there are different companies and production of a wider range of products (Røine and Brattebø 2002).

One side of the systems perspective contains *practical* examples that to a large extent are covered by the two other perspectives already. On the other side of the coin we find the *analytical* aspect of the system perspective. Lifset and Graedel (2002, p. 3) mention four forms in which the "systems orientation is manifested": i) use of life cycle perspective, ii) use of materials and energy flow analysis, iii) use of systems modelling and iv) sympathy for multidisciplinary and interdisciplinary research and analysis. These are in fact all analytical aspects and approaches to employ for solving complex problems. For instance, the 'use of life cycle perspective' involves the use of LCA as a method for 'examine the environmental impacts of products, process or services', which is an analytical part of industrial ecology (Brattebø et al 2006). The life cycle perspective of policies like integrated product policy (IPP) and EPR is in this theoretical framework already covered by the networks of actor's perspective.

Moreover, studying the resource perspective and the network of actors' perspective requires a systems approach. It is *analytically* important to be able to distinguish between which material flows and actors to look at, respectively, and which one to exclude from the study. The systems perspective contributes to make this clear as well as admitting that those flows and actors being outside of the system also have influence. The crucial question is then what comprises the analytical systems perspective and how we analytically and methodologically define a problem and find a solution to it[26]?

2.5.1 The analytical systems perspective

It is for *analytical* purposes that we define systems.[27] Only open systems exist, and these contain webs of components forming a complex totality interacting with its surroundings. The components within the system are integrated by flows of energy, materials, information, money etc. between them. Every component can be regarded as a system itself, a subsystem, which can be broken further down into smaller components (sub-subsystems) (Checkland 1999, Asbjørnsen 1998). The system is then a limited part of the entire world with flows into, within and out of the system.

Analytically, it is far easier to deal with smaller than larger systems. The high degree of interconnectedness and complexity of society and nature requires that simplifications, for analytical reasons, must be done. This is, however, only analytical shortcomings to understand the real world, and extending the system perspective means "to move closer to reality". The level of analysis (global, national, local, processing plant, companies and so forth) and the intention of the analysis decide how the system – and based on this, subsystems and sub-subsystems – are defined (Checkland 1999, p. A24). How the system is defined is decisive for the results, and as O'Rourke *et al.* (1996) put it: 'by drawing the industrial box small enough, anything it seems can be an optimized ecosystem'.

A processing plant, exemplified as level 1 in Figure 2.14, consists of several modules (unit operations) that are designed and integrated through exchanges of materials and energy so that the entire plant, and not the single modules, is optimised[28]. However, if the system borders are extended, shown as the second level in Figure 2.14, by including material extraction and secondary production as well, the process designer might optimize the "new and extended system".

Turning to the third level in Figure 2.14, the product level, we include the whole life cycle of the product. A product designer may strive to close material and energy loops for the product throughout its entire lifecycle. This new and extended system perspective indicates the fact that environmental impacts occur throughout the product life cycle and not only in the production phase.

On the last level in Figure 2.14, several product systems are integrated through exchanges of material and energy from both processes and products. Exchanges of process wastes between various product systems are the situation in Kalundborg[29]. As for material and energy from products, the integration is shown from recycling phase to production phase in either the same product system (closed loop recycling, e.g. gold) or in other product systems (open loop recycling, e.g. recovered plastic packaging used in chairs (Håg 2000)).

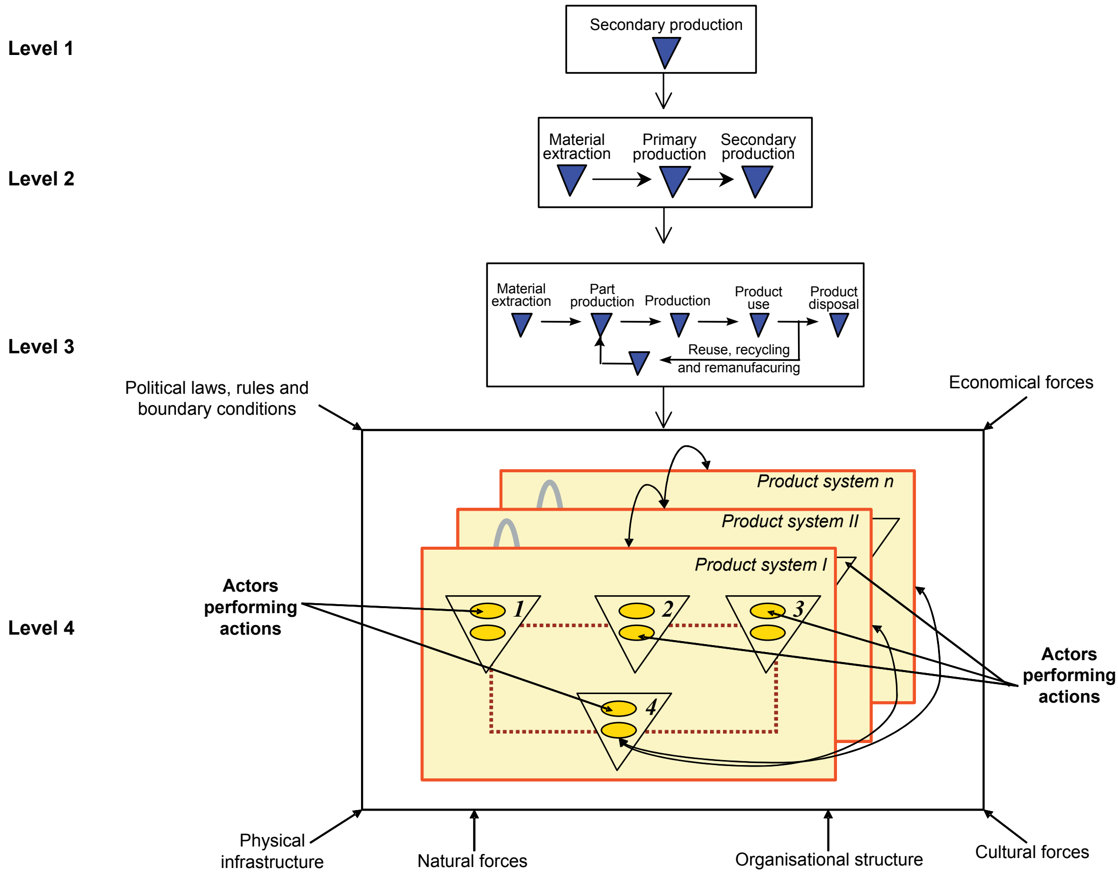


Figure 2.14 Different levels of systems analysis

At all levels of Figure 2.14 there are factors that influence the industrial metabolism in a system and society. This is exemplified on level 4. Knowledge on these non-technological or non-metabolic factors, for instance the influence of policy strategies and measures (studied by political scientists), the influence of changing individual behaviour (studied by psychologists), knowledge on how do societies change (studied by sociologist), and the influence of micro and macro economic mechanism and rationale by the actors (studied by economists), is important to have in order to achieved a steered evolution of the society towards environmental improvements. It is, thus, to a larger extent accepted that solutions to complex environmental challenges must be sought outside the technological realm through interdisciplinary and system-oriented approaches. Design of social institutions and policy frameworks is just as important as designing new products and processes (Ehrenfeld 1995).

2.5.2 Methodological aspects of the systems perspective

As mentioned in Chapter 2.1, systems analytical methods like LCA and MFA have been at the core of the activities within the industrial ecology field. As suggested by for instance Brattebø et al. 2006, we might distinguish between methods based on monetary metrics and methods based on physical metrics. In addition, there are combinations of these. Table 2.3 below shows an overview of the most common of these:

Table 2.3 Important industrial ecology analytical methods and indicators. Source: Brattebø et al. 2006

Physical metrics	**Monetary metrics**	**Combined methods and indicators**
Life cycle assessment (LCA)	Input-output analysis (IOA)	LCA-MFA
Material flow accounting (bulk-MFA) and Substance flow analysis (SFA)	System of national accounts (SNA)	Environmental IOA and Hybrid LCA
Energy analysis and Exergy analysis	Cost-benefit analysis (CBA)	Eco-efficiency
Environmental risk assessment (ERA)	Life cycle costing (LCC)	De-coupling

These methods and indicators provide information on the two first points of White's definition. In this context, we might also distinguish between those methods that map the actual flows of material, products, substances within the economy and those that in addition assess the environmental (and eventually human) effects of these flows.

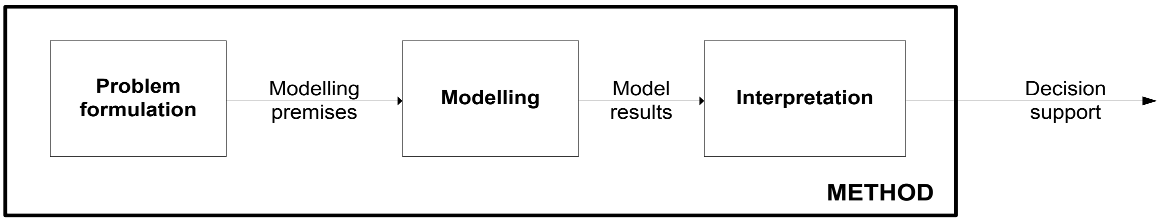


Figure 2.15 Methods seen as a framework for modelling and its accompanying activities, problem formulation and interpretation.

A general methodological approach to these methods is suggested by Heijungs and Røine (2006), as illustrated in Figure 2.15. Problem formulation is to state the intention with the analysis. The modelling part is about defining the system in terms of elements to be included and setting the boundaries along the time, space and scope dimensions. Then, expressing the relations between the elements in the system as well as expressing the entire system is necessary to get the mathematical representations of the system. The output from this modelling exercise is input for developing interesting indicators for analysing the problem to be studied.

(Endnotes)

[1] The 'International Society of Industrial Ecology' (ISIE) with its own journal, *Journal of Industrial Ecology*, was established in 2001. There are several books on the topic like Graedel and Allenby 1995, Ayres and Ayres 2002, Erkman and Bourg 2002 and Brattebø et al. 2006. Comprehensive education programmes on graduate level as well as research programmes illustrates a field in 'institutional' growth.

[2] Besides the *Journal of Industrial Ecology*, academic journals like *Journal of Cleaner Production*, *Resource, Recycling and Planning*, *Ecological Economics*, *Progress in Industrial Ecology*, *Journal of Environmental Policy and Planning* and *Business and the Environment* , to mention a few, all offer articles and dedicated issues on this field.

[3] A person in the process industry might consider industrial ecology as a shift from traditional process oriented HES activities to a system and lifecycle-oriented product focus (Marstrander 1994). This may reduce the consumption of materials and energy, which in turn will reduce financial costs for companies while also benefiting the environment. A person in an NGO may, on the other hand, consider industrial ecology more as a macro oriented concept reducing the overall consumption in order to promote sustainability.

[4] It is here important to note that this does not imply that all principles found in Nature, should be adopted. The selection must be subject to case-specific considerations.

[5] This definition is slightly modified from Allenby (1992) "[I]ndustrial Ecology may be defined as the means by which a state of sustainable development is approached and maintained. It consists of a systems view of human economic activity and its interrelationship with fundamental biological, chemical and physical systems with the goal of establishing and maintaining the human species at levels that can be sustained indefinitely - given continued economic, cultural and technological evolution".

[6] Industrial metabolism is described as "the economy's metabolism, in terms of materials mobilisation, use and excretion to create "technomass", is compared with the use of materials in the biosphere to create biomass. The economy thus is viewed only in terms of its materials stocks and flows". (van der Voet og Kleijn 2000).

[7] Metaphors can contribute to better understanding of nature. Metaphors "extents far beyond its use as an artistic tool for poetic language, into the realm of creative thinking, where it functions as an inducer of new ideas" (Johansson (2003), p. 70, in Ayres and Ayres 2002. In this sense the metaphors go beyond describing an idea towards becoming fundamental parts of the understanding itself. It seems, however, that metaphors are usually used for describing and understanding something that already is a natural (or social) phenomena, but that we – yet – cannot understand through regular (mathematical) language. In the case of industrial ecology the situation is, however, somewhat different, the metaphor is used for providing ideas on how things should be or should have been in order to approach sustainability.

[8] Academia is indeed also part of the real world since it supplies this with knowledge, information and strategies, but for analytical purposes and for the sake of distinguishing between the 'academic' part of industrial ecology and the real world part of industrial ecology, these appear as two entities here.

[9] Various nomenclature is used on this, for instance society, technosphere (Karlsson (1997) and production-consumption systems (Kay 2002, Brattebø et al 2006)

[10] As noted by Lifset and Graedel (2002, p.10), the field is clearly "driven by concerns about human impact on biophysical environment". This concern is based on the assumption that today's actual interactions between

industrial systems and natural systems are not sustainable.

[11] Fundamental to all material flows and metabolism is the law of mass conservation (Lavoisier 1789): ”Mass can never be lost in a physical or chemical process – apart from energy-mass exchanges.” (Kleijn 2000). Lavoisier wrote that ”we may lay it down as an incontestable axiom, that, in all operations of art and nature, nothing is created; an equal quantity of matter exists both before and after and experiment, the quality and quantity of the elements remains precisely the same; and nothing takes place beyond changes and modifications in the combination of these elements” (Hudson 1992).

[12] Centuries ago the population and its resource use was very small compared to the capacity of ecosystems to handle the impacts from human activities. Technological development has made more resources available, but one consequence is that some resources have become scarce and the emissions from society are sometimes higher than the nature can tolerate. Several researchers go even further, claiming that for sustainable development, attaining correct prices is not sufficient. It is just as important that prices are correct *in relation to* the Earth's limited resource base, in other words that the level of the activities is correct. Georgescu-Rougen (1971), Daly (1991), O'Neill (1996) and Ehrenfeld (1995, 1997) support this view. They claim that the economic system is a subsystem of the natural ecosystem, and that the volume (throughput) of the economic system must not grow to such a size that it threatens the stability of the ecological system. This means that even if prices are correct we do not necessarily achieve sustainability.

[13] Despite the fact that we regard for instance metals as non-renewable, we must note that, according to the 1st law of thermodynamics, materials cannot disappear. They can only be transformed into another form (quality) or be “placed” so that they become inaccessible for human purposes.

[14] This is the same situation as when snow falls to the roof of a house. More and more snow can be added to the roof, but only until a certain point where the framework of building does not stand any more and the construction collapses. The buffer capacity in chemical solutions has the same property.

[15] For instance, carbon in form of methane or oil (petroleum) is extracted from environment, processed in society and emitted as CO_2, hence increasing the amount of CO_2 in the atmosphere (and correspondingly reducing the amount of petroleum in the ground. Thus, the society has processed inflows of petroleum to output of CO_2, releasing energy for human purposes.

[16] See for instance ”Dematerialisation” by Ayres (1994) in Greening the industry, “Dematerialisation and rematerialisation as two reoccurring phenomena of industrial ecology” by Bruyn (2002) in A handbook of Industrial ecology and Cleveland and Ruth (1998)

[17] Dematerialisation can both be denoted a strategy and an indicator for the development towards reducing the amount of materials brought into the society (or a defined system).

[18] There are several definitions of eco-efficiency. The WBCSD defines eco-efficiency as ”the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with the earth’s estimated carrying capacity” (DeSimone and Popoff 2000). The OECD defines eco-efficiency as “the efficiency with which environmental resources are used to meet human needs” (OECD 1998c).

[19] It is important to note that the mimicry approach and the interface approach might provide different

answers. Although the metaphor prescribes closing the loop, the analytical interface approach might conclude differently because the resource use, for actually carrying out the loop closing in a given system, is higher than what is gained. This depends on type of product (the complexity involved), type of materials; type of infrastructure (energy sources, transportation) and of course the economic realities in this.

[20] To understand how societies evolve and change it is fruitful to make a methodological distinction between a positivistic and a hermeneutic approach. The basic premise of a positivistic approach is that 'true' knowledge is possible to discover. Only one truth exists, it is out there, and the task of science is to find it. Sociologists that regard structures and functions of a system as the subject, express a view where social phenomena follow an objective lawfulness, analogue to what is found in Nature. Causalities are to be identified. This is a normal view of natural science and the quantitative part of social science. On the other hand, social reality can be explained and understood as a hermeneutical system where the meaning of the social reality, the "truth", is decided by how it is interpreted by individuals. Knowledge must be understood in its context, and in all interpretation and understanding there are parts dependent on the totality and vice versa. Moreover, all understanding is subjective and builds on a certain pre-knowledge (e.g. the theory that is the frame of reference for studying a phenomena), expectations and pre-assumptions. Scientists like Weber, Heidegger, Gadamer and Goffman argue that social phenomena follow hermeneutic paths where the individual's intentions, needs, choices and actions are those which construct social reality.

[21] Within the industrial ecology concept, which emphasises the role of interdisciplinary activity, this approach is valuable, trying to combine the positivistic practice of natural science and the more hermeneutic practice of social science. Natural scientists seek to understand the complexity, mechanisms and dynamics of nature, while social scientists understand and interpret societies and the systems within. How can changes and dynamics within a system or a society be analysed and understood? What are the forces contributing to change and what are the interactions between them? These are questions that for instance sociologists try to theorise about.

[22] There are numerous examples that Giddens' structuration theory is applicable at both company and society level. As for the former, Giddens' structuration theory is beginning to have a growing influence in management science. Principles of structuration have been applied at the organizational level (Ranson et al. 1980, Pettigrew 1987) and as an explanation for industry level activity (Huff et al. 1994). Applications of structuration theory have also yield insight into organizational culture (Riley 1983) and technology transfer (Orlikowski 1992, Desantis and Poole 1994).

[23] Civil society is certainly capturing 'consumers' as well, but we choose here to treat this group separately as this is a key group within the field of industrial ecology. For a broad introduction to the consumer aspect of the field, see *Journal of Industrial ecology* 9(1-2).

[24] Industrial ecology is, however, *not* exclusively for industry and about what industry can do, but rather just as much about what the authorities, academia, media, politicians, consumers, NGOs and industry can do together to meet environmental challenges. As Capra (1996) contends, understanding the *interplay and the interaction* between these actors is the decisive factor if we are to succeed with the aim. Hence, as suggested by Erkman (1997) and Brattebø et al. (1999), every actor must first understand the materials and energy flows and the environmental influence of these flows in a given life cycle system. Second, the actors must understand how they may contribute to reduce the environmental load within and from the defined system.

[25] Although the figure shows a reasonable relation between different improvement strategies, it is worth noting that all systems innovations do not necessarily result in total environmental improvements. Building a new airport with improved passenger and freight handling is indeed a system innovation, but it does not necessarily improve environmental conditions from a broader systems perspective. Thus, technological innovation must both have a direction and a rate that is consistent with the aim of sustainability.

[26] Systems thinking is not a new endeavour, but is a significant part of academic approaches on how to study complex systems. In cybernetics, biology, organizational theory, political science and economics, just to mention some, systems thinking has been developed and employed for decades (Sastry 1995, Richardson 1991). For every of these disciplines, understanding the relation and connectedness of the different components in the systems, how they relate and interact, feed-back mechanisms and delays and self-regulation have been significant in order to understand the behaviour of the system.

[27] We may say that it is not a question of whether there is a systems perspective or not, but whether there is a narrow or broad system perspective. The system perspective is argued to be an alternative approach to the reductionistic and mechanistic approaches (Blanchard and Fabrycky 1998).

[28] In quantitative studies, the relations between the components are expressed mathematically (e.g. chemical engineering (Skogestad 2000), system dynamics (Forrester 1961, Sterman 2000). By using software programs we are able to simulate the system behaviour, given the structure of the system and certain initial conditions. In business dynamics, for instance, causal loop diagrams are employed to show the causal relation between parameters that influence each, and then to show the entire system behaviour if one parameter is changed. The challenge is, as always, to decide what is within and what is outside the system, since the factors closed to the system border, surely are influenced by factors just outside the system border.

[29] In this context, the cascading principle is a theoretical very important principle. Energy cascading is quite usual in processing plants, but in Kalundborg the cascading is carried out by different companies. The basic idea in cascading is to utilise the exergy in the flows as many times as possible on their way to zero exergy. The cascading principle is also applicable for products and materials (Sirkin and Houten 1993).

3. EPR – A PUBLIC POLICY PRINCIPLE

As is evident from the previous chapter, the metabolism in industrial systems is influenced by a number of actors and factors, in which the governmental bodies play a significant role. Governmental environmental ambitions have increased during the last 20 years, and industrial actors are now facing far stricter regulations and compliance issues than even just two decades ago[1]. However, reaching these ambitious objectives has, in more recent years, to a larger extent relied on market-oriented policies and measures and the power of market mechanisms (Wallace 1995).

EPR is part of this trend. For the last 15 years it has been a frequently used policy principle throughout OECD-countries for dealing with product-oriented environmental problems in a life cycle perspective. On the international level, the European Union has implemented several EPR-based directives. The Packaging Directive (EU 1994) requires that member states should recycle between 50 % and 65 % of all generated waste from packaging materials, and that each material should at a minimum be recycled 15 % and recovered 40 %. Electrical and electronic equipment (EEE) face two directives; the Waste Electrical and Electronic Equipment (WEEE) Directive (EU 2003a) that includes a collection target of 4 kg per capita per year from private households by 31 December 2006, and the Restriction of the Use of Certain Hazardous Substances (RoHS) Directive (EU 2003b) that prohibits new EEE put on the market from 1 July 2006 from containing any of the following six hazardous substances: *lead*, *mercury*, *cadmium*, *hexavalent chromium*, *poly-brominated biphenyls* (PBB) or *poly-brominated diphenyl ethers* (PBDE). The EoL Vehicle Directive EU (2000) is a fourth example of an EPR-based EU Directive[2].

On a national level, Germany was the first country to pass take-back legislation for producers within the packaging sector, introducing the Packaging Ordinance in 1991. In the Netherlands covenants[3] between government and industry were signed in 1991. As for EEE, Norway was the first country to pass an EPR-based legislation in 1998 (NMoE 1998a,b). All EU member states have implemented the Packaging Directive (EU 1994), while WEEE and RoHS Directives (EU 2003 a,b) are currently being approved in all national legislation. For non-EU countries such as Japan, Canada, Australia and US, EPR has been implemented variously, but the highest attention has been on the same sectors as in the EU; packaging, EEE, batteries and vehicles (OECD 2001).

These examples give a glimpse of EPR policy instruments and regulations implemented worldwide. There are large variations in how the policies are designed and implemented. Below we will explore the key aspects of EPR, by first looking into EPR as a policy principle, then go on to describe EPR policy instruments and finally look at the industrial implementation of these policy instruments.

3.1 EPR as a policy principle

A number of environmental policy principles are formulated in various international conventions and declarations. As suggested by Christophersen (1997), environmental principles may be divided into two main categories; i) those regulating the relationship between mankind and nature and ii) those regulating the relations between humans. For instance, the carrying capacity principle and the precautionary principle can be positioned within the first group, while the Pollution-Pays-Principle (PPP) (OECD 1975) is within the second category.

Some scholars and governments consider the PPP to be the governing principle for EPR policies. PPP is based on the assumption that those *physically emitting* are those 'paying'. Producers within an EPR-regime pay for the environmental impacts caused by their products and are, thus, considered to be the polluter. Others, for instance Davis (1998), Lindhqvist (2000) and Tojo (2004), dispute this position by arguing that PPP was developed to be a guiding principle for *process-related emissions* (Davis 1998, p 29). EPR is *product*-oriented (Lindhqvist 1992, Lifset 1993), and PPP is thus not applicable.

Within EPR the responsibility is placed on one group of actors (the producers), although these actors are not the actual physical emitters. They are however, assumed to be those who have best resources and capacity to reduce the overall environmental impact from products throughout their life cycle. Based on this argumentation, Davis (1998) proposes that EPR is not based on the polluter-pays-principle, but is rather a policy principle itself. In this thesis, EPR will be understood as a policy principle[4]. However, the term 'EPR' comprises a policy principle that has only conceptual content and is thus not a regulatory instrument in itself. The principle must be applied through various tangible EPR policy instruments in order to be of any practical importance. But what is the actual conceptual content of EPR?

3.1.1 The conceptual content of EPR

EPR is often, and mistakenly, considered to be synonymous to 'take-back schemes' where producers are responsible for achieving a certain recycling target. EPR is more than this. A frequently quoted definition of EPR is given by Thomas Lindhqvist. He defines 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 entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product" (Lindhqvist, 2000, p. 154).*

Dissecting this definition, two main parts emerge, respectively, as *ends* ('to promote total life cycle environmental improvements of product systems') and *means* ('extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product').

Following the categorisation by Christophersen (1997) above, the EPR principle has one foot in each group. The objective is to obtain total life cycle environmental improvements. As explained in Chapter 2, life cycle thinking comprises of a number of phases and activities, and obtaining 'total life cycle improvements' requires consequently coordination of various policy instruments in order to avoid sub-optimisation. We here suggest integrated product policy (IPP) as an appropriate policy strategy for securing this.

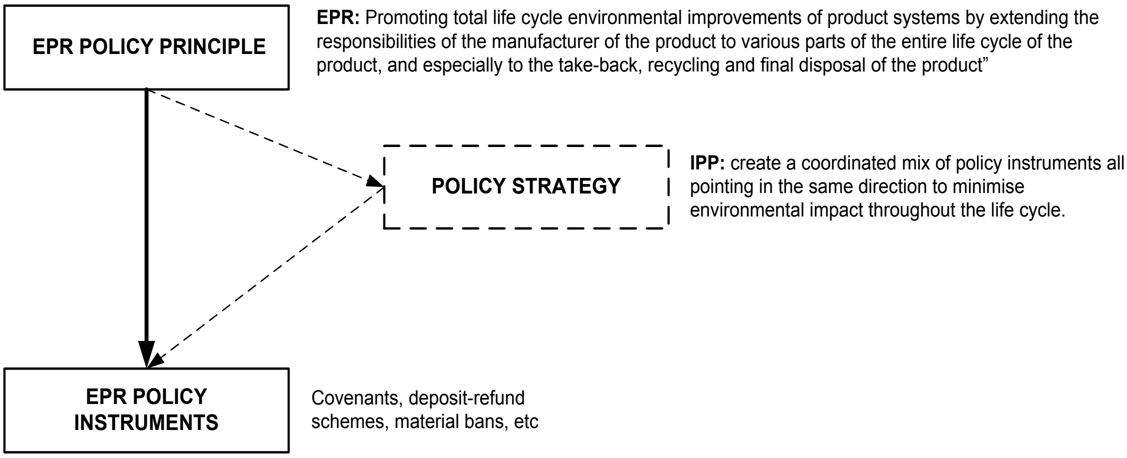


Figure 3.1 EPR Policy hierarchy with governmental intervention

In short, IPP is a coordinated mix of policy instruments all pointing in the same direction to minimise environmental impact throughout the life cycle[5]. In our context, industrial ecology is pointing out the direction. Moreover, a consequence of employing IPP as the policy strategy for developing coordinated EPR policy instruments, is that this also 'invites' policy makers to integrate EPR-based policy instruments and non-EPR policy instruments[6] in order to obtain 'total life cycle improvements'. Figure 3.1 shows the EPR policy hierarchy including EPR policy principle as the overarching principle on which product-oriented, tangible EPR policy instruments are designed. In this design process IPP must be employed as a system-oriented strategy for avoiding sub-optimal solutions.

Turning to the second part of Lindhqvist's definition, we see that the crucial feature of EPR as a policy principle is the identification of the 'producers' as those being responsible for the environmental performance of their products throughout the life cycle. The reason for this is that producers are in the best position to improve the whole life cycle environmental performance through their product design choices (Davis

1998, p. 33), that preventive strategies are considered more effective than 'end-of-pipe' solutions, and that by extending responsibility, the producers also get feed-back on the design of new products (Lindhqvist 1998). This position is supported by Lifset (1999, p 1), noting that

> *"EPR is a critical complement to source reduction because it provides individuated (targeted) incentives to producers to engage in design for environment (DfE) related to end of life (EoL) management – to use less material and design for recyclability"*

The question is then how the producers can get *incentives* to produce products with minimised environmental impact throughout the life cycle.The incentives are provided through EPR policy instruments. Lindhqvist (1992), Tojo (2004) and Tojo et al. (2005) have employed the usual distinction between regulatory instruments, economic instruments and informative instruments (Vedung 1998) for categorising current EPR policy instruments. This classification, however, provides only minor information on the incentives for the producers. To be able to analyse the strength of the policy instruments, it is necessary to determine what the incentives are and how they are incorporated in the producers' decision-making processes. In order to better understand how EPR policy instruments actually stimulate producers to act according to the EPR policy principle, we propose an alternative categorisation of EPR policy instruments.

3.1.2 Three categories of EPR policy instruments

Considered from a governmental policy point of view, we distinguish between three categories of EPR policy instruments:

1. policy instruments that are designed with targeting commitments for the producers *within* their core domain business areas (the upstream production phase)
2. policy instruments that are designed with targeting commitments for the producers *outside* their core domain business areas (the consumption phase and the end-of-life phase)
3. policy instruments targeting consumers and end-of-life phases aiming at influencing producers' behaviour through market mechanisms.

Authorities might direct EPR policy instruments straight towards the producers or via consumers so that their demand for more environmentally friendly products stimulate producers to design differently. Figure 3.2 illustrates these three categories.

Upstream companies, like all companies, are facing various types of regulation, and, along the lines of Giddens' structuration theory, the eventual mix of these policies are structural input to actors and their decisions making processes. Traditionally, they have had to comply with regulatory restrictions, targets and licences put on their core activities, particularly related to production process emissions to air, water and soil as well as solid waste management. This category is found in the lower left part of Figure 3.3 ('production process emissions) and in the upper part of Figure 3.3 (z) and can be considered as PPP-based policy instruments due to its point-emission character[7].

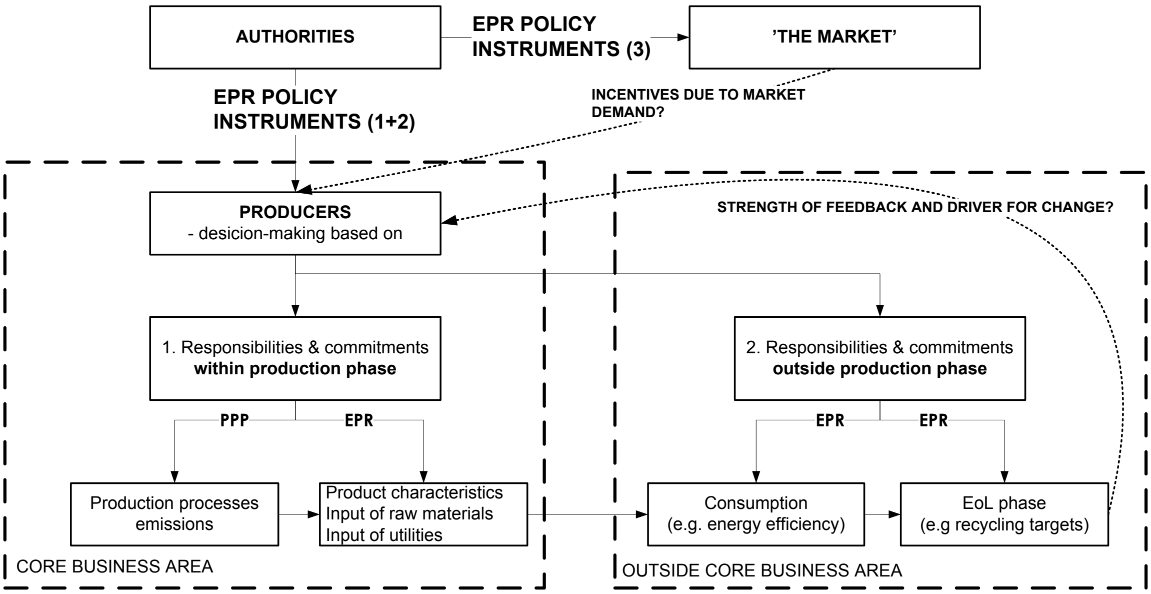


Figure 3.2 Three directions for EPR policy instruments

The new trend however, is that regulatory mechanisms have been extended to include additional commitments *within* their core business area related to production output and product characteristics (y in Figure 3.3, e.g. banning certain substances in products), to input of raw materials (x in Figure 3.3, e.g. requiring recycled material) and utilities necessary for running the processes (u in Figure 3.3, e.g. new renewable energy sources).

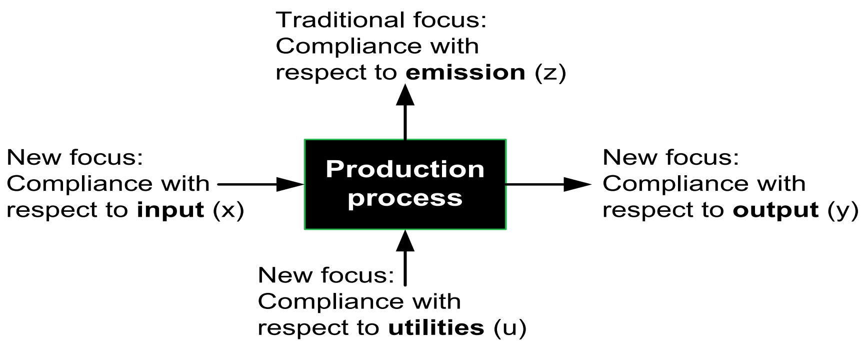


Figure 3.3 Distinction between traditional and new focus in environmental policy

There are at least three reasons as to why policy instruments directed towards these points within the core business area can be considered EPR-based. First, these policy instruments (e.g. RoHS) comprise products and not production processes. Second, the main environmental impacts from these products appear when these become waste, hence in another phase of the life cycle than the producers' core business areas. Finally, this group of policy instruments is preventive as they, in the case of RoHS, remove the hazardous substances from the product instead of treating them in the EoL-phase.

Contrary to this stand point, OECD (2001, p 51) states that

> *"the core intent of EPR is to extend the responsibility for products at the post consumer stage away from the taxpayer and municipalities and towards the producer of the products".*

OECD, thus, considers the uniqueness of EPR to be that the producers have commitments (responsibilities) *outside* their core business area. The responsibility, OECD argues, is not *extended* if the measures taken are just targeting another point within their core business area. In this thesis, however, we consider these policy instruments as being classified under the EPR umbrella, partly due to the product-orientation and their preventive characters, and partly due to the need, in an industrial ecology perspective, for an integrated product policy.

The second category comprises EPR policy instruments that explicitly give producers obligations for activities and results *outside* the production phase. Indeed, the most apparent understanding of the term 'extended' is the extension of commitments from production phase only, towards commitments in the other phases of the life cycle as well. As shown in Figure 3.2 producers have 'responsibilities and commitments outside the production phase', in principle throughout the whole life-cycle of the given product, that must be taken into account when they make decisions.

An underlying assumption within the EPR principle is that when producers have responsibility for other parts of the life cycle, this might give them incentives to improve the design of the product and carry out technological change and innovations. As noted by Lindhqvist (1998, p.6); "…it is the feedback to the design of new products which is the key element", and by including the waste management costs in the product price, producers might consider this as an incentive to reduce these costs (OECD 1998a). Consequently, the strength of these incentives for making product changes depends on how the actual EPR policy instrument is formulated. This, as illustrated in Figure 3.2, is another preventive aspect of EPR.

The two categories above contain EPR policy instruments that give producers regulatory commitments. The third category of EPR policy instruments aims at stimulating consumers to demand more environmentally friendly products, and hence, stimulating producers to design differently. This is within the EPR policy principle because the aim is to induce changes in companies' behaviour. For instance, if the market (due to EPR policy instrument) demands less packaging to be used, then, in a perfect market, the producers would act accordingly[8]. Going beyond compliance is to take responsibility, not primarily for the sake of the environment, but for the sake of its own business.

Similarly, if an EPR policy instruments require the producers to reduce the amount of packaging, the producers must obey this in order to comply. This shows that the different drivers might cause the same output. However, the market often provides a stronger and quicker signal than public policies do, but from an IPP perspective, the combination of these is preferable. That said, this third category is to a very limited extent employed deliberately by EPR policy makers.

In summing up, EPR is proposed to be a policy principle that can support the IPP strategy and complement PPP as the governing principle. In order to achieve the objective of reducing the total environmental impact, policy instruments must be designed and oriented directly towards producers or indirectly via the market so that "anywhere in the chain has appropriate incentives to be concerned about life cycle environmental impacts of the whole product system" (Davis 1998, p 32). Achieving this should follow an integrated product policy strategy, stimulating both the supply side and demand side for environmental friendly products. Below we will look closer into issues related to policy implementation and industrial implementation of EPR.

3.2 Policy implementation of EPR

Policy implementation of EPR includes all political and administrative processes for passing a law or regulation in national assemblies and bringing it into force, either on a national or international level. As Figure 3.4 shows, this is followed by the industrial implementation which concerns the actions taken by industrial actors to comply with the policy instruments in the national legislative frameworks.

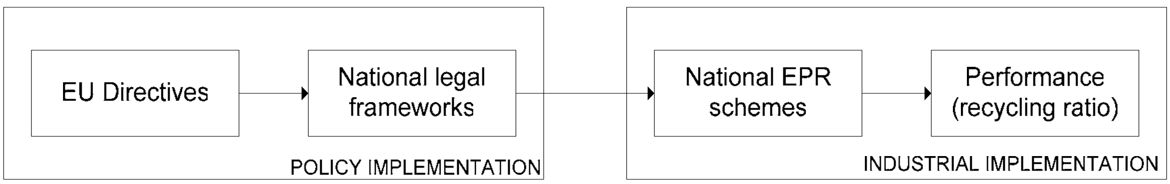


Figure 3.4 Policy implementation and industrial implementation of EPR

A number of issues are to be decided during the policy implementation phase; type of environmental problems, selection of type of EPR policy instruments, type of responsibilities and degree of responsibility, type of practical solutions to EPR-systems, and, finally, sanctioning mechanisms. All these issues will be discussed below.

3.2.1 Environmental problems to be solved

Policies must be selected and designed according to the environmental problem to be solved. As mentioned in Chapter 2, environmental problems in highly complex industrial systems are a challenge to grasp. OECD (2001) suggests a number of objectives for EPR policies, which all indicate potential environmental problems, for instance reducing use of raw materials, reducing energy use and increasing reuse and recycling of products.

The general trend in both EU and Norway is that waste is generated more than ever (NMoE 2001, 2003a, 2005; EEA 2005). Some EPR policy instruments are designed to reduce the environmental effects of waste[9] in the end-of-life phase, by internalising environmental externalities and the costs of waste handling into the product prices. In the majority of current EPR policies the overall objective is to reduce the environmental effects from end-of-life phase through increasing the recycling levels. The generation of waste is, however, a consequence of past production and consumption activities before products are turned into waste. EPR policy instruments therefore are also aiming at waste reduction (Røine et al. 2001).

The environmental problems connected to plastic packaging waste are, if not treated properly, higher volumes of waste to landfills followed by increased emissions as well as increased input of virgin material to industrial production systems. Lifset and Lombardi (1997) argue the latter to be the most significant one.

3.2.2 Designing EPR policy instruments

International bodies (e.g. the European Union) and national authorities may apply various types of EPR policy instruments, depending on the type of environmental problem and type of product. In Chapter 3.1.2 we suggested a categorisation for this. Independent of category, EPR policy instruments are part of the 'National legal frameworks' (see Figure 3.4). Covenants, regulations, permits, trading schemes or combinations of these are some of the national policy instruments employed. Figure 3.5 gives an overview of various EPR policy instruments for plastic packaging sectors in selected EU countries.

Figure 3.5 illustrates further that EPR policy instruments might either be implemented through regulatory measures or through non-regulatory measures such as covenants. The difference is that in non-regulatory regimes the authorities do not have apparent sanctioning mechanisms at hand if there is non-compliance, except from threatening with a legally binding regulation. Most current EPR policies for plastic packaging are, however, connected to the regulatory body in the country. These policies might either be governmentally driven, like the packaging waste recovery notes (PRN) – system in the UK or industry driven like in Germany, Sweden, France, Belgium and Italy.

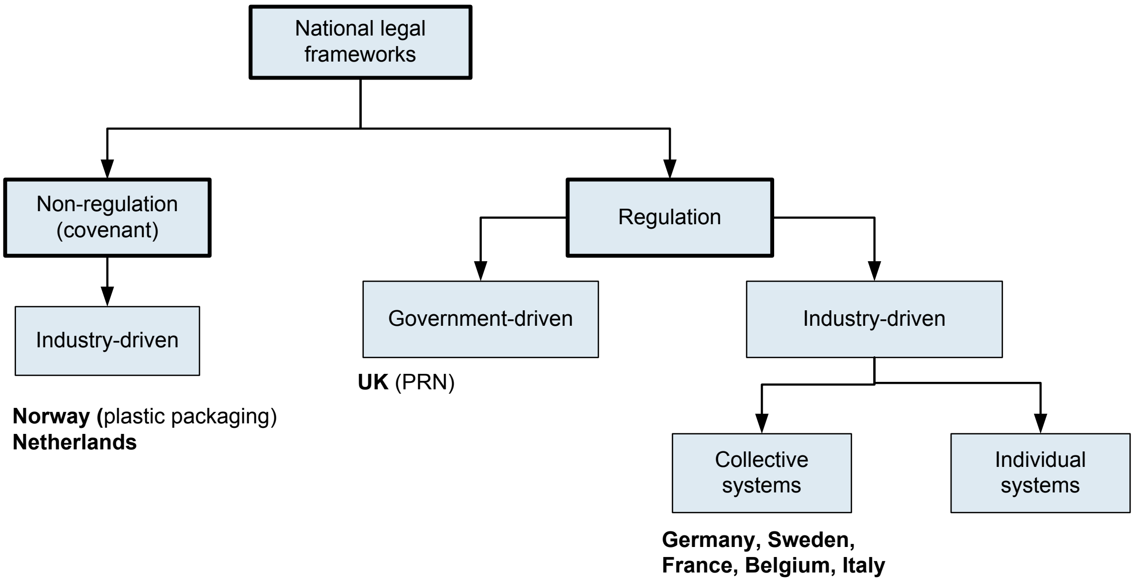


Figure 3.5 Overview of policies and policy implementation at EU and national level for plastic packaging [Source: EPRO 2005]

The types of EPR policy instruments mentioned above are general categories that, during the policy implementation, are 'filled with content'. Table 3.1 below provides some examples of EPR policy instruments organised along Vedung's (1998) categories and the categories suggested in Chapter 3.1.2.

Table 3.1 Examples of EPR policy instruments grouped along Vedung's categories (1998) and categories suggested in Chapter 3.1.2.

	Regulatory instruments	**Economic instruments**	**Informative instruments**
Core business domain	Recycling content requirements, Substance bans	Material tax	
Outside core business domain (Consumption)	Covenant (packaging optimisation/ waste reduction)		
Outside core business domain (End-of-life)	Covenant: (Take-back system) Regulation (Deposit-refund system)	Advanced disposal fee	
Through the market			

The EPR policy instruments presented above might be designed and given substance in various ways. For instance, important questions to clarify are: Who are the producers? What type of responsibility are they facing? And to what extent are the producers responsible?

The term 'producers' is a collective term for all upstream companies that are involved in the EPR schemes, and is not limited to the manufacturer of the product. As far as plastic packaging in Norway is concerned, the entire value chain including plastic producers, plastic packaging producers, packers & fillers as well as wholesalers and retailers have all signed the covenant with the Norwegian Ministry of Environment.

Lindhqvist (1992) proposed a frequently quoted typology for types of responsibility within EPR. He distinguished between legal responsibility, physical responsibility, economic responsibility, informative responsibility and ownership. These types of responsibility are to a large extent concentrated on commitments in the EoL phase and not closely related to the production phase.

If the producers are given a financial responsibility, it is still a debate how far this responsibility actually should go – full cost coverage or shared costs. In Germany there is full cost coverage as the Duales system represents a parallel system to the municipal waste management system (Muenk 1998). In most other EPR schemes there is a sharing of costs, for instance between waste generators, municipalities, consumers and PROs. Within plastic packaging in Norway there is a principle of 'net deficit cost coverage', which means that Plastretur provides a subsidy that, theoretically, shall compensate for the deficit when choosing a material recycling route instead of a cheaper alternative (e.g. energy recovery and landfill). Everyone gets the same subsidy and the competition is then based on the internal efficiencies of each company.

The policy instruments normally clarify how the producers might carry out their responsibilities. We usually distinguish between collective systems, semi-collective systems and individual systems. A collective system is often organised with PROs which on behalf of the producers, execute the commitments in the policy instrument. Collective systems might be found based on both negotiated agreements and regulations, as shown in Figure 3.5. The producers pay a licence fee to finance the collective system, and the fee does not necessarily reflect the costs of recycling for their particular product. On the contrary, in individual systems the producer must prove that his product is taken care of in an environmental friendly manner. There is a closer relation between the license fee paid and the costs of recycling the specific product (Tojo 2004). Finally, we find semi-collective systems where private (waste management) companies, take responsibility on behalf of their clients to fulfil their commitments. Within this category we also find the insurance companies that offer EPR-solutions for long-lived products (EE-products).

In order for policy instruments to be effective there must be credible sanctioning opportunities. As Figure 3.5 illustrates, the national implementation of EU directives can either take a non-regulatory or a regulatory route. In Norway, for instance, the covenant on plastic packaging does not explicitly state sanction, but there is an underlying premise for the covenant that if the producers do not reach the targets, then a regulation will be implemented (Hambro 2003). The question is how strong this threat ('shadow of the law') is considered by the actors. Most countries have a regulatory basis for their EPR schemes on plastic packaging. In the UK, for instance, the PRN-system, being the most market-oriented system of all European EPR systems on packaging, has financial penalties for non-compliance. This is the guarantee needed for the market to work well. (Simmons 2004). It seems, however, to be essential to either have a strong program for monitoring and ensuring compliance with negotiated agreements and/or an ongoing regulatory threat that will be triggered if industry fails to meet its obligations (Veerman 1998).

3.3 Industrial implementation of EPR policies

All policy instruments aim at influencing commercial market actors or consumers so that social beneficial objectives are obtained (Vedung 1998) By industrial implementation of EPR we mean processes that are initiated and carried out within industry as a consequence of the EPR policy instrument. Understanding the outcome of the industrial implementation of EPR, for instance the recycling ratio, requires closer studies of the processes within the industrial system that have produced the outcome (Weiss 1998). A majority of the papers that look into EPR schemes argue that dematerialisation has happened due to these schemes, without showing the causalities between this policy and the effects (e.g. Lindhqvist 2000, Hanssen et al. 2003). Hence, going deeper into the processes is necessary. This point is further supported by the fact that the importance of achieving changes upstream in material choice and design are frequently accentuated (Lifset and Lombardi 1997).

The formal transition point between policy implementation and industrial implementation is when the regulation is passed or the covenant is signed. Then most of the remaining political uncertainty is removed by agreeing upon the political boundary conditions within which industrial actors will operate. That said, industrial actors prepare themselves for the regulation and changing boundary conditions that are most likely will appear, and industrial changes due to the regulation might, thus, be observable ahead of the formal transition point.

As stated in Chapter 1, we will concentrate on collective systems. Figure 3.6 shows the interaction between various actors and the corresponding flows of material, money and information In the policy implementation process, the authorities (Ministry of Environment) design an EPR regulation or negotiate with the producers (upstream companies) on an EPR covenant. Other non-EPR policies such as energy policies, transport policies and industrial policies will also influence both upstream and downstream companies.

In collective systems, PROs are usually established to act on behalf of the producers to comply with the targets. A PRO's main tasks are to collect licence fees from producers and redistribute these financial resource as subsidies to downstream companies in order to lubricate the recovery system. Moreover, the PRO interacts with the market through information campaigns and contractual frameworks as to safeguard that the market is running as smoothly as possible. Understanding the role of the PROs, their strategies and means for reaching targets as well as their interactions with market actors in the networks of actors, is imperative to be able to improve current systems.

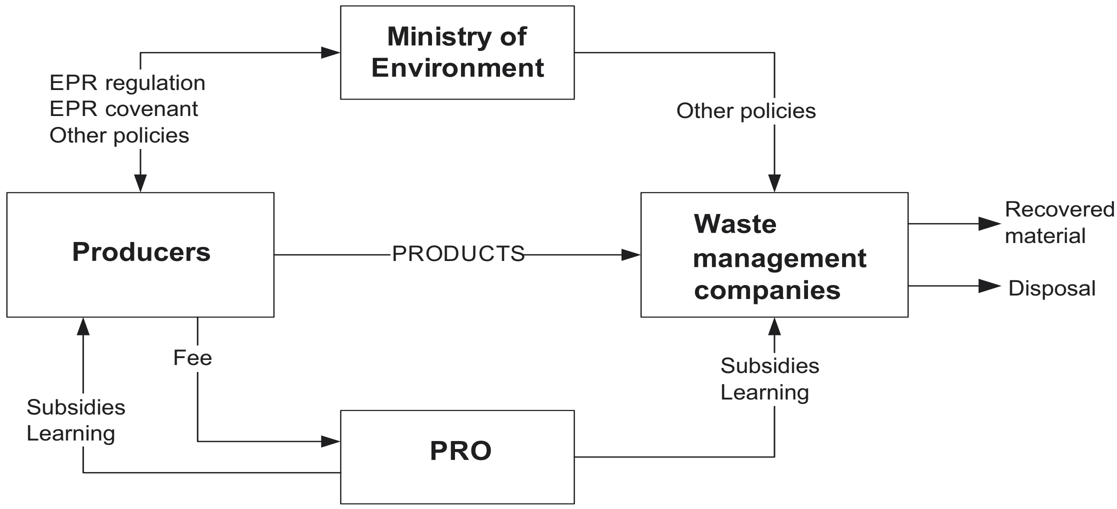


Figure 3.6 Structured overview of collective EPR systems

In collective systems, the producers might take various roles and responsibilities. Some producers do not, however, exercise producer responsibility at all, via not paying the licence fee. They are so-called 'free-riders'. This is altering the competition within the market as these companies take benefit from a system they do not financially contribute to. Those paying are then, relatively speaking, worse off.

The simplest and most usual way of a producer taking responsibility is to pay the licence fee corresponding to the amount of products put on the market. If this is the only consequence of the EPR policy instrument, the producer is showing weak responsibility. To these companies, the licence fee is like any other tax paid to the government. The producers might, however, perform a stronger responsibility beyond just paying the fee. The costs of running the collection and recycling system depend on how the product is designed, both with respect to recycling and to the entire life cycle environmental impacts as such. If the producers choose a material that is easily collected and recycled, they express a more active producer responsibility. As discussed in Chapter 2, the premises for how easy the product is to recycle are decided in the design phase. Several argue that in collective systems there are, however, a lack of incentives for design for recycling as such efforts do not provide reduced licence fees. However, a general optimisation of the product is beneficial both in terms of economy and environment and expresses an active responsibility. If the producer also demands recycled material, for whatever reason, so that the collection and recovery systems turn into being demand-driven, and not only supply-driven, this behaviour by the producer expresses a strong and active producer responsibility. The industrial implementation of EPR might be characterised as successful if these criteria are fulfilled.

Strong producer responsibility is also shown through active participation and ownership in the PROs, since important decisions on how to design the recycling system and hence comply with the regulation are taken here. Moreover, a strong producer responsibility is present if producers take internal decision in their organisation that contributes to making it easier for the PRO to achieve the targets. Finally, within EPR schemes the waste management companies play an important role as they are the operators of the actual recovery system. Understanding the interactions between these companies, the upstream companies and the PROs completes the picture of the networks of actors within EPR schemes.

(Endnotes)

[1] One example of this is the Kyoto Protocol, that relies on flexible market mechanisms e.g. emission trading systems and Clean Development Mechanisms (CDM), for reducing GHG emissions.

[2] For more information on the EoL Vehicle Directive, see Tojo (2004), p. 88-92 (Chapter 4).

[3] Covenant is in this thesis synonym to negotiated agreement and to voluntary agreement.

[4] In its early years, EPR was regarded as a policy strategy (Lindhqvist 1992, 1998), but has during recent years been considered as a policy principle. This change is related to the fact that EPR is not based on PPP and that EPR becomes more than just a take-back scheme by potentially being the broad principle to employ when developing environmental product policy instruments in a life cycle perspective.

[5] Integrated Product Policy (IPP) is an EU initiative defined as “Public policy which explicitly aims to modify and improve the environmental performance of product systems” [E & Y et al. 1998, p. 33]. Another definition of IPP is proposed by Centre for Sustainable Development (CfSD): IPP is a “public policy aiming at greening the marketplace through the integrated use of supply and demand side tools”. Environmental Product Policy (EPP) is a more generic term than IPP referring to product-oriented environmental policies at a national level inside and outside Europe.

[6] The term ‘non-EPR policy instruments’ is here employed to denote all those *public* policy instruments and measures that are not based on the EPR principle. Examples of such instruments are found within governmental energy policies, transportation policies, industry policies, innovation policies as well as fiscal policies. The challenge of IPP is to coordinate across the various departments (Ministry of Environment, Ministry of Industry and Commerce, Ministry of Finance etc) and across the various problem areas (waste, climate, acidification etc). Of particular importance seems to be the combination of environmental issue with

commercial, industrial and innovation issues. This is significant for EPR since it aims at bringing incentives for firms to innovate new and improved products.

[7] Davis (1998, p 32) argues that traditional policy instruments with focus on point-emissions are actually based on the EPR principle; 'EPR as a broad principle states that the manufacturers of products bear a degree of responsibility for the environmental impacts of their products throughout the product's life cycle, including [...] impact from the manufacturer's production process itself, ...' In that case, EPR is not only product oriented, but also process-oriented. However, taking into account that this does not represent an extension of producers' responsibility, we will not define these traditional policy instruments as based on EPR.

[8] So far we have presented EPR as an entirely government-driven policy for influencing the producers as market actors. In addition, EPR is regarded as a policy principle also applicable to entirely voluntary efforts (OECD 2001) As discussed in Chapter 2.4, companies might, like what for instance Xerox has done, *take* responsibility to establish take-back schemes for their own products. Carrying out this entirely voluntarily strategy without any kind of governmental intervention is also considered to be part of the EPR concept. The motivation is in this case not driven by public policies, but rather by, for instance, environmental leadership for market advantage, regulation and potential regulation, economic return and better decision-making as well as corporate commitments to the environment, in all by the belief that this is a sustainable *business* strategy.

[9] A product that is not needed anymore in its present form, is usually regarded as waste. But what if other people need the product, is it then also waste? Is it waste if it is reused in the use phase? The last definition of waste is found in White Paper 44/1991-92 to the Norwegian Parliament: "waste is discarded movable properties or substances. Waste is also regarded as redundant moveable properties from tertiary sector, from production and treatment plants. Waste water and waste gas are not considered as waste". (NMoE 1992)

4. ANALYTICAL FRAMEWORK

The purpose of the analytical framework is to explore how we are going to study the main research question, so that others can test the reliability by employing the same analytical framework and the same empirical evidence to see if they reach the same conclusions. It includes some important steps:

1. *What to look for – deciding on the data needed for answering the research question*. Of particular importance is to select data from "the infinite number of facts that could be recorded" (King et al. 1994, p 34)
2. *How to find it – outlining how the data will be collected.* A number of methods are available, ranging from literature studies, via case studies and comparative studies to experiments and surveys. Often there is a combination of these, for instance that within a case study, surveys and in-depths interviews are used as tangible tools for gathering information.
3. *How to interpret – outlining how the collected data will be interpreted.* How do we intend to treat the data collected from empirical studies?

Obviously, the analytical framework must be adjusted to the specific purpose of the research, although existing frameworks might be applied if these are developed with quite similar research questions and theoretical perspectives in mind (Ayres and Ayres 2002, foreword). In this case, the general theoretical framework provided in Chapter 2 points towards a general analytical approach for studying industrial systems. First, combining the resource perspective and systems perspective in studying the industrial metabolism at various levels of the system is an appropriate strategy for getting an overall picture of the system. It provides information on the significant flows, on the most important group of actors and on their physical relations. Moreover, the flows are most usually expressed in terms of weight units, although recently monetary units to a larger extent are employed (Strømman 2005, Brattebø et al 2006).

Second, in order not just to describe the metabolism but also to understand it, it is necessary to look into the underlying mechanisms of the system. By combining the networks of actors' perspective and the systems perspective, we are able to identify the most critical actors within the system, their incentives, measures and strategy as well as the interaction between the actors, that all, to a greater or lesser extent, have an influence on the metabolism. In total, this provides additional knowledge to the study of the industrial metabolism.

This dual approach is in line with Giddens' structuration theory. The material flows constitute the structures within the system, being 'decided' by the actors and their decisions. On the other hand, the existing metabolism puts restrictions on the actual space of freedom that the actors have. Hence, both approaches should be employed interchangeably in order to interpret the causalities.

The underlying systems perspective can be applied both on sector and company level depending on the type of information sought. Usually, however, an overall picture of the system related to the dependent variables (for instance loop closing, fraction of new renewable energy sources) is gained, before moving into the system (black box) for finding independent variables, underlying causal mechanisms and explanations.

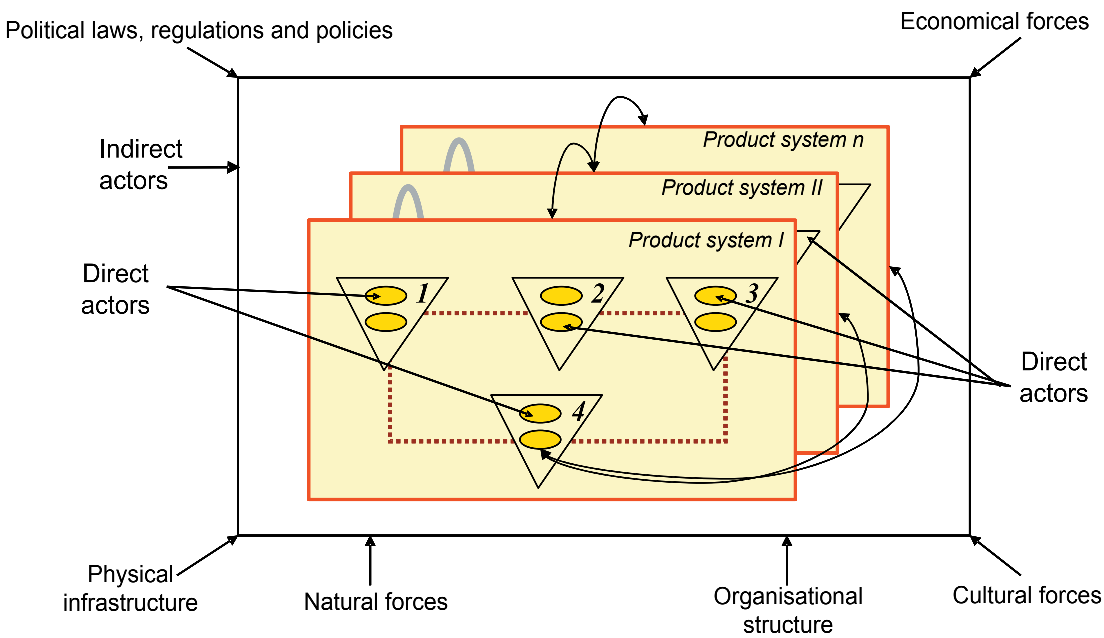


Figure 4.1 Material flows and influencing actors and factors

In a systems perspective, we analytically distinguish between direct and indirect actors, see Figure 4.1. Some indirect actors will have stronger influence to the material flows than others. Identifying the position of various actors can be done both theoretical and empirical. Some actors are pre-qualified for being particular important actors within EPR-systems, for instance producers and PROs. Then, an empirical study of the EPR-system will discover their actual influence. Further, in such a study, we are able to identify other influential actors in the particular EPR-system.

According to Giddens (1984), structure is either confirmed or altered through actors' actions. These structures comprise part of the factors that might be decisive for the industrial metabolism. White (1994) includes '…*economic, political, regulatory, and social factors*…' in his definition as factors that potentially influence the material flows and the environmental consequences of these. Moreover, Frosch (1994) suggests six areas of barriers to recycling: *technical, economic, informational, organisational, regulatory and legal*. Ehrenfeld (2000b) proposes 'barriers to sustainable practices' as *regulatory barriers*, *organisational inertia*, *economic obstacles* and *lack of market demand*. These factors can be connected to various actors, for instance lack of market demand is directly connected to consumers and indirectly to authorities that through *regulatory* mechanisms might influence the market demand. This clearly shows the importance of studying the actors in order to discover the key factors and key conditions for an effective system. That said, not only external factors influence a specific actor. Internal factors, both for corporates and individuals, have a current underlying set of beliefs, values and norms that are confirmed or altered through action and input from external factors, that all might be decisive for the decisions made and subsequently effects on the industrial metabolism.

Public policy is one of several influencing factors to industrial behaviour. Accepting that other factors may be equally or even more important, the analytical challenge is thus to examine the *relative importance* of policy instruments. We may, for instance, very well think of the situation where material flows are redirected towards increased recycling ratios, without any technological changes on a company level, any significant policy instrument, or any improved recycling facilities, but simply because this has turned out, for whatever reason, to be economically beneficial for the direct actors.

4.1 Specific analytical framework

Our main research question stated in the introduction is:

> *What are the key conditions for successful industrial implementation of collective EPR programmes in the Norwegian plastic packaging system, according to an industrial ecology perspective?*

Basically, the key conditions are understood here as those factors that influence the results of the industrial implementation of EPR. Through the case study (Part II) we will gather empirical evidence for analysing the research question and hence identifying the key conditions for an effective industrial implementation of EPR. Implicit in this analysis is to also discover the barriers and limitations for an effective implementation and, consequently, how to overcome them. As outlined above, this implies a two-step approach; i) analysing the overall system performance and ii) analysing the material flows, key actors and mechanisms within the system, as well as external factors outside the system.

To begin, we look into the overall results from the plastic packaging system. EPR aims at reducing the environmental effects of products throughout the life cycle. The targets stated in the Norwegian covenant on plastic packaging are 30 % material recycling, 50 % energy recovery as well as an un-quantified objective of 'waste reduction'/'packaging optimisation'. Obviously, the quantitative targets refer to loop closing.

As for waste reduction, we can think of primarily three strategies for obtaining this; i) dematerialisation, ii) increasing residence time of products in their use phase and iii) recycling. Although recycling is a waste reducing strategy, this is covered by the quantified targets, and we therefore focus on waste reduction strategies *before* the product become waste, or more precisely waste prevention as defined by OECD (2000), see Figure 4.2. Waste prevention is related to products while, for instance waste minimisation is related to waste.

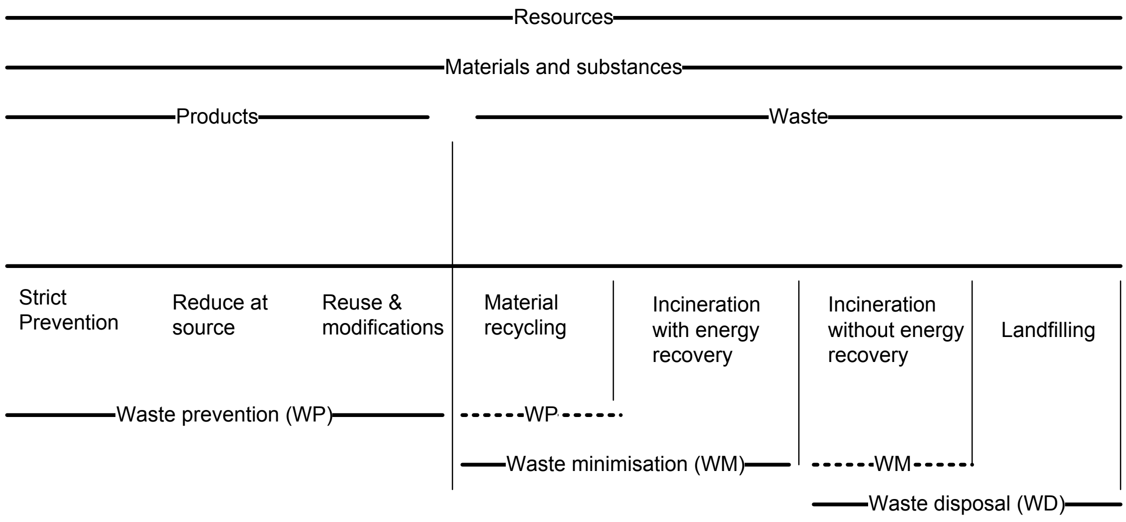


Figure 4.2 Defining waste prevention, waste minimisation and waste disposal. Modified from OECD (2000)

The overall strategy for obtaining this should be to i) minimise input of virgin material and ii) keep the material within the industrial system as long as possible. The latter point depends, however, on the energy demand for doing this and the difference in energy efficiency between the alternative products. Moreover, both strategies depend on how the products are designed. Since residence time is not possible to measure on an overall level, but needs to be studied on an individual product level, we will here measure waste reduction through dematerialisation. Hence, we will look at the developments of loop closing and dematerialisation during the time period 1995 – 2004.

This provides only however, knowledge on the overall system's performance. Therefore identifying the more detailed flows we are able to analyse the underlying parameters for the development of the indicators 'dematerialisation' and 'loop-closing'. However, going into details about the material flows does not provide any substantial information on *why* the flows become the way they are. A material flow analysis does not include assessments of the driving forces and decisive factors for the observed material flows. Thus, exploring the key conditions requires in-depth knowledge about the system of concern. Building on the general analytical approach presented above, this can be carried out in two interacting steps:

1. Analysing the internal metabolism on various levels in the system. This points to identifying where significant losses of material quantity and material quality are within the system.
2. Analysing key actors and key factors in order to understand the underlying mechanisms and drivers on various levels in the system. This points to studying actors on sector levels (PRO) and on company levels along the entire life cycle, including primary upstream companies, downstream companies and secondary upstream companies.

These analytical steps constitute the analytical framework for this study and are discussed below.

4.1.1 Overall systems performance

The analysis of the overall systems performance related to industrial implementation of EPR will be based on Figure 4.3. The system is plastics world wide, containing three subsystems i) plastic packaging in Norway, ii) non-packaging plastics in Norway and iii) plastics abroad. Although the plastic packaging system in Norway (that is the share of the plastic packaging in Norway that is under the covenant, conf. Chapter 1.3), is the main system to be analysed in this study, the two other subsystems interact with our core system through recycled material from plastic packaging to the production phases of the other subsystems ($X_{3,4}$ and $X_{3,7}$). $X_{3,4}$, for instance, is the flow from node 3 to node 4 in Figure 4.3.

However, Figure 4.3 is a simplified flow sheet as some flows are not indicated. For reasons of simplicity, we have not included for instance the export of collected plastic packaging waste to be recovered abroad. This is because the most interesting aspect with respect to the overall systems performance is how much of the generated plastic packaging waste ($X_{2,3}$) is actually recycled or recovered, and not where this is done. Hence, all Norwegian plastic packaging waste that potentially can be recovered, is recovered, whether this is carried out domestically or abroad, is included in $X_{2,3}$. Moreover, and due to similar reasons, we have not paid attention to the import of both virgin and recycled plastic packaging to 'plastic packaging in Norway', but rather aggregated all inflows of virgin material to 'plastic packaging in Norway' in flow $X_{0,1}$.

The material input ($X_{0,1}$) to the system contains two possible flows; virgin material and recycled material from other product systems. For all practical purposes, we assume that this flow entirely consists of virgin material. $X_{0,1}$ also includes what is imported either as bulk or as final plastic packaging. Further, input of recycled plastics to node 1 is assumed to come from node 3 (closed loop), although there might be imports from the other subsystems as well through $X_{0,1}$.

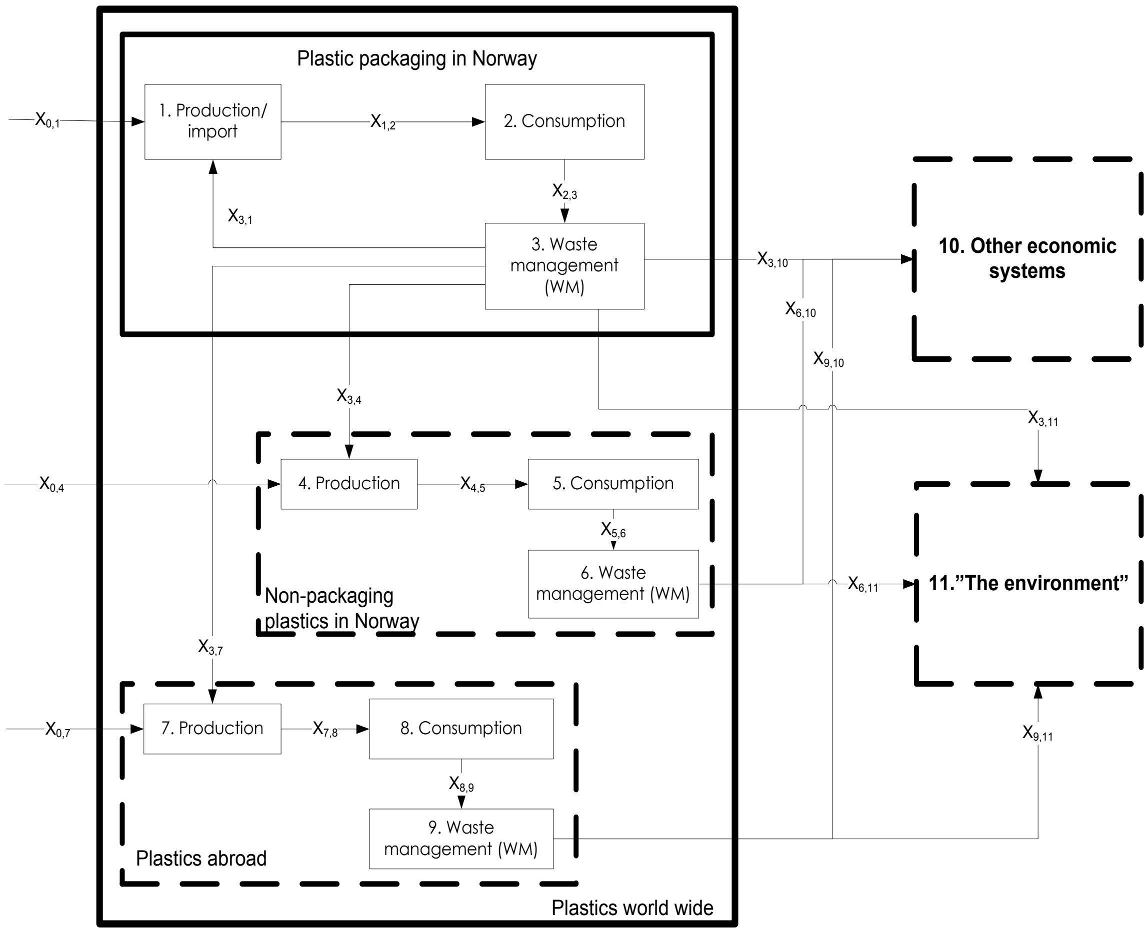


Figure 4.3 Schematic overview of the plastic packaging system.

The production phase consists of all activities and processes from extraction to final product. Consumption is the use phase with input of produced plastic packaging and output of plastic packaging waste. For plastic packaging with a lifetime of less than one year, produced ($X_{1,2}$) equals consumed ($X_{2,3}$). Only reusables may have a life time longer than a year, but these constitute only around 1 % of total material flows and are thus negligible (Skjervold 2003). Moreover, the output from node 3 is distributed in the five outflows $X_{3,1}$, $X_{3,4}$, $X_{3,7}$, $X_{3,10}$ and $X_{3,11}$. Node 10 'Other economic systems' represent energy recovery ptions like combustion with energy recovery.

4.1.1.1 Loop closing (waste management system)

Loop closing is here defined as the relation between the inflow of plastic packaging waste ($X_{2,3}$) and the outflows of recycled and recovered material, measured on a weight basis. The recycling ratio (α) can be expressed as

$$\alpha = (X_{3,1} + X_{3,4} + X_{3,7}) / X_{2,3}$$

while the recovery ratio (β), also including the plastic packaging going to energy recovery, is expressed as

$$\beta = (X_{3,1} + X_{3,4} + X_{3,7} + X_{3,10}) / X_{2,3}$$

where $X_{3,10}$ is the flow of plastic packaging waste that is energy recovered. For reasons of simplicity we consider the amounts going to feedstock recycling and chemical recycling to be within the flows $X_{3,1}$, $X_{3,4}$, and $X_{3,7}$ or feedstock recycled.

The expressions above are indicators of the quantitative performance of the system. Equally important to measure is the quality of the recycled material. Quality is defined in various ways. For instance, Sirkin and Ten Houten (1993) in their cascading theory have defined resource quality as 'an expression of a capacity to perform various tasks at various degrees of difficulty'. Thus, the effectiveness of the loop closing depends also on how the material qualities are employed in new products. If recycled material of a higher quality than needed is employed in new products, the efforts in the recycling system to obtain high quality are not optimal (Røine et al. 2001).

Another way of assessing quality is through the market mechanisms, by looking at the market price for recycled material compared to virgin material. The material value out of the recycling system depends on a number of factors, for instance the input quality (in $X_{2,3}$) and the costs of running the recycling system to get the specific material quality, and is therefore not an optimal quality indicator. We will, however, employ the value of the recycled material as an indicator of the quality because this represents the output from the system, it is comparable to the virgin material, and if we consider that the value of the plastic packaging waste into the recycling system is zero, it also expresses the effectiveness of the recycling system. That said, the discussion on material quality will be limited in relation to the quantity discussion as data on this is poor.

4.1.1.2 Dematerialisation (plastic packaging system in Norway)

Measuring dematerialisation has been subject to a number of studies, primarily on a national level, but also on sector and company level. When measuring loop closing above, we estimated the relations between inflows and outflows in the *waste management system* as an indicator for the degree of loop closing in the plastic packaging system. When measuring *dematerialisation* we consider the entire plastic packaging system in Norway.

As discussed in Chapter 2, dematerialisation is primarily about reducing input of material to a system. Including recycling in the system, we see from Figure 4.4 below that the dematerialisation dimension can be measured in at least two ways. First, dematerialisation can be related to total consumption ($X_{2,3}$) of material in the system, regardless of the source of the material. Second, dematerialisation can be measured as the net input of *virgin* material to the system ($X_{0,1}$). The distinction between these two indicators is the fraction of recycled material contributing to fulfil demand (consumption).

First, if dematerialisation with respect to waste reduction shall take place, the consumption of the material (in tons) must be reduced over time, $\Delta X_{2,3} < 0$. This may appear if for instance a function is fulfilled with less material (e.g. leasing (Stahel 1994) or electronic post (email) instead of physical, traditional post). Proper design of the products makes this possible. From an industrial ecology point of view, due to the assumption that recycled material causes less environmental burden than virgin material (particularly true for metals), another way of expressing dematerialisation is to assess the development of virgin material input ($X_{0,1}$) over time. Hence, if $\Delta X_{0,1} < 0$, then dematerialisation occurs. These two forms of dematerialisation are in absolute terms.

	Absolute dematerialisation *[tons/yr]*	**Relative dematerialisation** *[tons/GDP]*
Total consump-tion	**If $\Delta X_{2,3} < 0$**	**If $\Delta X_{2,3}/\Delta GDP < 1$**
Virgin Material Input	**If $\Delta X_{0,1} < 0$**	**If $\Delta X_{0,1}/\Delta GDP < 1$**

Figure 4.4 Various expressions of dematerialisation

However, dematerialisation is also frequently expressed as the relation between material consumption and GDP (Cleveland and Ruth 1999). The basic idea is that if the material consumption increases more slowly over time than GDP, then there is a decoupling between these indicators. The function is fulfilled more efficiently and thus, there is a relative dematerialisation, although the total consumption in fact is increasing. Hence, if $\Delta X_{2,3}/\Delta GDP < 1$ or $\Delta X_{0,1}/\Delta GDP < 1$, there is a relative dematerialisation, see Figure 4.4. Consequently, the upper left corner of Figure 4.4 is the preferred expression of dematerialisation, while the lower right corner is the less advantageous alternative.

The material flows ($X_{i,j}$) represent the plastic packaging only, while the GDP express the entire economy. In order to adjust the overall GDP to the most relevant sectors in Norway, hence leaving out the sectors with neglectable plastic packaging intensity, we develop the indicator 'GDP relevant sectors' and use this for expressing the economic activities within those sectors related to plastic packaging.

If all recycled plastic packaging were kept within the plastic packaging system in Norway, the indicator for dematerialisation could be expressed as $\Delta X_{2,3} = \Delta X_{3,1} + \Delta X_{0,1}$. In practice, however, the materials go to other product systems ($\Delta X_{3,4}$, $\Delta X_{3,7}$, $\Delta X_{3,10}$) as well. Say that the parameter γ express the relation between open loop closing ($\Delta X_{3,4}$ and $\Delta X_{3,7}$) and closed loop closing ($\Delta X_{3,1}$). If the answer to fraction $\gamma = X_{3,1}/(X_{3,1} + X_{3,4} + X_{3,7})$ is close to 1, the recycling system improves the dematerialisation of the plastic packaging system in Norway, while if the fraction's answer is close to 0, the recycling activities do not contribute to dematerialisation of plastic packaging in Norway. However, since we are not taking into account the inflow of recycled material from the other subsystems in Figure 4.3 we assume that export and import of recycled material to the plastic packaging system in Norway outweigh each other.

4.1.2 Opening the black box

In order to understand the key conditions for effective implementation of EPR, we ask: Where are the major losses of quantity and of quality, making the recycling ratio lower than 1? The answer provides useful information on where in the life cycle a key condition for successful implementation of EPR may be found, and consequently where to concentrate measures and strategies to improve the system. Hence, we need to investigate further the black box of plastic packaging recovery systems in Norway.

Moreover, we look at how the EPR policy instruments provide incentives for the producers to carry out changes upstream. Thus, our study is taking into account the efficiencies of the take-back scheme and the incentives for design changes upstream when analysing the industrial implementation of EPR.

We primarily employ two analytical levels: sector level and company level, and use material flow analysis and actor analysis in a combined manner. The system perspective is applied both for the material flows and for the actors. As noted by Ehrenfeld (2000,p 198) 'One must look inside a company to see what is really happening and to identify those activities that authentically represent the company's commitment to environmental excellence and sustainability'.

4.1.2.1 Disaggregating the material flows

'Plastic packaging' is a collective term for all types of packaging containing a majority of polymers. Being able to identify the loss of materials within the waste management system, we will disaggregate this material flow. There are at least three options to categories the disaggregated flows. First, the *type of product* expresses the functionality, properties of the product and/or for what purpose it is employed. Examples of categories within this group are: film, rigid packaging (bottles and cans), EPS and reusable packaging. Second, plastic packaging can be classified based on who the waste generators are, the *'markets'*, for instance an industrial company or a private household. Finally, the *type of polymers*, for instance low density polyethylene (LDPE), high density polyethylene (HDPE), poly propylene (PP) and PET. Table 4.1 below shows the various options.

Table 4.1 Categories of plastic packaging

Category of plastic packaging	Examples
Type of products	Film, rigid packaging, reusable packaging, PP-bags, EPS
Type of polymers	LDPE, LLDPE, HDPE, PP, PS, EPS, PET, PVC
Waste generator	Industry & commerce, agriculture, aquaculture, households

It is possible to use all these categories. However, the polymer category seems most complicated to employ due to the great variety of polymers and relatively poor data quality (Schjefte 2003). Conversely, in the actual recycling process, the polymers are what count, since it is technologically difficult to recycle mixed fractions of polymers with various melting indexes. That said, since we employ an actor perspective we select to follow products and markets throughout the empirical investigation.

Figure 4.5 illustrates the waste management system. The inflow to the system is $\sum_{i=1}^{4} X_{M1,i}$ which is the total amount of generated plastic packaging waste from the four markets; industry, households, agriculture and aquaculture. The latter two are separated from 'industry' partly because they are distinct systems within the Norwegian EPR scheme on plastic packaging, partly because data of high quality are available on this and, finally, partly because it will be more readily compared with EPR schemes abroad.

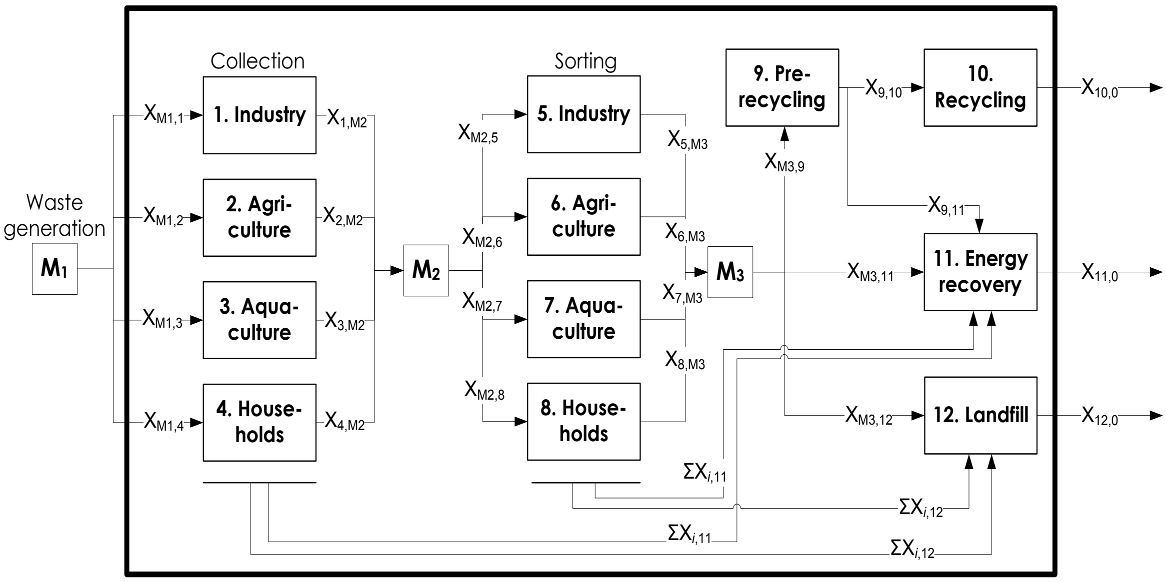


Figure 4.5 Processes and flows in a waste management system, box 3 in Figure 4.3

M_1 is the aggregated amount of generated waste, which is distributed to the four sectors as shown in nodes 1 – 4, 'sorting and collection'. These represent how the plastic packaging waste is sorted and collected at the waste generators' location. The collection efficiency is expressed as:

$$\eta_{\text{coll}} = \frac{\sum_{i=1}^{4} X_{i,M2}}{\sum_{i=1}^{4} X_{M1,i}}$$

Residual waste goes straight to landfill, while the rest is collected, sorted and pre-treated by a waste management company. These processes are illustrated by boxes 5-8, and the corresponding efficiency is

$$\eta_{\text{treat}} = \frac{\sum_{i=5}^{8} X_{i,M3}}{\sum_{i=5}^{8} X_{M2,i}}$$

The plastic packaging waste is sent to final treatment; recycling, combustion with energy recovery or combustion without energy recovery/landfill. The recycling efficiency can be expressed as:

$$\eta_{\text{rec}} = \frac{X_{10,0}}{X_{M3,9}}$$

For the entire system, the recycling output is $X_{10,0} = (\eta_{coll} * \eta_{treat} * \eta_{rec}) * \sum_{i=1}^{4} X_{M1,i}$

where $X_{10,0}$ is the output from recycling, $\sum_{i=1}^{4} X_{M1,i}$ is the input to the waste management system, η_{coll} is the collection efficiency, η_{treat} is the sorting efficiency and η_{rec} is the recycling efficiency, the latter including both box 9 and 10 in Figure 4.4. Based on Figure 4.4 above, we define the overall recycling ratio as $\alpha = \frac{X_{10,0}}{\sum_{i=1}^{4} X_{M1,i}}$ and the overall recovery ratio as $\beta = \frac{X_{10,0} + X_{11,0}}{\sum_{i=1}^{4} X_{M1,i}}$

Obviously, the indicators above can be employed on all four markets, indicating the efficiency and recycling ratios within these sectors. Moreover, and as described above, each of these flows can be expressed using the same formula. For instance, the inflow of industrial plastic packaging can be expressed as

$$X_{M1,1} = X_{M1film,1} + X_{M1rigid,1} + X_{M1ppbag,1} + X_{M1reuse,1}$$

where film, rigid, pp-bags and reusables represents the four type of products we will look at here.

A final dimension to be studied is how the plastic packaging is actually sorted and collected. For instance, the plastic packaging might be sorted for material recycling, sorted for energy recovery or not sorted at all (mixed waste). How the plastic packaging is treated, by for instance the waste generator, is particularly decisive for the loss of material. Various indicators can be developed from Figure 4.4 on this:

$\mu_1 = \frac{X_{M2}}{X_{M1}}$ (how much of the potential is collected by the waste generator)

$\mu_2 = \frac{X_{M2rec}}{X_{M1}}$ (how much is sorted for recycling by the waste generator)

$\mu_3 = \frac{X_{10,0}}{(X_{10,0} + X_{11,0})}$ (fraction of material recycling to total amount recovered)

These material efficiency indicators will be extended to also include the costs associated with processing plastic packaging waste to useful re-granulated plastics to be employed in new products. As Underdal (1992) notes, including the costs of a process provides information on how efficient the system actually is. Costs do not tell us anything about the effectiveness of reaching a target, just how costly it is. Cost studies are in a way important for the actors and their particular interests in the actual cases. Expressing the unit costs over time provides valuable information for analysing the *efficiency* of the waste management system, for instance:

$$\mu_4 = \frac{costs\,[NOK / year]}{X_{10,0}\ [kg / year]}$$

Only the costs of the PRO, Plastretur, will be included here as these represent the additional costs for redirecting the material flow towards the increased recycling ratio. The costs will distinguish between running costs and fixed costs. Running costs are those costs that are directly related to the material flows and that increase linearly to increased material flow. Fixed costs, on the other hand, are independent of the magnitude of the material flows.

Plastic packaging operates in close connection with other alternative packaging materials, for instance metals, glass and paperboard. Although these materials are outside the plastic packaging system, we will include them in the analysis since they mutually influence each other. This reflects the position that the dematerialisation may appear part of an actual dematerialisation activity of plastic packaging products. However, it might also be that the amount is reduced due to the substitution of one packaging material with another.

These indicators will be analysed along a timeline, basically from 1995 when the covenant on plastic packaging was signed until 2004. The intention is to discover trends that might help to explain the overall recycling ratios and dematerialisation. The timelines are indexed with 1995 as the base year. Finally, data is collected from various sources.

Statistics Norway provides information on the GDP, while Plastretur, Plastics Europe and Mepex provide the main information regarding material flows and costs.

4.1.2.1 Key actors and influencing factors

As mentioned in Chapters 2 and 4.1, we include an actor perspective in this study. In this part of the analytical framework, where we are entering the core of the plastic packaging system for finding explanations for the observed, quantitative trends displayed above, identifying the key actors is the starting point for getting closer to the key conditions.

First, we distinguish between sector level and corporate level. On the sector level, we find actors and groups of actors that contribute to the overall systems performance. We make a distinction, for analytical purposes, between direct actors and indirect actors. The most important groups of direct actors are the producers, the consumers and the end-of-life actors. Each of these has a particular role in the system. Further, each of these groups consists of sub-groups of actor, for instance 'plastic packaging producers', 'packers and fillers' and 'retailers', all having their particular roles as well. In order to analyse the key conditions for successful industrial implementation of EPR, we will during the empirical investigation explore the various roles of these groups of direct actors.

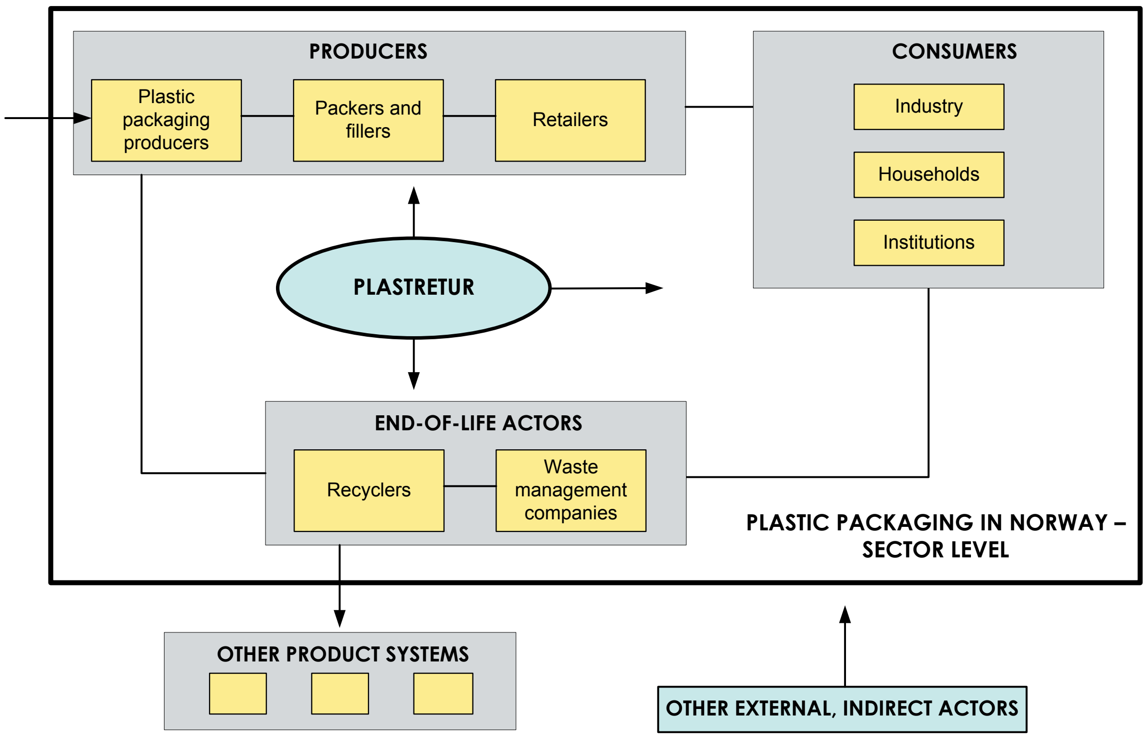


Figure 4.6 Actors on sector level in the plastic packaging system in Norway

Figure 4.6 illustrates various actors within the plastic packaging system in Norway.

Plastretur as the PRO is given a key position, being the main indirect actor. Other indirect actors will through the empirical studies, be mapped and their roles will be discussed. In Chapter 7, we study all the groups of actors shown in Figure 4.6.

We employ Giddens' structuration theory for looking into these groups of actors and organisations. According to Giddens, the way actors behave relies on four interplaying categories of structure. As mentioned in Chapter 2, the allocable and authoritative tools and resources give power to actors to carry out intended actions. In the case studies we will thus look for the strategies, resources and power the actors have to carry out intended actions as knowledgeable actors. This ability is indeed depending on their power relative to other actors as well. This underlines the important interplay between the actors being decisive for the final outcome. However, there are underlying sets of beliefs and norms within each corporation and individuals that also contribute to the decisions made and the actions taken. Understanding why corporates act the way they do, is of key importance for understanding the relative importance of EPR and consequently the key conditions contributing to effective implementation of EPR.

This requires that the analysis is carried out on the company level as well. The company level is the single companies in the boxes in Figure 4.6, for instance the companies hidden behind the label 'packers and fillers'. It is on this level, within these companies, that important decisions are made related to innovation and product improvement, and the effects of the EPR policy instruments can be understood (Ehrenfeld 2000b). For instance, as noted by (Fagerberg 2005), in order to comprehend 'innovation', understanding the decisions made in companies and organisations is imperative, as well as the exogenous conditions that influence these processes. We will put particular emphasis on understanding to what extent technological change and innovation have occurred within companies and the role of EPR to this. Is it really so that EPR '…force designers and planners to consider issues left out of the customary focus on cost and performance' (Ehrenfeld 2001, p 224)? In short, do EPR policy instruments enforce upstream companies to act differently so that they contribute to making the recycling target easily achievable, for instance through design for collection and recycling?

Moreover, we will look into the organisational aspects within the companies being decisive for the product changes that, on an aggregated level, might contribute to higher recycling ratios. However, in order to analyse the relative importance of EPR to these observed changes, we will get a broader picture of the organisations, by looking at what happened prior to the introduction of EPR. We will study how the corporates have changed on other resource related areas that are not directly relevant for EPR and the take-back schemes, for instanced energy efficiency, resource utilisation and internal waste and waste water treatment. And finally, how has EPR contributed to changed norms and beliefs concerning their way of considering resource related challenges?

In concluding the analytical framework for studying key actors and factors, we will analyse various actors on different levels and positions in the life cycle, and particularly focus on their incentives for carrying out changes (e.g. innovations and design for environment) that contribute to improved overall systems performance.

4.2 Research method

The research question contains two main parts: 'key conditions' and 'successful industrial implementation'. The latter is the dependent variable that we will explain, while 'key conditions' are the independent variable. In order to identify the key conditions, we must therefore operationalise 'successful industrial implementation'. As discussed above, loop closing and dematerialisation are characterising the performance of the EPR system, and are thus indicators for the dependent variable. We measure these for the period 1995 – 2004 and look at the development over time to determine if it is a 'successful implementation'.

We interpret *improvements over time* as 'successful implementation'. Improvements with regard to loop closing and dematerialisation are about increasing the recycling ratio and reduce the material consumption, as explained above. Identifying where the flows of plastic packaging face significant losses of material quantity and quality is thus important in order to understand the development over time. In the covenant, exact targets are given (30 % material recycling and 50 % energy recovery), but we will not make a strict definition of successful saying that reaching the targets implies a 'successful implementation', while below this is not successful. In this study, we are interested in studying the mechanisms and driving forces, and learning from these processes. The targets are therefore not the important aspect. However, they will be used as points of reference, but not for defining 'successful'. In our definition, thus, successful implementation of EPR is that we can see improvements over time connected to loop closing and dematerialisation.

We will employ various data sources available on the Norwegian system for plastic packaging. Our main source of information is a study carried out by Mepex Consult for Plastretur (Plastretur 2002a). This study estimated the total amount of plastic packaging entering the Plastretur system in year 2001. Plastretur thus employed this to determine an updated denominator for calculating the recycling ratio reported annually to Norwegian Pollution Control Authority (SFT). This study was updated in 2004 (Bjørn and Syversen 2004), and we have employed these updated numbers for 2001 as our base year. In order to develop time series for the period 1995 – 2004 we have employed data on growth rates from Plastics Europe (2005). This will be discussed in more detail in Chapter 6.

When the time series are identified, what will we look for in order to find the key conditions? We expect to find the critical factors at places where the losses of material quantity and quality are largest. We will therefore look at the processes and the flows of plastic packaging within the system. However, in order to understand why losses appear at these places, we will also look into the actors that influence these critical phases.

Key conditions for successful implementation of EPR can be studied from primarily two aspects. First, the key conditions for achieving high degree of loop closing (downstream-related) and second, the key conditions for stimulating upstream actors to design differently in order to obtain dematerialisation or to prepare the ground for making the recycling as effective as possible

The key conditions can be considered as critical factors for improving the loop closing and dematerialisation when implementing EPR. We are also looking for barriers to successful implementation. What seems to be the barriers for moving towards the targets or for improving the recycling ratio or increase the dematerialisation? We are not stating that if these conditions are fulfilled, then the implementation of EPR will be successful. We are rather saying that these are critical factors during the implementation of EPR for making it successful, hence improve over time.

The 'key conditions' will be developed based on the empirical investigations and not on theory. We will, however, discuss our findings in relation to literature on the field in order to bring new knowledge to the field.

As we have elaborated more closely in Chapter 1, the case for this study is Norwegian plastic packaging industry. Within this system 17 organisations have been studied. The main organisations are Plastretur and Tine Norske Meierier (Tine). We will go more in detail on these organisations in Chapter 7 and Chapter 8 respectively. The reason why selecting individual companies (and not the whole sector since this is a collective system) is to learn more about how companies act according to a public policy and to learn more about whether EPR has initiated other industrial ecology practices than present in EPR initially. If it has, it would be called a successful implementation in an industrial ecology perspective.

The selection of Plastretur as the first main case is due to several reasons. First, the organisation has a key role in the system and represents an institutional addition compared to before. Second, Plastretur is by far the company with greatest knowledge to the overall system. Its raison d'être is to have responsibility on sector level. Third, the overall objectives for Plastretur are related to the overall system performance, which is contrary to the profit-seeking organisations on company level.

This study is based on a number of interviews during the period 2001 – 2005 with employees at all levels of the organisation, on participating observations for longer periods and on direct participation in the daily business activities. In practice unlimited insight into the statistics, both related to material flows and financial data, has provided a quantitative basis for the study of Plastretur.

The selection of Tine as the second main case study rests on several factors. First, Tine pays more in fees to Materialretur than any other company. They are significant consumers of both inner and transport packaging, contributing to Materialretur with more than 5 % of the total licence fee paid by plastic packaging companies. Second, their apparent environmental profile and environmental raw material make the company directly exposed to the issues we are discussing here. Third, we might expect that this company has the motivation and resources to change their packaging routines. Fourth, they control the entire value chain from 'field to table', which indicates that they presumably have a wider life cycle perspective already inherent in their organisation, and that they might have quantitative data on various parameters over a longer period of time. Finally, Tine is owned by farmers that are directly related to the covenant by the plastic packaging waste that is generated due to storage of the feed/hay.

This study is based on more than 25 in-depth interviews with employees at various levels and organisational roles in the period September 2001 – October 2003, and on Tine's annual reports, annual environmental reports, statistics provided by the staff as well as on secondary literature about the company. A complete list of interviewees are found in Appendix B

The analysis is also based on empirical data from 16 other companies. They are selected on the basis of their anticipated influence. Recommendations from Plastretur on whom to pay attention to were significant. In addition, companies were selected so that there were representatives from literally the entire value chain from virgin polymer producer to consumers and waste management companies and finally to recyclers and users of recycled material. In order to supplement the Plastretur case on sector level, we needed to get an overall view of the Plastretur EPR system as seen from the individual companies' point of view. Therefore, a web-based survey among companies along the plastic packaging value chain was conducted to get statistical evidence on the trends that could be further studied and understood through the single company studies. In addition, data has been collected from annual reports, personal providence, official documents and evaluation reports, as well as from several interviews with selected indirect actors. Finally, a three months visit to the Norwegian Ministry of Environment was carried out in order to better understand the processes of policy implementation.

How the data will be interpreted is elaborated in detail above. Empirical results will be the basis for developing key conditions which will be discussed against existing literature in this field.

5. POLITICAL IMPLEMENTATION OF EPR ON PLASTIC PACKAGING IN NORWAY

The political implementation of EPR on plastic packaging in Norway was, according to our definitions made in Chapter 3, completed on 14th September 1995. On that date the negotiated agreement was signed and the policy framework for industrial implementation of EPR was in place. In order to better understand the industrial implementation of EPR on plastic packaging in Norway, this chapter provides a glimpse into the outcome of policy processes prior to the industrial implementation.

5.1 Prior to a comprehensive waste policy

Norway experienced remarkable economic growth during the decades after Second World War. The down side of this was increased pollution in the air, water and soil as well as increasing amounts of solid waste. A growing public debate on natural resources, the consumption of these and pollution followed the international debate initiated by Rachel Carson with her book *Silent Spring* in the beginning of the 60's (Carson 1962), and culminated in 1972 when Norway as the first country in the world to do so, established Norwegian Ministry of Environment (NMoE) (Jansen 1989, Nøttestad 2000)[1].

The first major attempt to design a preventive and holistic pollution policy was through the White Paper No 44 (1975/76) 'Strategies and measures against pollution' (NMoE 1975). It focused on issues such as accumulation of toxic substances, ocean pollution, acidification and long-term climate change, but was rather weak on waste issues. A holistic waste policy was not developed until 1992[2].

Two main pieces of legislation are administrated by the Norwegian Ministry of Environment; the Product Control Act (NMoE 1976) and the Pollution Control Act (NMoE 1981). The Product Control Act concentrates mainly on hazardous substances and the problems arising from acute pollution[3]. The Pollution Control Act has been the corner stone in Norwegian pollution policy[4] (Stokkeland 2000). It states a general prohibition against littering. Local authorities are responsible for collecting consumer waste[5] and 'consumer-like' waste from small companies and treat this in an environmentally friendly way (§30). The local authority should "determine a fee to cover the costs associated with the waste sector, including collection, transport, reception, storage, treatment, control, etc" (§34). The costs shall be fully covered by the fee. Industrial companies were, according to §7, responsible for their own production waste. In the amendment in 2004, 'consumer waste' was substituted with 'household waste', which did not include 'consumer-like waste from small companies'. This fraction is now defined as industrial waste, together with what previously was defined as production waste. This change, thus, extended the responsibility of the industry.

After the Pollution Control Act came into force in 1981, an 'Action plan for recycling' was developed, and there were some pilot projects carried out on recycling of paper, plastic and organic waste. These projects, however, failed in selling the recycled material and were terminated without any success (Nøttestad 2000).

5.2 From White Paper to EPR

Environmental issues re-entered the Norwegian political and public arena via the UN Report World Commission for Our Common Future (WCED 1987). Industry started to look at environmental issues as business opportunities, and media and environmental NGOs achieved increased attention on pollution issues (Dahle 2002). They became significant factors for influencing industrial and governmental activities (Nøttestad, 2000). Another important trend was that local authorities, from the late 1980's received earmarked grants for implementing waste management plans (Opoku 1999). These annual grants were phased out in 2002.

The White Paper 44 (1991-92) (NMoE 1992) became the fundament for waste management in Norway throughout the 90's[6]. A large majority of the Norwegian Parliament supported its main ideas and strategies of a holistic waste policy. It stated that socio-economic considerations should be the basis for decisions concerning waste management. Due to the uncertainty however, about knowing the exact environmental consequences of the different waste management options, the principle on prioritising preventive strategies when the options seemed "approximately equal" was stated (p. 7). Hence, the waste hierarchy was introduced as a guiding principle.

The White Paper argued that in order to reduce the amount of waste to disposal sites and at the same time increase recycling, the actual costs of waste management should be reflected in the product price and become visible for the producers, importers, distributors and consumers. Primarily two options were suggested; i) fiscal taxes on packaging as an extension of the existing tax on beverage packaging and ii) the need for "the industry to take responsibility for recycling of products and materials" (page 7). It was nevertheless necessary to create incentives for the industry to include waste management aspects in product design and production, so that "the consumers were influenced to either avoid the product or buy a more environmentally friendly product" (page 7).

There were additional reasons for suggesting increased responsibility to the industry. Firstly, the industry had technological knowledge to cope with such problems. Secondly, the trend in Europe was going in the same direction where, for instance, Germany, Sweden and the Netherlands all were ahead of implementing this new type of policy. Simultaneously, the European Union was developing a directive on packaging and packaging waste (EU 1994) and Norway would have to comply with this. Moreover, the increasing internationalisation of Norwegian industry made this necessary. Thirdly, the traditional role of SFT as a controller had become both very extensive and expensive, and giving the producer's increased responsibility would reduce the administrative costs of SFT and NMoE (Hambro 2000). The role of the authorities "should be to set the targets and control that these are reached" (p 7). Finally, the environmental problems were more diffuse with several actors and required another type of policy than the traditional command and control policies (Aanestad, 2000).

Packaging was regarded as a major area for the follow-up of the White Paper 44 because it constituted a major part of the household waste, the amount was increasing and it was short-lived; this meant that experience from implemented strategies and measures could be gained relatively quickly. In addition, packaging was an important symbol of the consumer society (Berntsen 2005) and packaging was in focus in several European countries through the Packaging Directive (EU 1994).

In the 1994 National Budget, in autumn 1993, a tax for one-way beverage packaging was approved, creating benefits for reusable beverage packaging. In the revised the National Budget 1994, in spring 1994, the Government took this a step further by suggesting a packaging tax on some conserved food products. The Parliament postponed this because it wanted to create a comprehensive tax system for packaging based on types of packaging material (not on type of product) and asked the Government to propose strategies for extending the fundament for taxation on packaging, aiming to implement this in 1995. The basic intention for this was the need for stimulating increased use of packaging that is suitable for environmentally friendly collection and recycling and establishing effective recovery systems for several product groups and types of packaging.

In the 1995 National Budget in October 1994 (NMoF 1994), the Government re-suggested a tax of 1 NOK/per unit for hard sales packaging on all food products. This was, once more, postponed by the Parliament who asked the Government to propose a general plan for all packaging waste, including an overall system of taxation and of policy instruments, aiming at establishing recovery systems for these products. Moreover, the industry strongly opposed these suggestions on packaging tax, which would have increased the average costs by more than 12 % (Røsrud 2003), and consequently they took up the suggestions from White Paper 44 to establish a producer responsibility based on voluntary agreements, and developed the industry's model for obtaining the environmental targets (NHO 1995, Bjerk 2005).

Simultaneously, the Ministry of Environment had in 1994 invited industrial representatives for the plastic packaging value chain and appointed a working group to "suggest organisational and economic practical solutions for increased collection of plastic waste for recycling in Norway, including suggestions on policy instruments for obtaining this"[7] (NMoE 1995e, p.5; Mepex 1994). The working group, lead by the Ministry of Environment and consisting of eight representatives from the plastic packaging value chain, concluded, based on socio-economic analysis, "with considerable uncertainty in the analysis" (NMoE 1995e, p. 14), that "through the ongoing processes of reduced material consumption per produced unit and other waste reduction measures, the generated amount of plastic packaging might be reduced by 30 % by 2000, based on the market share and ranges of use that this material has today"[8]. The working group suggested the targets to be 30 % material recycling and 50 % energy recovery and that the plastic packaging chain should have the responsibility for achieving these targets within a certain deadline, formalised in a covenant between NMoE and the industrial representatives. It is, however, generally accepted both within and outside this group that this specific target was more based on political processes and negotiations between industry and NMoE, than on exact scientific results and calculations.

In the revised National Budget for 1995 (NMoF 1995) in May 1995, the Government presented two alternatives for the part of the packaging waste that is not included in the present taxation system; i) an expansion of the current environmental tax on beverage packaging to include all types of packaging, or ii) the suggestion by the working group. The Government argued that "when choosing a policy instrument a key point is to find solutions that contribute to the wanted environmental objectives at the lowest cost possible for society"[9] and concluded that it will support giving the responsibility to the industry. The main reasons for this were partly the problems of delimitation with a taxation system and partly that the industry itself showed willingness to take this responsibility. The Parliament approved this. If it was not possible to make agreements with industry or the industry did not achieve the targets, the Parliament would suggest taxation instead.

5.3 The covenant of 14th September 1995

The subsequent discussions between the NMoE and representatives from the plastic packaging chain followed the same lines as the working group had agreed upon (Røsrud, 2000). The covenant was signed on 14 September 1995. The overall objective was to "reduce environmental problems caused by plastic packaging waste by reducing the generated amount and by increasing the collection and recovery of this waste, where this is justified based on environmental, resource and economic considerations" (NMoE 1995a, p 1). The scope was all-inclusive, except for the plastic beverage packaging and packaging with content of hazardous substances, which were facing alternative legislation.

The covenant stated that the plastic packaging industry should establish a non-profit PRO by the end of 1995, and only corporates within the plastic packaging chain could own shares. On the contrary, corporates that were primarily within the downstream phase undertaking collection, sorting or recycling, were not allowed to participate in the PRO. The composition of owners should be equally distributed along the value chain, and all corporates within this chain were allowed to participate in the recycling system established by the PRO. Moreover, the PRO should aim at finding solutions for reaching the targets at lowest possible costs, and actively stimulate competition in all phases of the recovery system. Finally, the plastic packaging chain was responsible for financing the activities necessary to achieve the targets.

The covenant stated explicitly that the plastic packaging chain should, together with corresponding PROs for other packaging materials, strive at carrying out waste reducing measures and report it annually to SFT. Moreover, the plastic packaging chain should establish a collection and recycling system by 1st July 1996 and by 1999 reach, at a minimum, 30 % material recycling and 50 % energy recovery. Particular targets were set for EPS at minimum 50 % material recycling and 10 % energy recovery.

Moreover, the plastic packaging chain was given the responsibility to provide needed information to consumers and local authorities to ensure that the targets were met. By 1st April each year, the PRO should report to SFT the result, costs, and participants in the system and waste reduction efforts. On the other hand, the NMoE should contribute to "prepare the ground for an effective collection and recycling of plastic packaging waste", and make sure that proper statistics on generated waste exist.

Recalling the classifications of EPR policy instruments in Chapter 3, this covenant primarily targets producers outside their core industrial areas. However, the point of waste reduction points towards their core activities, which presumably would provide stronger incentives for the producers. On the other hand, there is no quantified target related to waste reduction, which might undermine this potential. This will be studied more closely and discussed in the succeeding chapters.

(Endnotes)

[1] For more on the establishment of Norwegian Ministry of Environment (NMoE), see Jansen 1989 and Nøttestad 2000.

[2] Major reasons for this was i) lack of knowledge on these complex waste issues, ii) waste was not regarded as that urgent compared to other environmental problems such as oil pollution, acid rain, protection of hydrometric areas, general water- and air pollution from point sources, iii) the local authorities, with poor economies resisted strong efforts and measures on this, and particularly the NIMBY (not in my back yard) sentiment was prominent, and iv) waste was not internally prioritised by the NMoE.

[3] Under this Act are regulations such as deposits on automobiles and lead batteries. The latter is the first EPR oriented regulation in Norway. The deposit system for automobiles was the first of its kind in the world and was the first governmental attempt to increase the recycling of a certain product. This system is

6. OVERALL SYSTEMS PERFORMANCE – DEMATERIALISATION AND LOOP CLOSING

As discussed in Chapters 2 and 4, the industrial metabolism and patterns of material production and consumption might be expressed through a variety of indicators at different points of the life cycle. We have chosen to focus on two 'industrial ecology' indicators that are of high importance when characterising the resource perspective of EPR systems, dematerialisation and loop closing. A fruitful entrance when studying defined systems is to provide some insight to the context (the 'surroundings'). The EPR systems presented below are parts of the larger material flow patterns in terms of geography, type of materials and sectors.

There are indications that the total material requirements worldwide are increasing in developed countries, although the material intensities show a slightly declining trend (Adriaaanse et al 1997). Similarly, decoupling between economic growth and resource throughput per capita and per unit gross domestic product (GDP) is observed for some countries, but the absolute resource use and waste flows continue to grow (Matthews 2000, Page xi). Figure 6.1A illustrates an increasing trend of domestic material output in some selected countries, hence no absolute dematerialisation. There are however, decreasing trends in the material outflow intensity (Figure 6.1B).

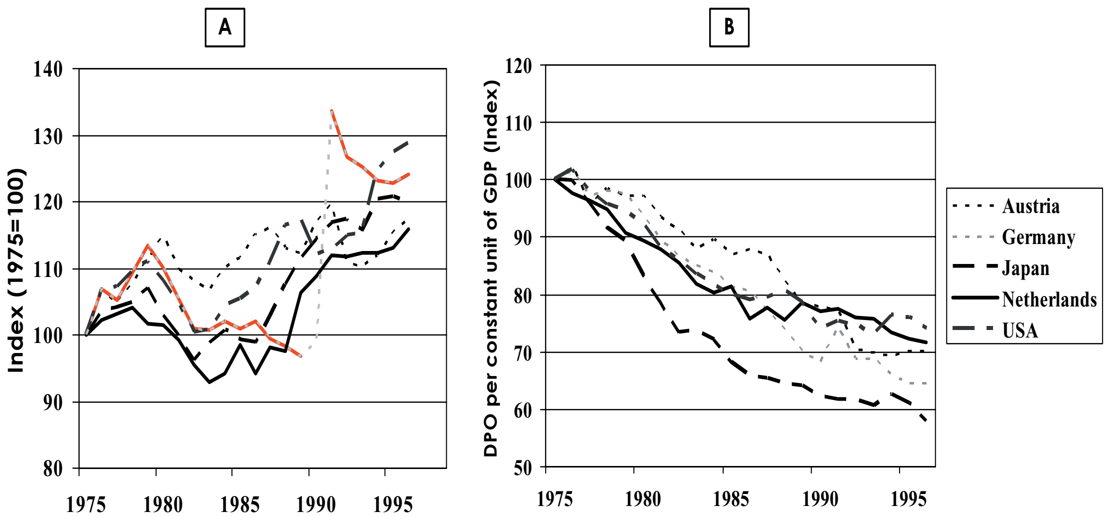


Figure 6.1 Domestic material output (A) and domestic material outflow intensity (B) in the period 1975 – 1996 Source: Matthews 2000

Such studies analysing the overall input, throughput and output have not to date been carried out for the Norwegian economy (Skogesal 2004a). However, the solid waste generation has increased by 13.4 % in the period 1993 – 2003, see Figure 6.2, indicating no absolute dematerialisation. Simultaneously, GDP has increased by 37.0 % in the same period. Hence, there is a decoupling between GDP and waste generation and thus a relative dematerialisation on this issue. Moreover, the growth in household waste generation is considerably higher than the growth in industrial waste generation in the same period, 56.1 % and 5.6 %, respectively. Consequently, there is no relative dematerialisation for household waste.

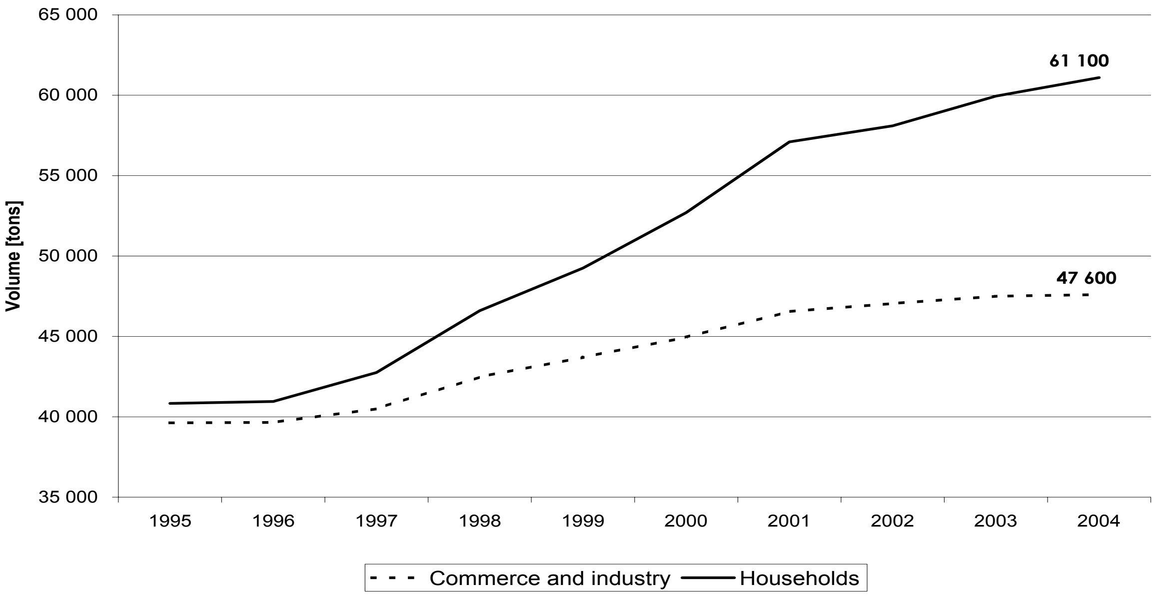


Figure 6.2 Development in total amount of waste and gross domestic product (GDP) 1993 – 2003 in Norway. Indexed 1993 = 100. Modified from NMoE 2005, quality checked by Skogesal (2005a,b)

Equally important as waste generated, is how this waste is treated. Figure 6.3 gives the fractions of various treatment methods in Norway in the period 1995 – 2004. We see that the actual amounts to landfill have decreased in the period, from 24.3 % to 18.0 %, despite the 13.4 % increase of generated waste. Measured in tons, the amounts to landfill have been relatively constant (NMoE 2005). The material recycling has increased from 27.7 % to 30.4 % during the same period. We also see that a higher amount of waste is material recycled than that which is landfilled. Still however, 32 % of total generated waste faces unknown treatment.

Total plastic consumption in Europe rose by 5.6 % from 2001 to 2003 (Plastics Europe 2005). Consumption of plastics as a material has grown 5 times since 1970, while other materials such as steel and aluminium have grown less, 1.7 and 2.8 times, respectively. The mechanical recycling of plastics rose by 11.3 % measured in tons, keeping the recycling ratio at around 14 % of total consumption in 2003. Plastics to landfill in Europe is on a 1993-level. Hence, relatively speaking, the recycling ratio has increased.

As for packaging, it remains the largest fraction at 37.2 % of total consumption in

2003, up 1.3 % from 2002. Mechanical recycling of post-user plastic packaging waste increased by 12.6 % in Western Europe in 2002, while plastic packaging waste increased by just 3.5 %. Consequently, the recycling rate for plastic packaging went up from 20.5 per cent in 2001 to 22.4 % in 2002.

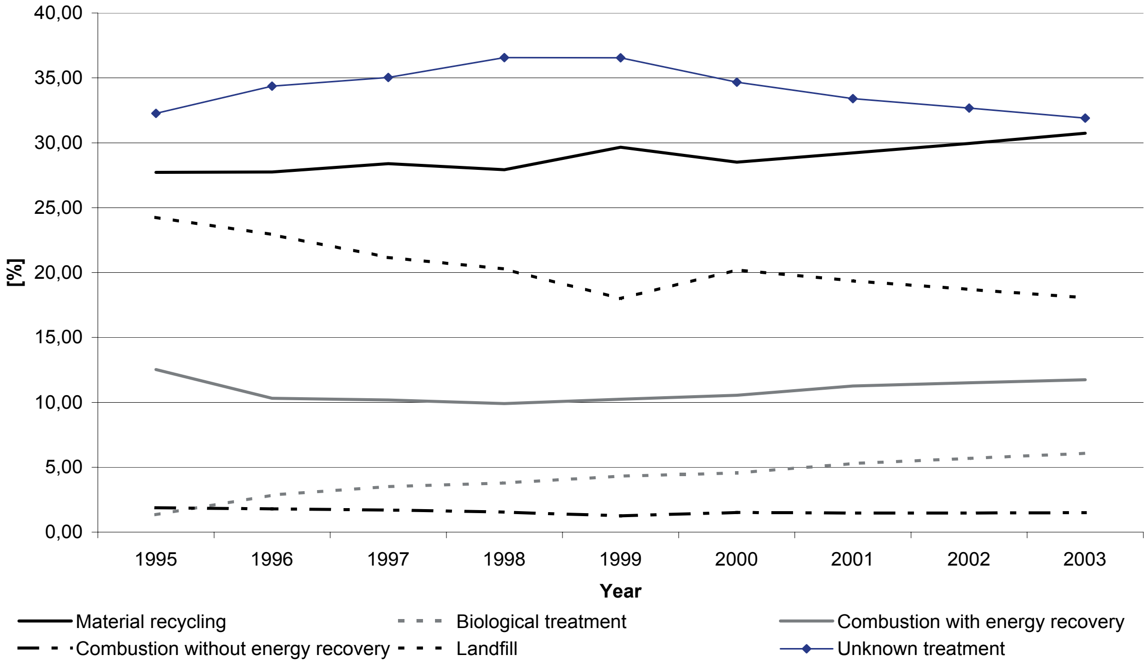


Figure 6.3 Percentage of various treatment methods 1995 – 2003 in Norway, measured in percentage of generated waste. Source: NMoE 2005

Given this introduction, in this chapter we will provide empirical information on loop closing and dematerialisation for the plastic packaging system in Norway. In addition, we give empirical information along two axes relevant for the plastic packaging system: i) other EPR systems in Norway and ii) EPR-systems on plastic packaging abroad. These are used later on as reference cases in the analysis.

6.1 Dematerialisation and loop closing plastic packaging in Norway

In order to calculate dematerialisation and loop closing in the plastic packaging system in Norway, the plastic packaging waste generation and the amount of recycled plastic packaging must be known. The official number on plastic packaging waste in 1995 was 95,600 tons (NMoE 1995e), but has been subject to some modifications since then.

As mentioned in Chapter 5, NMoE has been responsible for developing sufficient statistics on plastic packaging waste generation. Statistics Norway has on behalf of NMoE executed this task (Statistics Norway 2000, 2004, 2005). Their calculations are on plastics as a material group and not on packaging in particular and thus do not perfectly suit the purpose of this study. However, if we employ the most recently 2004-statistics (Statistics Norway 2005), and the assumption that packaging comprises 22 % of the total plastics consumption (Statistics Norway 2000), this corresponds rather well with the official numbers from 1995.

According to the covenant, SFT receives annual reports from Plastretur (1st of April) where the results achieved for the previous year are reported. In order to calculate the recycling and recovery ratio, Plastretur must employ a specific denominator reflecting the plastic packaging waste generation. By approving the recycling and recovery ratios, SFT also accepts the denominator used, hence being the official one.

Plastretur has throughout the years carried out two main studies to obtain a more precise denominator to be used in the annual reports to SFT (Plastretur 2000, 2003). The first study calculated the supply of goods to the market ($X_{1,2}$ in Figure 4.3) in 1998, primarily based on statistics from Statistics Norway. The second study calculated the plastic packaging consumption in 2001 and was based on triangulation of various sources: licence fees reported to Materialretur (the PRO responsible for gathering licence fees from all ‘packaging-PROs’), on the sector categorisations taken from NACE-codes, and on the packaging intensity in each sector. The 2001-numbers was later on updated in another study based on improved data basis (Bjørn and Syversen 2004).

However, the scientific basis and legitimacy for these denominators are beset with substantial uncertainty (NMoE 2000, Syversen 2005, Skogesal 2004b). For instance, according to Plastics Europe packaging comprised 37.2 % of total plastic consumption in 2003 (Plastics Europe 2004), which is a considerably different number than the 22 %-assumption by Statistics Norway. In order not to be that far from the official numbers reported to SFT (and thus to EU), we take the studies carried out by Mepex for Plastretur as the starting point for calculating the plastic packaging waste generation in the period 1996 – 2004[1]. According to those who carried out the two relevant Plastretur-studies, the last study with 2001-numbers is most reliable as the quality of the underlying data for this study was better (Syversen 2005).

In order to develop time series for the plastic packaging waste generation, we employ statistics from Plastics Europe to extrapolate the growth rates for the period 1996 – 2004 (Plastics Europe 2004, 2005). These statistics are based on numbers from polymer manufacturers and their production and sales data, indicating the volume of plastics and the distribution between various product groups[2]. We have weighted the household waste with 2/3 and industrial waste with 1/3 of the overall growth, according to Plastics Europe’s estimates (Plastics Europe 2004, p 7) and to Statistics Norway’s conclusion that the main growth in waste has appeared in households and not in industry, conf Figure 6.2. Moreover, we assume that the plastic packaging that becomes waste one year is also recycled the same year as there is only a marginal time delay in these processes. We also assume that the reusable packaging constitutes a negligible fraction that does not disturb this picture.

6.1.1 Consumption and waste generation – dematerialisation

Figure 6.4 shows four various calculations on the amount of plastic packaging generated waste. Statistics Norway (SSB) is represented with two estimates, based on their 2004-study (Statistics Norway 2005). One line shows the amount of plastic packaging waste if we employ Statistics Norway's own estimates of 22 % packaging of total packaging. The second SSB-line relies on Plastics Europe's assumption that packaging represents 37 % of all plastics. The third line shows the official numbers annually reported by Plastretur to SFT (Plastretur 1997-2001, 2002b, 2003-2005). The last line is our estimates based a variety of sources as explained above. In the continuation, we will employ our own estimates.

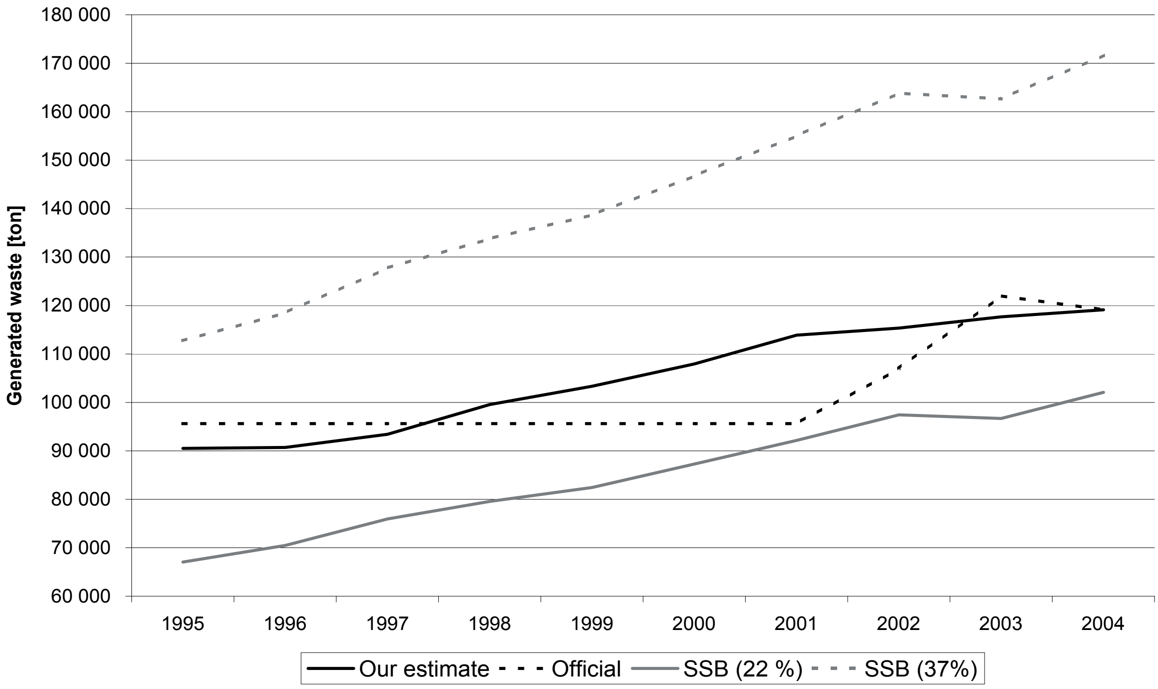


Figure 6.4 Time series on the denominator for Plastretur 1995 – 2004

All four graphs show an increasing trend. The growth rates for 'Our estimate' and 'SSB (22%)' show a rather similar trend, more than 31 % from 1995 to 2004, while 'SSB (37%)' increases somewhat more. Hence, there is no absolute dematerialisation in the plastic packaging system in Norway. We employ our estimates on the time series in the following analysis.

Figure 6.5 expresses the relation between the annual growth rates of the denominator (flow $X_{2,3}$ in Figure 4.3) and GDP. The latter is given as 'GDP relevant sectors' and 'overall GDP', as discussed in Chapter 4. If the ratio 'plastic packaging waste generation/ GDP' is lower than 1, the growth in plastic packaging consumption is lower than the growth in GDP, indicating a relative dematerialisation. The ratio 'plastic packaging waste generation /GDP relevant sectors' shows a relative dematerialisation, as the growth in denominator in the period 1996 – 2004 is 31 % while the growth in GDP in relevant sectors in the same period is 44 %, giving a ratio of 0.7. On the contrary, the growth in overall GDP is only 19.8 % in the same period, giving a ratio of 1.58. Hence, the plastic packaging intensive industry is experiencing a higher economic growth rate than industry overall and also a higher economic growth than growth in plastic packaging consumption.

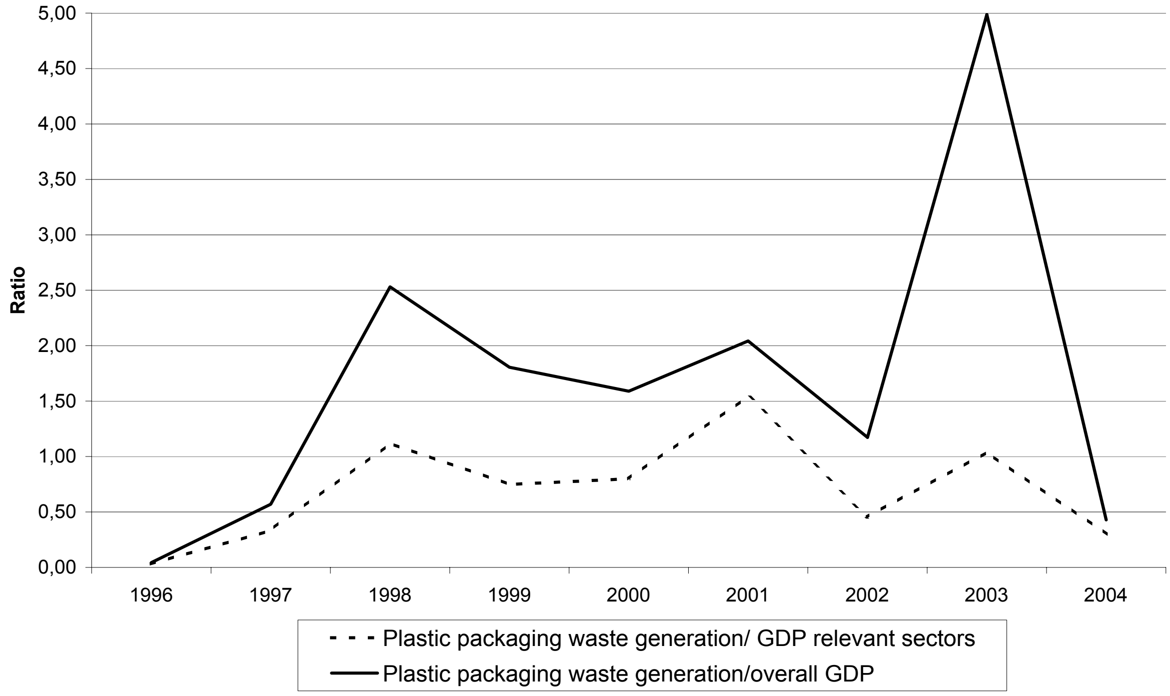


Figure 6.5 Growth rate ratios between GDP and generated plastic packaging waste ($X_{2,3}$ in Figure 4.3) 1996 – 2004 (based on 'Our estimate')

6.1.2 Output from waste management systems – loop closing

Figure 6.6 shows the output from the plastic packaging recycling system. The amount of collected plastic packaging is steadily increasing, while the amount actually material recycled is growing less quickly. For instance, from 1999 – 2002, there was only minor growth in the amount recycled (20,754 tons in 1999 and 20,840 tons in 2002), while in 2003 the number was 25,700, a growth of 23.3 % from 2002 to 2003. In the same period, the collection rose from 69,024 tons in 1999 to 82,640 tons in 2002 and 89,700 tons in 2003.

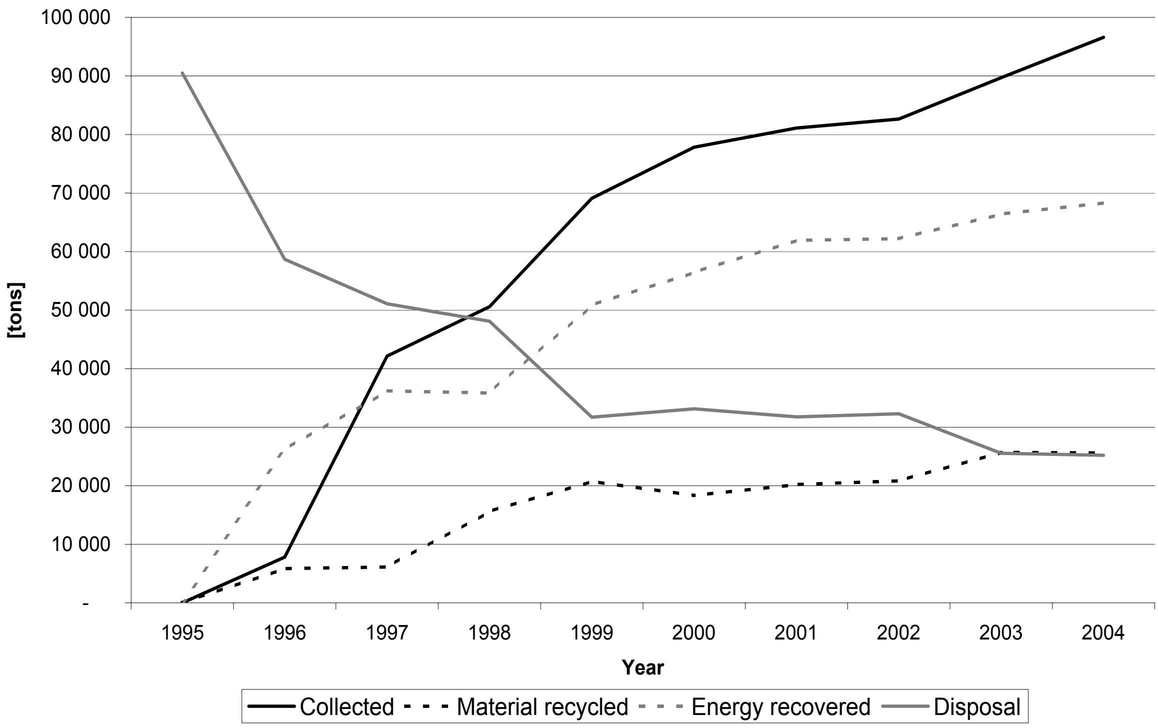


Figure 6.6 Time series in absolute terms on collection, recycling, recovery and disposal in Plastretur system 1995 - 2004

Numbers are based on information from Plastretur and is based on amount actually recycled and sold ($X_{10,0}$ in Figure 4.5). In the official numbers from Plastretur reported to SFT, he input to the recycling process is considered as recycled. Hence, Plastretur operates with higher numbers.

The recycling ratio has increased from 6.4% in 1996 to 21.5 % in 2004, while the collection ratio has increased from 8.6 % in 1996 to 81.1 % in 2004, see Figure 6.7. Here we see that the relation in percentage between energy recovery and material recycling is relatively stable during the last years.

This indicates that the growth in collection has not resulted in higher material recycling numbers, and consequently that more of the collected plastic is sent to energy recovery. The reason for this is that plastic packaging in household waste is mainly energy recovered and the growth in this fraction has been large, which provides a higher energy recovery ratio.

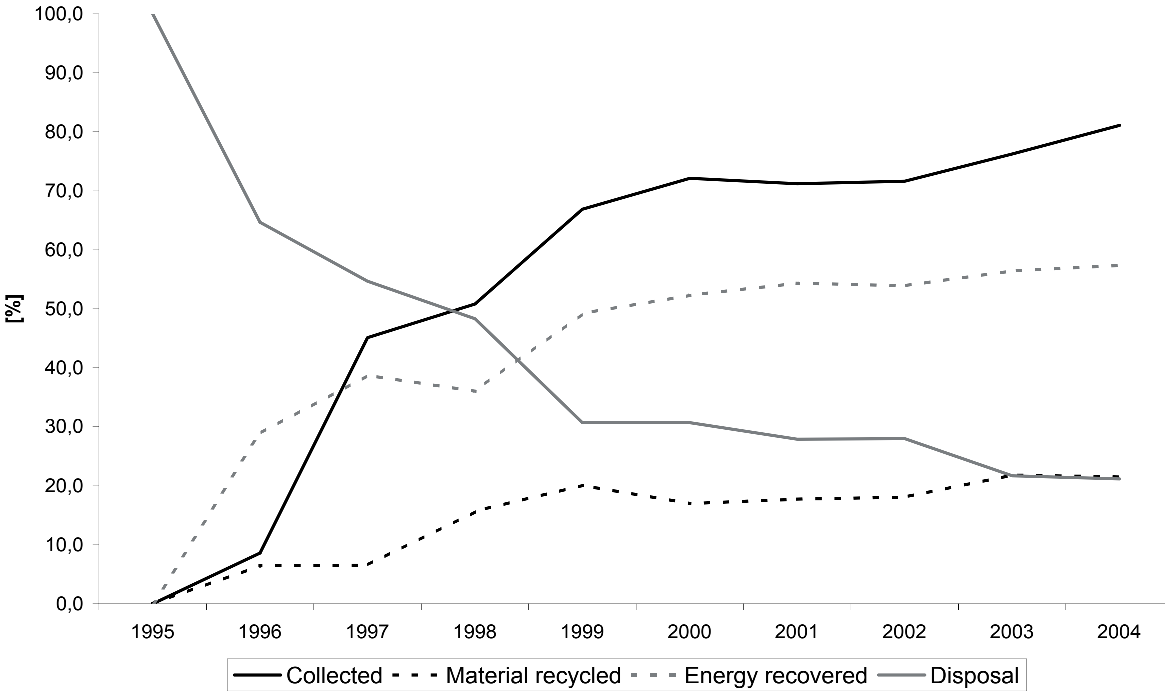


Figure 6.7 Time series in relative terms on collection, recycling, recovery and disposal in Plastretur system 1995 – 2004. The ratios are based on amount of generated plastic packaging waste (and not on amount collected).

6.1.3 Discussion – dematerialisation and loop closing

So far we have assumed that the virgin material input ($X_{0,1}$ in Figure 4.2) to the two other subsystems is constant and increased consumption in these subsystems comes from the input of recycled plastic packaging from 'our' plastic packaging system. Moreover, we assume that there is no input from the two other subsystems to the plastic packaging system in Norway, neither as virgin nor recycled material. Based on this, we are able to calculate the material input to the plastic packaging system in Norway along two different lines. First, the most simplified situation where we assume that all plastic packaging recycled remains in the Norwegian plastic packaging system, making this an entirely closed loop with zero outflows of recycled plastic packaging to the other sub-systems in Figure 4.3.

Second, we include the fact that not all the recycled plastic packaging in Norway remains in the Plastretur system, but that parts of it go to the two other subsystems as well. According to Gjester (2004, 2005) the distribution of recycled material is as given below in Table 6.1. Given this distribution of the plastic packaging, the virgin material inputs to the Plastretur system from 1996 – 2004, both in absolute terms and relative terms related to GDP, are illustrated in Figure 6.8 below.

Table 6.1 Distribution of the recycled material from Plastretur EPR system [%]

Receivers of recycled plastic packaging from Plastretur system	1996	1997	1998	1999	2000	2001	2002	2003	2004
Plastretur-system ($X_{3,1}$ in Figure 4.3)	100	100	80	80	45	29	29	25	25
Other plastic systems in Norway ($X_{3,4}$ in Figure 4.3)	0	0	0	0	0	1	1	2	2
Plastics abroad ($X_{3,7}$ in Figure 4.3)	0	0	20	20	55	70	70	73	73

The graphs are indexed. The graph 'virgin material input' depicts the material requirements of virgin material to comply with the consumption of plastic packaging. It shows that in the period 1996 – 2004 the material input increased by 10 % if considering a closed loop. Taking into account the growth in GDP in relevant sectors as discussed above, there is a relative reduction in virgin material input in 2004 to 76 % of the material input in 1996. Hence, there is a relative dematerialisation.

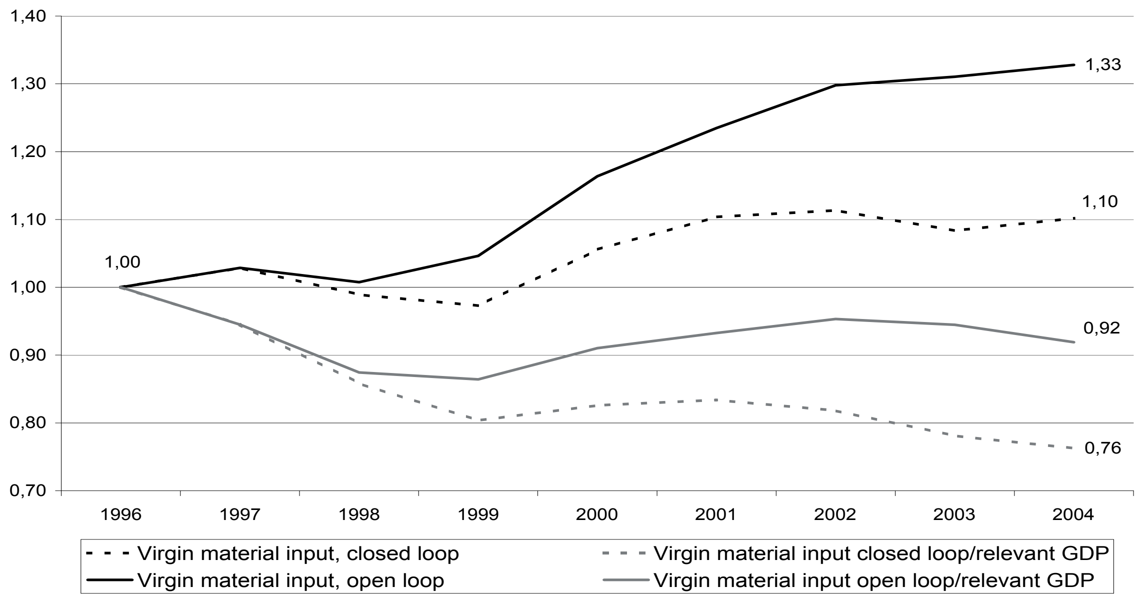


Figure 6.8 Indexed time series for material input in absolute and relative terms related to distributed or non-distributed recycled material

Moreover, if taking into account that not all the recycled material remains in the Plastretur system, we observe that the absolute virgin material input to the plastic packaging system has increased by 33 %, while related to the development in GDP in relevant sectors, the virgin material input in 2004 is 92 % of the input in 1996. Given our assumptions and that the most realistic situation is that recycled material also is distributed to other systems as well, the conclusion is that the virgin material input in absolute terms has increased by 33 % from 1996 to 2004 (no dematerialisation), while in relative terms it has decreased by 8 % (relative dematerialisation).

On the contrary, it is reasonable to assume that there is considerable import of recycled material to the Norwegian plastic packaging as well. This import is not primarily a consequence of the Norwegian EPR scheme on plastic packaging. For the plastic packaging system as such, however, this import will improve the dematerialisation due to reduced inflows of virgin plastic packaging. If assuming that the import of recycled material equals the export of recycled material from Norway, the virgin material inputs in absolute and relative terms are + 10 % and -24 %, respectively.

6.2 Additional Norwegian and foreign EPR systems

Although the Norwegian plastic packaging system is our main concern in this study, the trends observed in Chapter 6.1 can be 'tested' on other relevant cases as well. We have selected two types of reference cases; i) other EPR systems in Norway and ii) EPR systems on plastic packaging elsewhere in Europe.

6.2.1 Norwegian EPR systems

Figure 6.9 illustrates the development in waste management results for beverage cartons in the period 1999 – 2004. Norsk Returkartong is the PRO organising this system. All graphs show a rather stable development with the recycling ratio varying in the mid-40s. The generated amount of waste is in fact slightly reduced over the period (~10%) (Leiro 2005), so the total amount material recycled is obviously decreasing too.

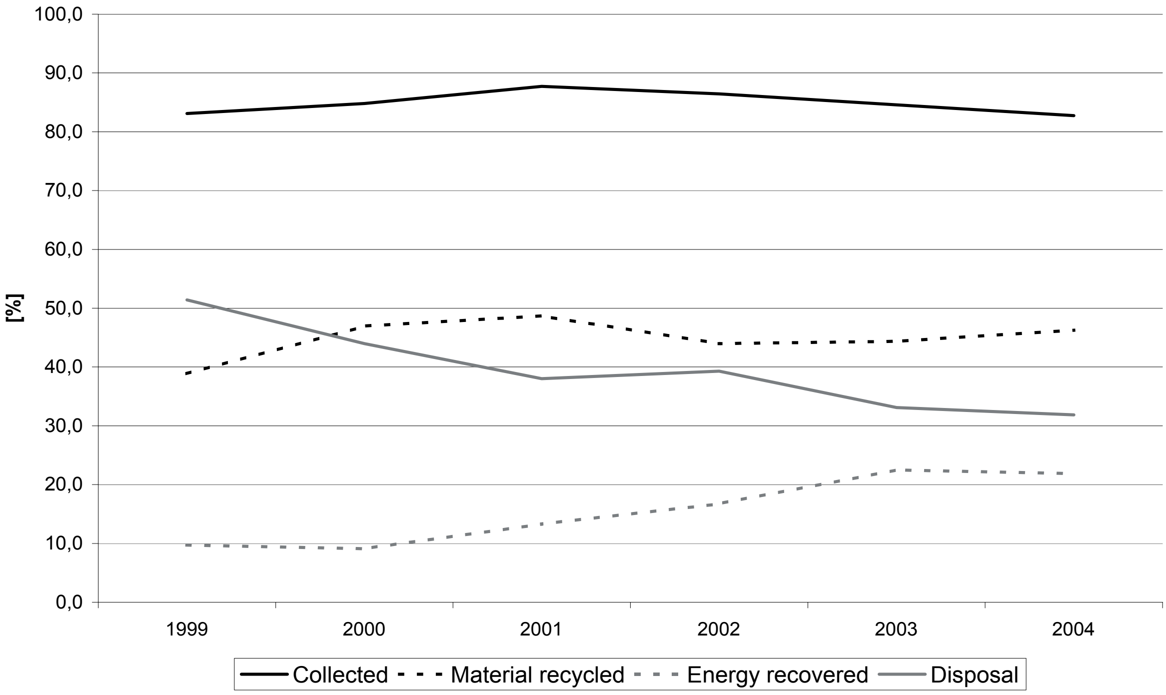


Figure 6.9 Collection and recycling results in Norsk Returkartong

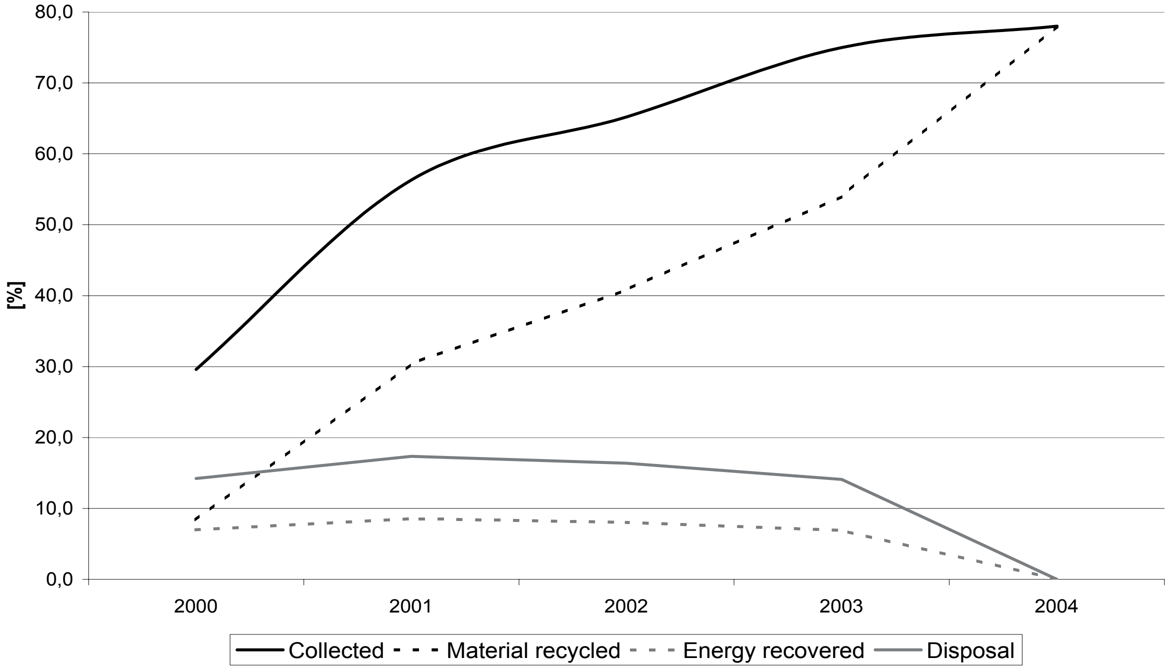


Figure 6.10 Collection and recycling results in Resirk system

The trend is different if we look at the Resirk-system, which is an EPR scheme for one-way beverage cans and PET-bottles. Figure 6.10 shows the development in collection and recovery for the PET-bottles in the period 2000 - 2004. The collection and recycling ratios increase strongly, to close to 80 %. Interestingly, in the numbers from Resirk (Castellano 2005, Eik 2005) all collected materials become recycled. Consequently, the energy recovery and landfill fraction, drops to zero.

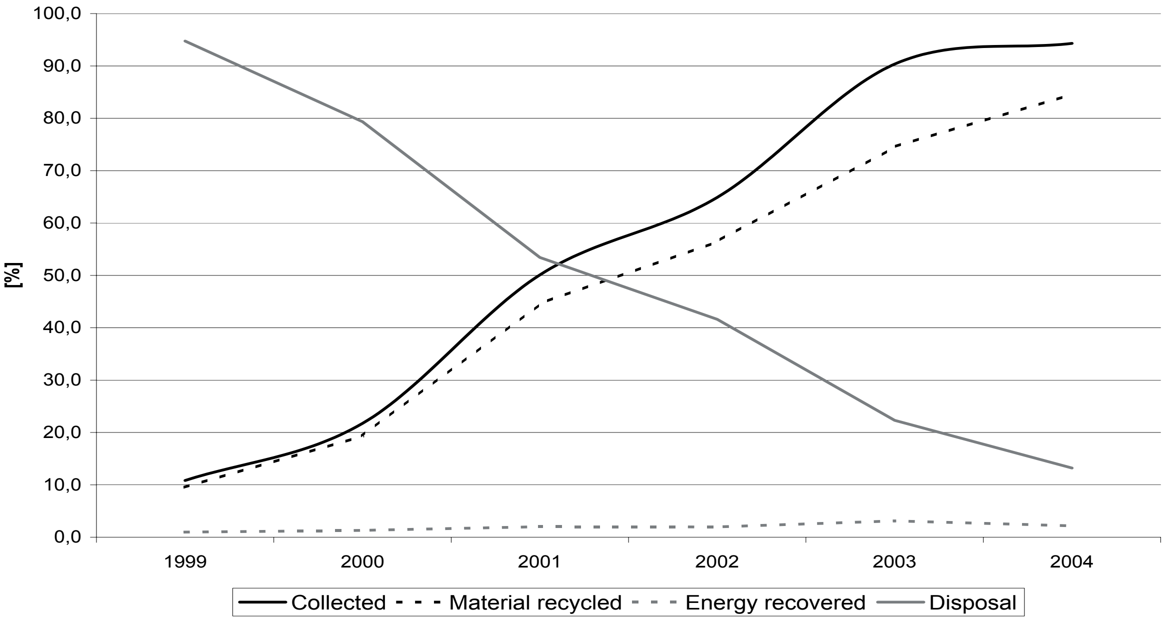


Figure 6.11 Time series in percent on collection, recycling, recovery and disposal in Renas EPR system 1999 - 2004

Leaving the packaging sector and looking into the electrical and electronic equipments (EEE), Figure 6.11, dealing with industrial EEEs within the Renas EPR system, shows a common trend for these products. The collection and material recycling ratios increase steadily throughout the period 1999 – 2004, while the amounts to landfill decline correspondingly. The energy recovery ratio is low throughout the period[3].

These are three examples of Norwegian EPR systems. In Figure 6.12 the material recycling ratios for a sample of Norwegian EPR systems are shown. The general trend is that the EEEs steadily achieve a higher recycling ratio, particularly the industrial EEE and consumer white goods EEE. The second trend is that packaging materials, except from one-way beverage PET, show no increase in the recycling ratios. As for beverage cartons and carton packaging the explanation is that the tonnage recycled has remained stable with consistent amounts of waste generation, while for plastic packaging there has been a similar growth rate in both waste generation and amount recycled on a weight basis, and consequently a stable recycling ratio.

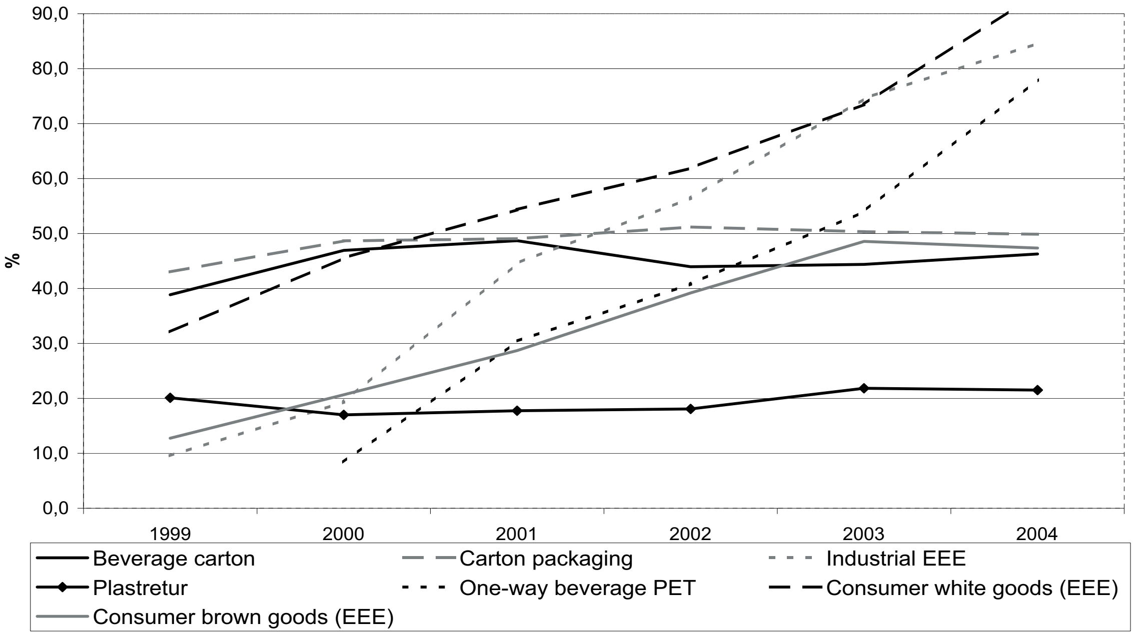


Figure 6.12 Recycling ratios for various Norwegian EPR systems 1999 - 2004

6.2.2 Foreign EPR schemes

Throughout Europe various plastic packaging EPR schemes exist. These differ in several ways, for instance related to scope (type of plastic packaging included and markets), the legislation and the organisation of the EPR scheme and measurement methodologies (EPRO 2005). For our comparison of the Plastretur EPR system with other plastic packaging systems in Europe, we have employed data from European Association of Plastics Recycling and Recovery Organisation (EPRO). The intention is to identify any trend in the development of material recycling throughout the period 1996 - 2003. Year 1996 is the indexed year for *every country* and the numbers are based on the amount of plastic packaging recycled measured on a weight basis. Figure 6.13 shows the results.

The general trend is that there is an increase in the tonnage of materials recycled. Plastretur has the steepest growth from 1996 to 2003, followed by Italy, France and the UK. All these countries grow by a factor of more than 3 (although the UK-figure drops in 2003). As for Sweden, Germany and Belgium, these countries appear to have a more modest growth. An explanation for the low growth for Germany is that it was the first country to start collection of packaging waste in 1992, and after experiencing a steep growth in the amount of recycling material in the period 1992 – 1996 (Lindhqvist 2000), the major 'potential' was already released by 1996. This explanation is supported through Figure 6.14.

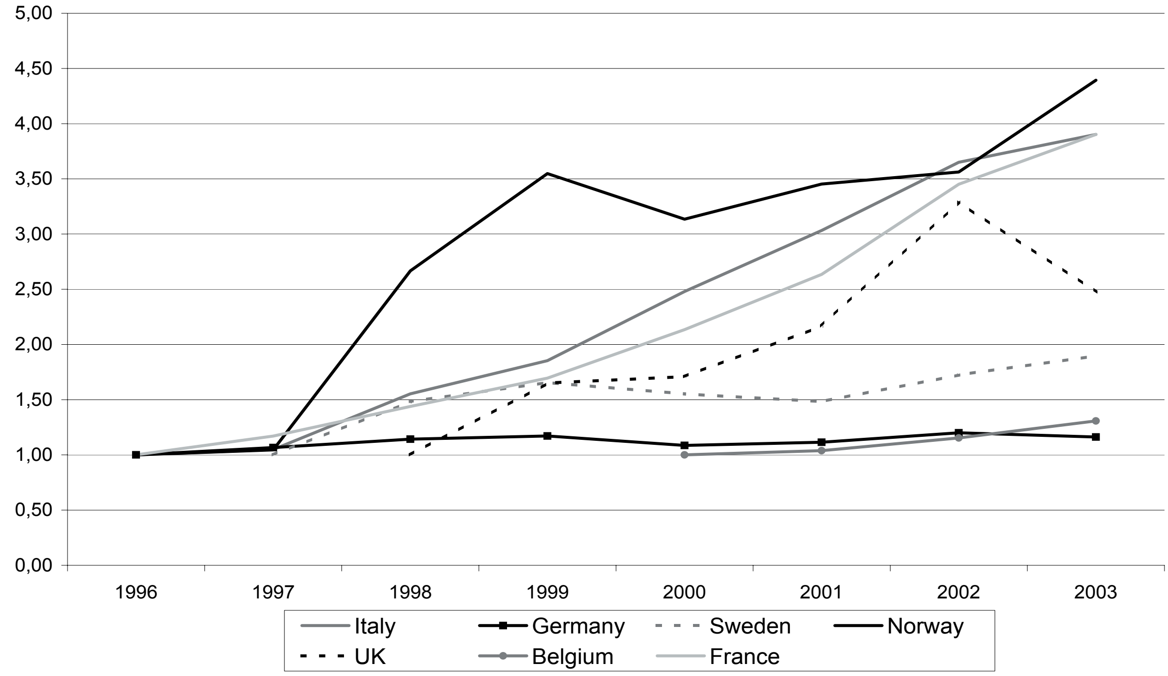


Figure 6.13 Indexed development of recycling ratio for selected countries Index: 1996 = 1

We should note that Figure 6.13 shows the official Plastretur numbers, which use the official amount of generated plastic packaging waste as denominator (see Figure 6.3) and input to the recycling process ($X_{9,10}$ in Figure 4.5) as amount recycled (nominator). Hence, the numbers are higher than what is presented elsewhere.

Figure 6.14 shows the overall recycling ratio for these countries. Germany has a recycling ratio of 82 %, and next there is a long step down to Belgium (only industrial waste included) with 47 % and further down to Sweden on 35 %. Moreover, those countries with the steepest growth in tonnage recycled in Figure 6.13, have the lowest recycling ratios.

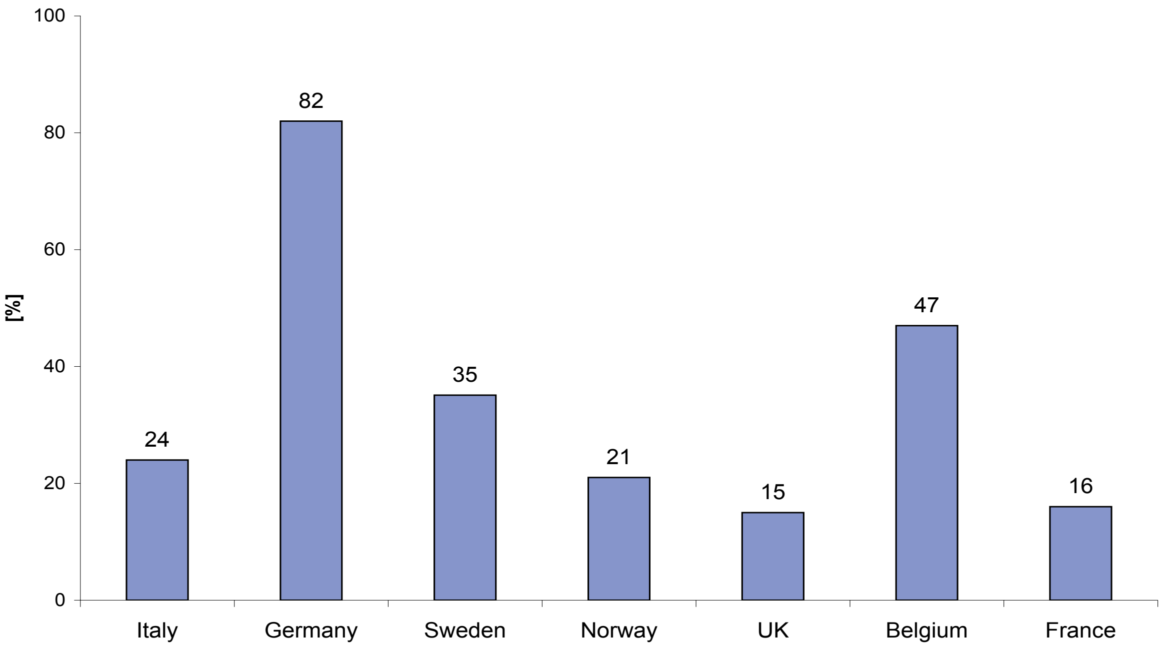


Figure 6.14 Overall recycling ratio for selected countries in 2003

6.3 Discussion

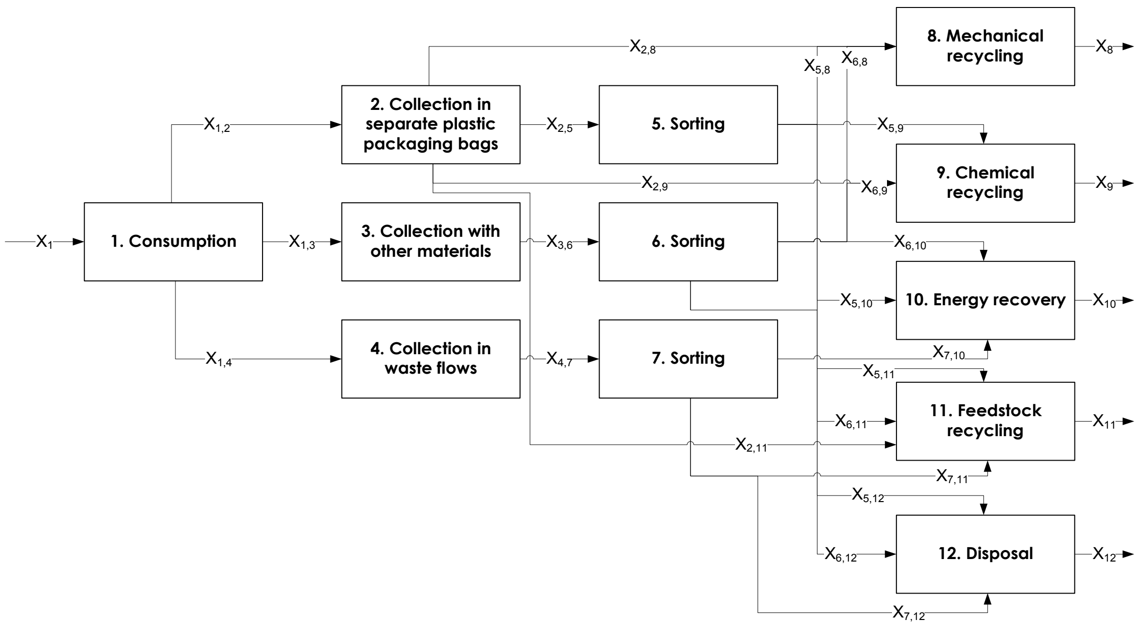
The results presented above have both methodological and empirical aspects. These will be discussed below.

6.3.1 Methodological discussion

The methodological issue is related to *how* the indicators are measured, as different ways of measuring make it inevitably more difficult to compare the results. Figure 6.15 illustrates the different practices among various EPR schemes in the selected countries on how to measure the overall recycling ratio.

We can see that the main difference is between Germany and the others. In Germany the overall recycling ratio is measured as the relationship between the output from sorting plants (node 6) and the amount for which a licence fee has been paid. Thus, free-riders are not taken into account. For instance, in Norway the number of free-riders is around 30 % (Røine 2003). The other countries measure the recycling ratio basically as the relation between inflow to box 1 (X_1) and the inflows to recycling. However, there are variations on what recycling activities are included, some simply include mechanical recycling, some add chemical recycling and some also add feedstock recycling and energy recovery.

Another methodological aspect is connected to measuring the amount of mechanical recycled material. The uncertainty is not related to *how* this is measured as the PROs usually have reliable measuring points for these flows. The uncertainty is rather related to *where* it is measured. Several countries measure the input to the recycling plant, as indicated in Figure 6.15, while others, for instance Norway, measure the input to the extruder in the recycling process, hence after pre-treatment, drying and removal of unwanted items. In fact no country measures the output from the recycling process as the amount recycled (nominator).



	Italy	Germany	Sweden	Plastretur	UK	Belgium	France
Overall recycling ratio	24	82	35	21	15	24	16
How measured	Input to 8,9 and 11/X_1	Output from 6/ licenced amount	Input to 8 and 10/X_1	Input to 8,9 and 11/X_1	Input to 8/X_1	Input to 8/X_1	Input to 8/X_1

Figure 6.15 Flows in recycling system and calculation of recycling ratio

According to the EU directive, only mechanical recycling (box 8) and chemical recycling[4] (box 9) should be included into the term 'recycling'. Hence, feedstock recycling[5] is not accepted as material recycling. However, given the fact that feedstock recycling makes it possible to reuse the substances for material purposes and not only for energy purposes, the Norwegian government has, for instance, accepted feedstock recycling for everything above 22.5 % material recycling. This equals the amount that goes beyond the EU target on 22.5 % material recycling of plastic packaging.

Another methodological issue is how the data for measuring the recycling ratio is calculated. The statistics on plastic packaging consumption, ($X_{2,3}$ in Figure 4.3), is a result of more or less structured methods, estimates and poor national statistics. The values of the denominator in the different countries may deviate from the "reality", and will inevitably influence the recycling ratio. For instance, Sweden with a population of 9 million, operates with a denominator of 155 ktons (Schyllander 2004), while Norway with 4.5 million inhabitants has a denominator of 119 ktons (2004), both EPR schemes have more or less the same scope when it comes to type of products and markets included in the EPR scheme (Sundt 2004). Hence, the waste generation per capita in Norway is much higher than in Sweden, although these countries are comparable when it comes to standard of living and culture. One explanation might be the reliability of the studies determining the denominators.

6.3.2 Empirical results

The general trend for EPR systems in Norway is that the recycling rates for packaging have increased from the start of the industrial implementation of the EPR schemes, but that it seems more challenging to take a step further. This is to a large extent supported by the trends elsewhere in Europe. As for EPR schemes for EE products, the recycling ratios seem to increase at a constant rate. We are however, not able to analyse the degree of relative and absolute dematerialisation, but the trends in the recycling ratio support the impression that Plastretur is not in a unique position.

However, as discussed in 6.3.1, the results hide a number of assumptions and various measurement methodologies. For instance, there are various options when carrying out recycling activities; mechanical, chemical and feedstock. Mechanical recycling is regarded as most important from an environmental point of view, which is also reflected in the EU Directive on Packaging and Packaging Waste. The composition of these recycling options is thus important to understand. For instance, in Germany 53 % of what is counted as recycled is mechanical recycled. In Norway in 2003, 90.5 % was mechanically recycled. (EPRO 2005)

This discussion and the results illustrate the need for looking in more detail at the material flows in order to explain the results. This will be done in Chapter 7.

(Endnotes)

[1] However, it is important to note that developing these time series is not the key issue of the thesis, but they do represent trends for the development. The key issue is to understand the industrial implementation of EPR.

[2] The consumption of plastics in Europe is distributed between the product groups as follows: automotive (8 %), households & domestic (20.1 %), building and construction (18.5 %, packaging (37.2 %), large industry (5.8 %), agriculture (1.9 %) and electrical & electronic (8.5 %) (Plastics Europe 2004).

[3] As for Renas, Elektronikkretur and Hvitevareretur, the denominators are based on a consultancy report (NMoE 1996) which is considered somewhat imperfect (Murvold 2003, Rønningen 2003a, Wiik-Svendsen 2003). This report was the basis for the regulation and covenant in 1998, and concluded that 144,000 tons of EE waste was generated annually. SFT has now revised this number, partly based on a report from Renas and partly based on input from Hvitevareretur, although not based on new analysis of the issue. The new denominator, as given

in Figure 6.11, is 114,000 tons. (Renas 56,000, Hvitevareretur 29,500, Elektronikkretur 30,000). This is 25.3 kg per capita.

[4] Chemical recycling implies a change of the chemical structure of the material, but in such a way that the resulting chemicals can be used to produce the original material again. Such processes include monomer recovery. There are few commercial techniques available which accomplish this, but one outstanding exception is nylon carpet recycling.

[5] Feedstock recycling is defined as a change in the chemical structure of the material, where the resulting chemicals are used for another purpose than producing the original material.

7. EPR ON PLASTIC PACKAGING IN NORWAY – SECTOR LEVEL

Chapter 6 showed that there has been no absolute dematerialisation in the plastic packaging system in Norway. There is however, a decoupling between GDP and the consumption of plastic packaging, while the input of virgin material to this system has grown on a somewhat similar rate as GDP. From the governmental point of view, these indicators are sufficient to measure the achieved outcomes relevant to the policy objectives. However, it says nothing about *why* the recycling rate is actually on this level or anything about *how* to improve it. Neither does it tell us the costs of achieving this recycling rate. These costs are operating costs to run the system, and relevant to the added value of the flows of materials. So, how can we explain these results and in particular the role of EPR in this?

In Chapter 6 we discussed the overall performance of the plastic packaging system in Norway, by looking at the relation between input and output to the waste management system, and consequently the recycling ratios. In this chapter we will look in greater detail into the actual waste management system. Where are the greatest losses of material quantity? Moreover, what are the costs of improving the recycling rate, and hence, reduce the loss of material quantity? And where is the greatest potential for improving the performance?

This chapter starts off by going deeper into the material and cash flows in Chapter 7.1 and 7.2. In Chapter 7.3 we elaborate on the actors related to the system. Then, finally, in Chapter 7.4 we present and discuss the role and responsibilities of Plastretur in light of some strategic, operational and organisational issues.

7.1 Understanding the Plastretur system by studying material flows

As outlined in Chapter 4, analysing the (in)efficiencies in a system requires a thorough understanding of the material flows. Both in EU and Norwegian legislation, as well as in input-output tables for economic activity and interaction in a country, we usually distinguish between the overall categories 'households' (consumers) and 'industry'. In this study we disaggregate 'industry' into the categories 'commerce and industry', 'agriculture' and 'aquaculture'. The main reason for this being that Plastretur operates with these categories, making data availability easier. Moreover, these sectors are relatively clearly distinguishable at the point of waste generation, and also operate as rather independent systems.

7.1.1 Overall picture of the four markets

Below we disaggregate the plastic packaging waste generation and the recycling ratios into four markets. Plastretur and companies within the plastic packaging chain in Norway are the main sources of information in this chapter. Plastretur develop their statistics based on reported amounts from waste management companies (WMC) and recyclers which is the basis for the payment[1].

7.1.1.1 Generation of plastic packaging waste

Figure 7.1 below shows the time series of amount of generated plastic packaging waste in the period 1995 – 2004. These numbers are discussed in detail in Chapter 6. There is a total increase of generated plastic packaging waste with of more than 31 % in this period.

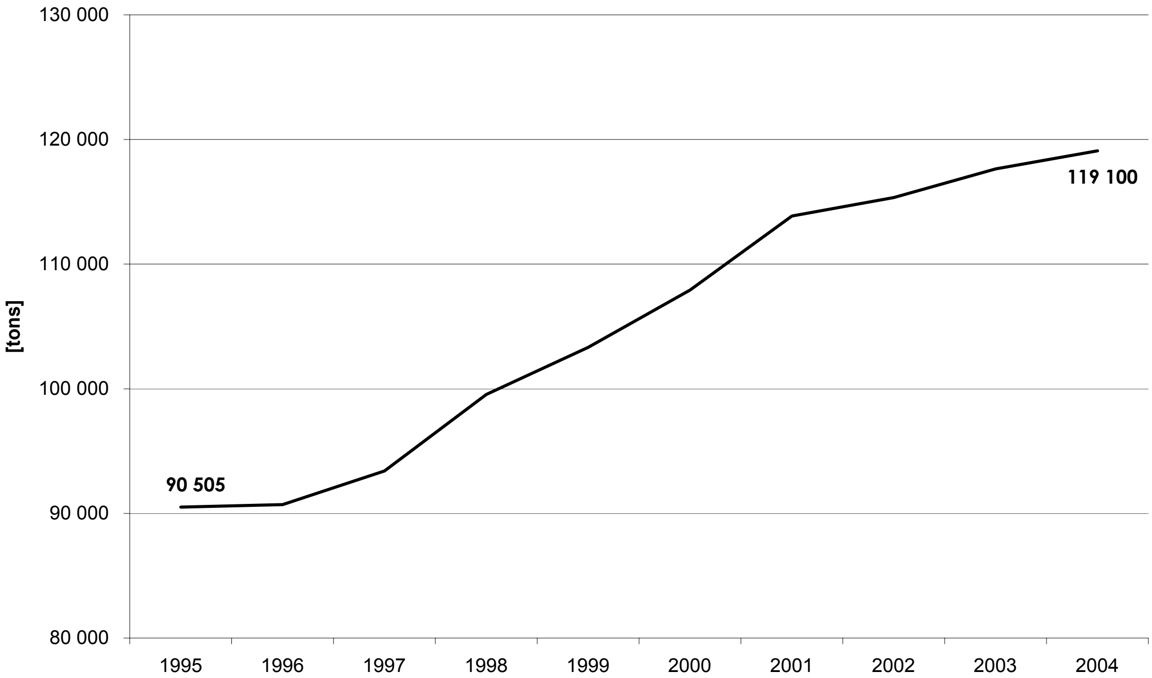


Figure 7.1 Amount of generated plastic packaging waste in Norway, 1995 – 2004.

This flow is decomposed into the four markets and the various group of plastic packaging products as presented in Chapter 4[2]. Table 7.1 sums up this decomposition with a quantified example from 2004 on the amount of generated waste. The distribution for the entire period 1995 – 2004 is shown in Appendix C.

The category 'industry and commerce' embraces all the industrial plastic packaging products generated as waste that are not included in the categories 'agriculture' and 'aquaculture'. This is clearly the largest category when it comes to volumes and diversity within the industry sector. Transport film is the largest type of product, amounting to

68 % of the total within this sector. This product is used for transporting products from primary (bulk) producers and secondary producers (packers and fillers) to wholesalers and further to retailers and single shops. For every reloading, the transport film is removed (become waste) and new is added to bale and protect the products during further transportation. There are industrial sub-sectors that are more transport film intensive than others, both in total and relative to the turnover. Grocery wholesalers are by far the most packaging intensive sector (Røine 2003).

Table 7.1 Plastic packaging waste generation in Norway in 2004 (in tons) (Plastretur 2005)

	Industry and commerce	Agriculture	Aquaculture	Household	Total
Film	32,500	7,200	~0	39,500	79,250
Rigid	12,300	300	~0	21,550	34,150
PP-bag	1,600	900	2000	~0	4,500
Reusable packaging	1,200	~0	~0	~0	1,200
Total	47,600	8,400	2,000	61,100	119,100

Figure 7.2 displays the development in the amount of generated plastic packaging waste in the two major markets, 'industry and commerce' and 'households'. We observe that the amount within commerce and industry has increased by 20 % from 1996 to 2004, while the comparable household fraction has increased by more than 49 %. The growth in total plastic packaging consumption is estimated to be two thirds in households and one third in industry and commerce (Plastics Europe 2004). Plastic packaging products waste from households are to a large extent 'sales packaging' and related to the daily purchase of food, clothing and other groceries, as well as larger purchases such as furniture, sporting equipment, white and brown goods and other electrical and electronic products.

The types of polymer in households vary, and so does the degree of dirt on the packaging at the point of becoming waste. As an example, plastic packaging protecting food is usually some kind of laminate, which is very hard to material recycle by way of mechanical processes (Mustafa 1993). In addition, this type of plastic packaging is normally rather dirty, at least compared to the industrial transport film. Plastic packaging waste generated in the household is the largest group when it comes to tonnage. The growth in household plastic packaging waste can be explained by a transmaterialisation from glass, metal and corrugated cardboard to plastics. As for industrial plastic packaging, this has become thinner due to polymers of improved properties related to strength (Skilhagen 2002).

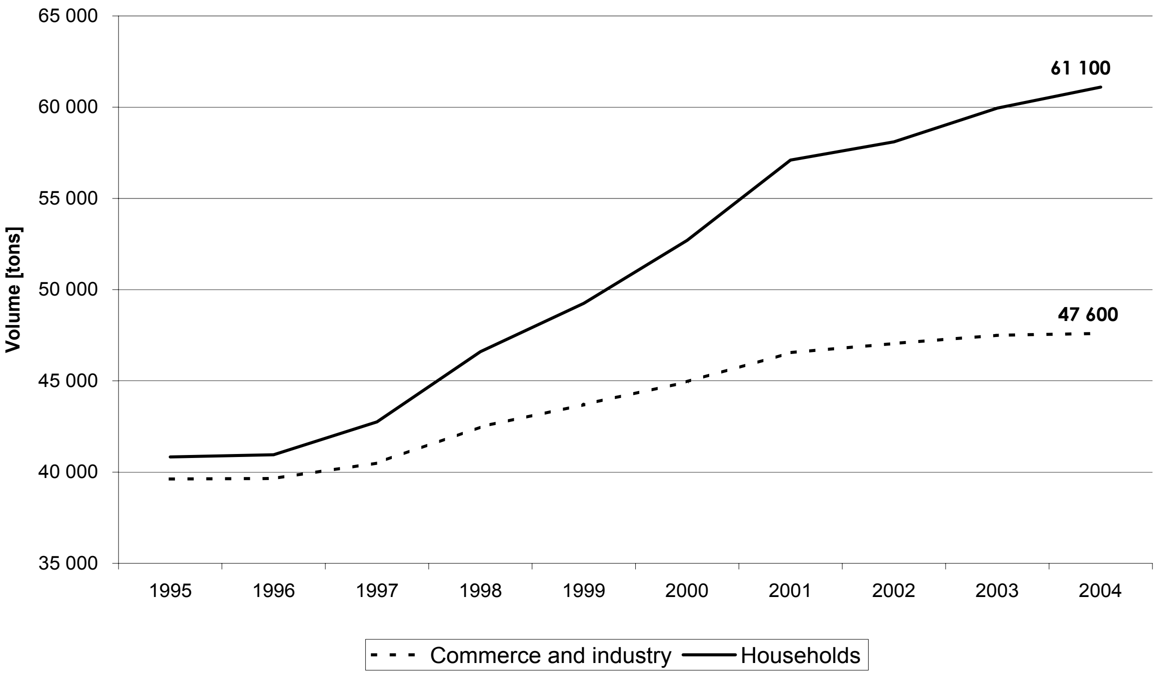


Figure 7.2 Generated plastic packaging waste in commerce &industry and households 1995 – 2004

The total amount of generated plastic packaging waste in agriculture and aquaculture shows a diverging trend, respectively, with the former increasing by 21 % while the aquaculture is decreasing by more than 37 %, see Figure 7.3.

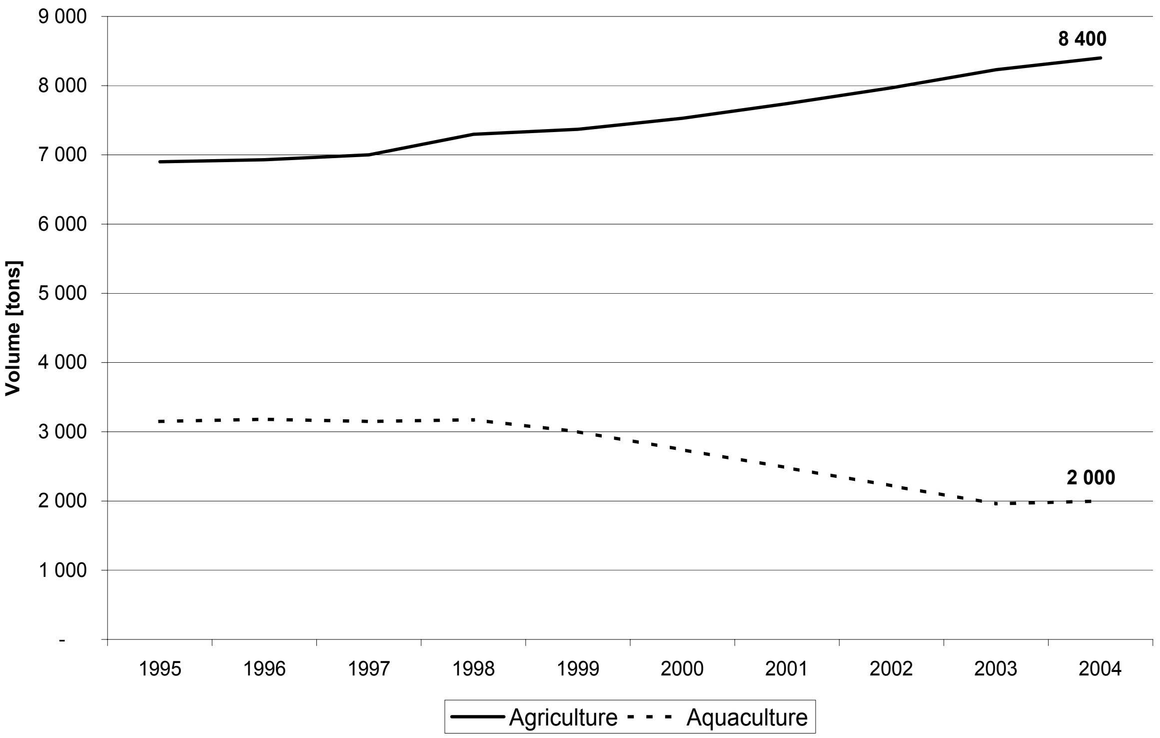


Figure 7.3 Generated plastic packaging waste in agriculture and aquaculture 1995 – 2004

'Agriculture' includes all the plastic packaging becoming waste connected to activities in the agricultural sector, in total 8,500 tons in 2004 (Skjervold 2005). The main plastic packaging product within this sector in Norway is the film used for storing the hay to be primarily used in meat and milk production, counting for approximately 85 % (Schefte 2003)[3].

The plastic packaging products from aquaculture are those used in cultivating fish in fish farms. Norway is a leading global actor in this market, which contributed to the generation of 2000 tons plastic packaging waste in 2004. The most significant product in this respect is the feedbags, which are basically made of polypropylene (although with some LDPE as inner bags as well). The consumption of plastic packaging within aquaculture has shown a declining trend, mainly due to some technological improvements, by bringing the feed in bulk from feed production plants to the aquaculture fields without employing feedbags (Kristoffersen 2002).

7.1.1.2 Overall recycling results

Obviously, with increasing amounts of generated waste, the amount of recycled material must increase by the same rate to remain on the same recycling level. In Chapter 6 we saw that the overall recycling ratio was generally operating around 20 % from 1999 to 2004. If this indicator is disaggregated into markets, we get the picture as shown in Figure 7.4.

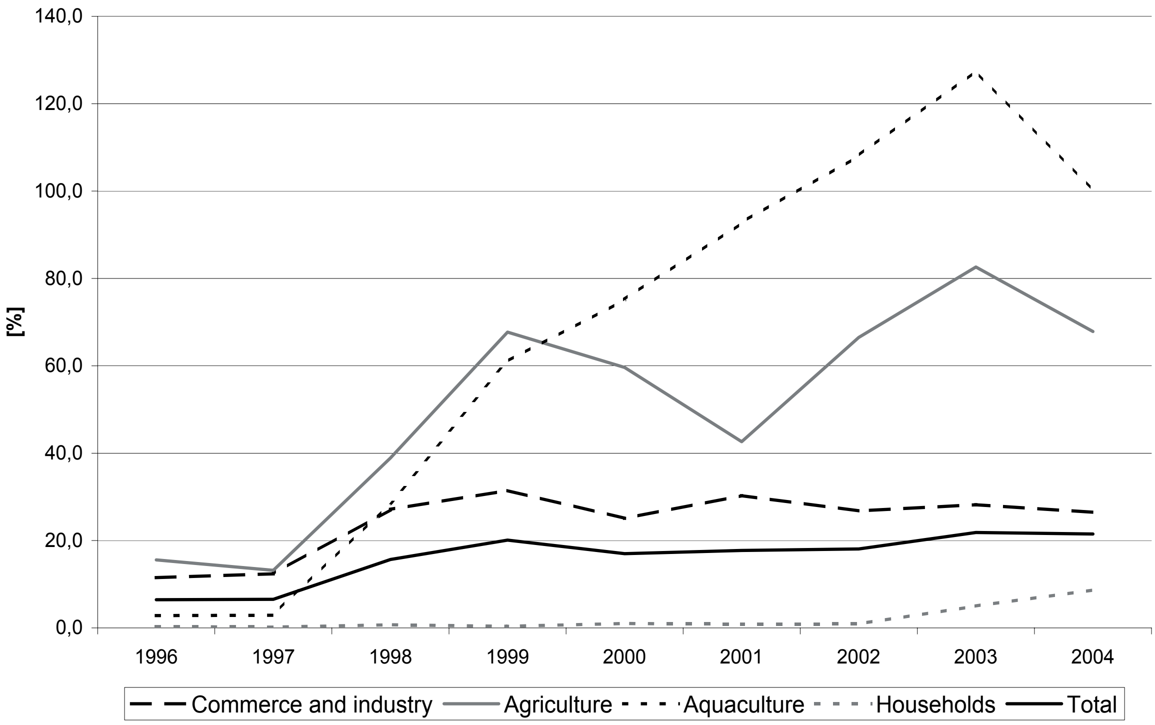


Figure 7.4 Material recycling ratios in total and for the four markets, 1996 - 2004

This shows that aquaculture and agriculture have the highest recycling ratios, while households have been close to zero, but has since 2003 increased considerably due to feedstock recycling. Industry and commerce is also above the total recycling ratio, indicating that the amount of generated plastic packaging waste from households is high.

The reason for the high recycling ratio for aquaculture in 2003 was that waste was collected in 2001 and 2002, but not recycled before 2003 (Gjester 2004). 'Commerce and industry' is the market contributing most in tons to the total amount of recycled plastic packaging, illustrated in Figure 7.5 below.

Figure 7.5 Amount of recycled plastic packaging per market 1996 – 2004.

The industrial sector contributes more than 50 % of the total recycled amount, leaving for instance the household sector far behind. However, although the amount of recycled plastic packaging has increased every year since 1996, and whilst the target is moving closer, the target for 2004 is still more than 10,000 tons away. In other words, total efforts are close to 30 % below target, as illustrated in Figure 7.6.

Even these disaggregated numbers cannot explain why the overall recycling ratio as presented in Chapter 6, is only 21.5 %. In order to better understand the results presented so far, and to analyse how to possibly improve the performance in the future to comply with the objectives in the covenant, the material flow approach guides us in identifying where the losses of quantity actually are.

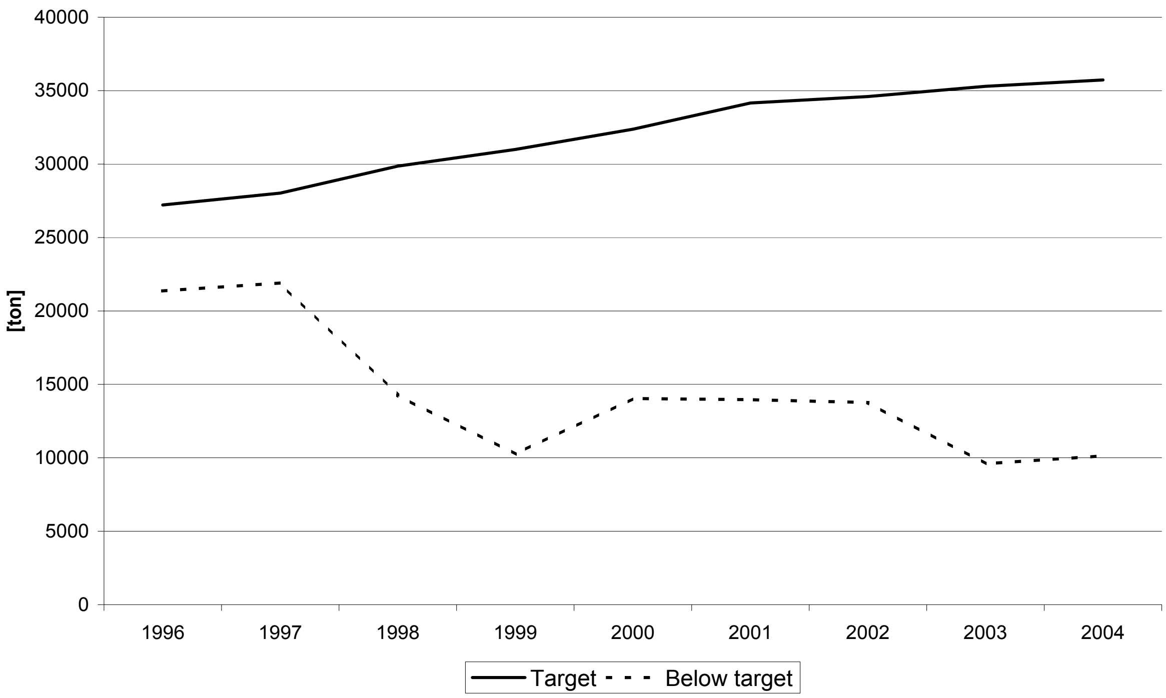


Figure 7.6 Plastretur's material recycling target (30 %) and distance from target, measured in tons/ year

7.1.2 Efficiencies within each market

Inevitably material will be lost throughout the waste management system, but efficient system will minimise the loss of material, both in quantitative and qualitative terms. The overall recycling ratio (α_{rec}) is a product of the internal efficiencies in the system, which in Figure 4.5 in Chapter 4 was defined to include the collection efficiency (η_{coll}) at waste generators place, the sorting efficiency (η_{treat}) by the waste management company and the recycling efficiency (η_{rec}) by the recycler. The recycling ratio is known, while the sorting efficiency and recycling efficiency is estimated based on information from various actors (Plastretur, Folldal Recycling etc). Hence, we can calculate the collection efficiency as shown below:

$$\alpha_{rec} = \eta_{tot} = \eta_{coll} * \eta_{treat} * \eta_{rec} \rightarrow \eta_{coll} = \eta_{tot} / \eta_{treat} * \eta_{rec}$$

The first process within the system as shown in Figure 4.5 is 'collection' with efficiency η_{coll}. The inflow to this process is the actual generated amount of waste, while the outflow is the amount collected *which is meant for material recycling*. Hence, the plastic packaging collected in residual waste or in energy fraction, is regarded as lost in this collection process, going either as flows $\sum_{i=1}^{4} X_{i,11}$ or $\sum_{i=1}^{4} X_{i,12}$. Very few collectors, if any, sort the energy fraction or residual waste fraction after being collected (Schefte 2005, Ren Analyse 2002). Each of these markets has specific values for this efficiency.

The 'collection' efficiency is primarily determined by two factors; the degree of source separation by the waste generator and to what extent the waste management company keep this fraction separated from other materials[4]. The second process in the waste management system, 'sorting' is the activities at the site of waste management company (WMC) before being transported to recycling plants. Simple treatment, baling, rough sorting by mechanical digger or more advanced sorting are some of the possible activities in this process[5].

The third process is material recycling of the plastic packaging. As seen from Figure 4.5 there are two steps of the recycling process, node 9 Pre-recycling and node 10 Recycling. The reason for this distinction is that the statistics provided by Plastretur and annually reported to and accepted by Norwegian Pollution Control Authority (SFT), is based on the fact that the outflows from 9 Pre-recycling (flow $X_{9,10}$) is regarded as recycled. Although there obviously is loss of material during the actual recycling process as well (node 10), this is not taken into account in the official statistics. From 2004 onwards, the statistics will be even "kinder" since from then on the inflow to node 9 ($X_{M3,9}$) is accepted as actually recycled (SFT 2005). In our calculations, however, we use the actual output from the recycling process ($X_{10,0}$ in Figure 4.5) as the point of measurement. Our results, thus, are somewhat lower than the official numbers reported SFT. The reason for selecting these numbers is that it better corresponds to the reality, as well as it identifies a general (political) acceptance of showing a higher recycling rate than in fact is.

The efficiency of the pre-recycling process (node 9) might be disaggregated into at least three sub-efficiencies; i) dirt and water following the material, ii) impurities that is not plastic packaging (wood, stone, etc) and iii) impurities that are plastic packaging, but not of sufficient or right quality to enter the recycling process. The efficiency of the actual recycling process (node 10) depends primarily on the homogeneity of the polymer inflow (e.g. melt index) and the non-polymer dirt following this inflow. Since the efficiencies depend on the type of product, we distinguish between the product groups as described above. Below we will go through the efficiency factors as they appear in 'industry and commerce' and 'households' as these are the two most important ones when it comes to volumes and potential for improvements, see Table 7.1.

7.1.2.1 Industry and commerce

Figure 7.7 shows the amount of plastic packaging recycled in tons within 'commerce and industry', disaggregated into the four product groups. Clearly, film is the far most significant contributor to the overall recycling result form industry and commerce. Moreover, recycling of reusable plastic packaging has been reduced the latest years, mainly due to reduced amount of generated waste (3,900 tons in 1996 and 1,200 tons in 2004, see appendix C).

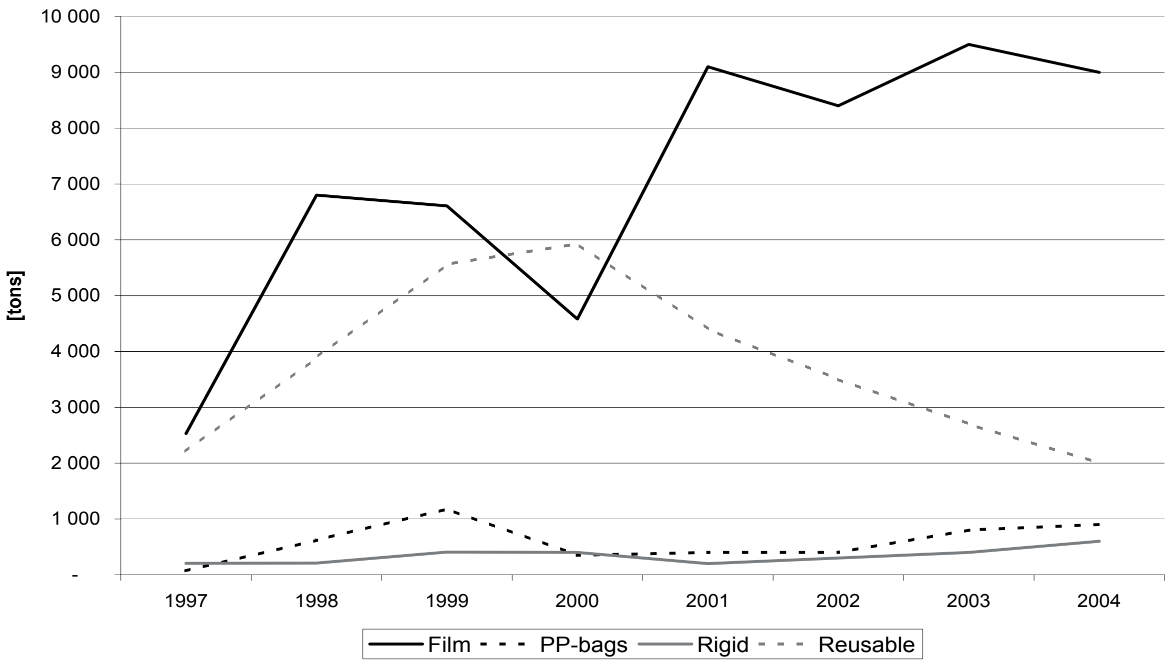


Figure 7.7 Tons recycled in commerce and industry 1997 – 2004

Finally, rigid plastics are recycled to a very low extent (4.9 % in 2004), which is particularly interesting due to the relatively high amount of generated waste of this product group (12,300 tons) being 25.8 % of plastic packaging within commerce and industrial, and 10.3 % of total amounts of plastic packaging.

The recycling ratios for the various groups of products within 'commerce and industry' are given in Figure 7.8 below. Reusable plastic packaging has a high recycling ratio already in 1997 because there was already a well-functioning recycling system for reusables when Plastretur started. The recycling ratio has dropped the latest years because the amount has gone down, and there is not high activity in this area any more as it was in mid90's (Strand 2005).

However, our recycling ratio for reusables is significant lower than Plastretur's official numbers as we have excluded 1,500 tons of screw caps from the amounts recycled, as these are not packaging within the Plastretur system (Syversen 2005). The figure also tells that the highest potential for improvements is primarily within rigid plastics due to high volumes of generated waste and low volumes of recycled material.

The recycling ratios in Figure 7.8 are results of the efficiencies within the waste management system. These are given in Table 7.2. The efficiencies for sorting, pre-recycling and recycling are based on empirical studies and experiences, and provided by Plastretur and various plants in Norway (Gjester 2003, 2004; Schefte 2003, 2004; Tamnes 2002, 2005). These are average numbers, taking into account that there are several sorting and recycling plants, both in Norway and abroad. The interval for pre-recycling (node 9) indicates that the efficiency has improved from 0.70 in 1996 to approximately 0.94 in 2004. Based on these efficiencies and the overall recycling ratio, the collection efficiencies for the various product groups are calculated. The collection efficiencies are shown for 2004.

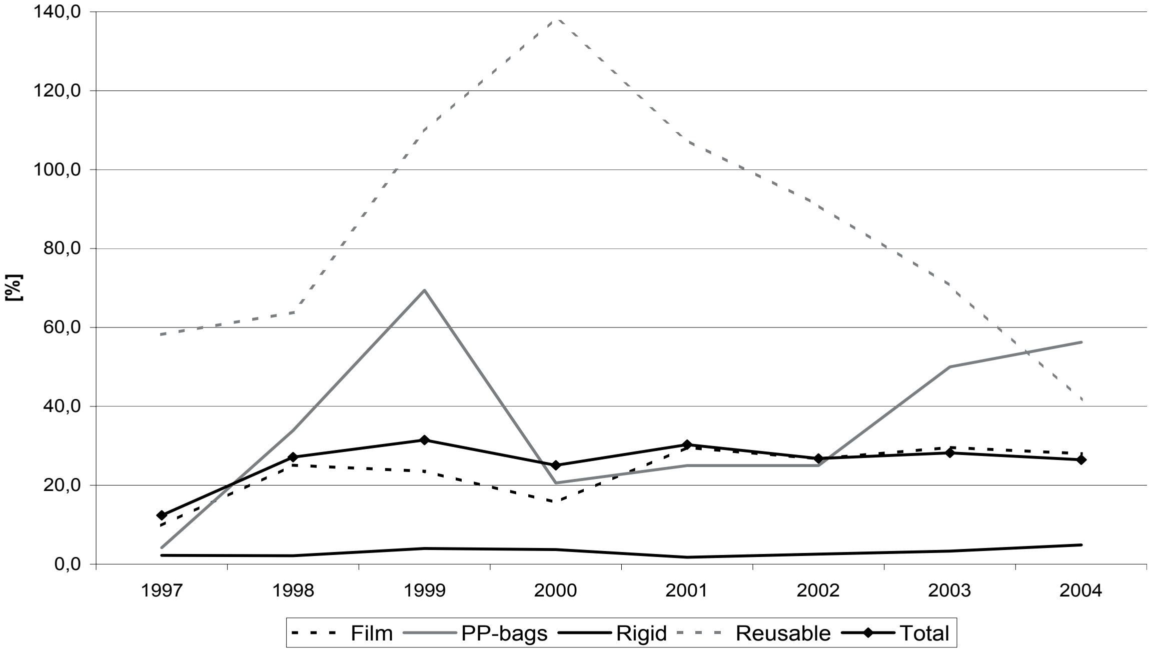


Figure 7.8 Recycling ratios for product groups within commerce and industry. The denominator for each recycling ratio is the amount of generated waste for the specific product in the specific market.

Table 7.2 Efficiencies for industry and commerce (Schefte 2005, Gjester 2005)

	Recycling ratio	**Sorting**	**Pre-recycling**	**Recycling**	**Collection**
Film	0.28	0.8 [6]	0.70 - 0.94	0.85	0.43
Rigid	0.05	0.7 [7]	0.8 - 0.97	0.95	0.08
PP-bags	0.56	0.8	0.97	0.96	0.75
Reuse	1.67	1	0.99	0.98	0.43

These efficiencies clearly show that collection is the most inefficient part of the waste management system. Particularly for rigid plastics, there is a significant potential for improvement. That said, the potential for improvement is, however, given by the difference between the current situation and the potential. This potential is decided by for instance i) the total amount of plastic packaging (loss), ii) the type of plastic packaging and processing technology (recyclability), iii) other types of design for environment issues and iv) the drivers and barriers for improving the flows. The latter is very important since it also involves non-technical factors, like organisational culture.

This advocates the need for more qualitative studies concerning the actors and factors influencing the stocks and flows.

7.1.2.2 Households

Figure 7.9 shows the amount of material recycled plastic packaging from households in the period 1996 – 2004. Although there is a steep growth the last years, particularly for film, the tonnage of recycled material is rather modest.

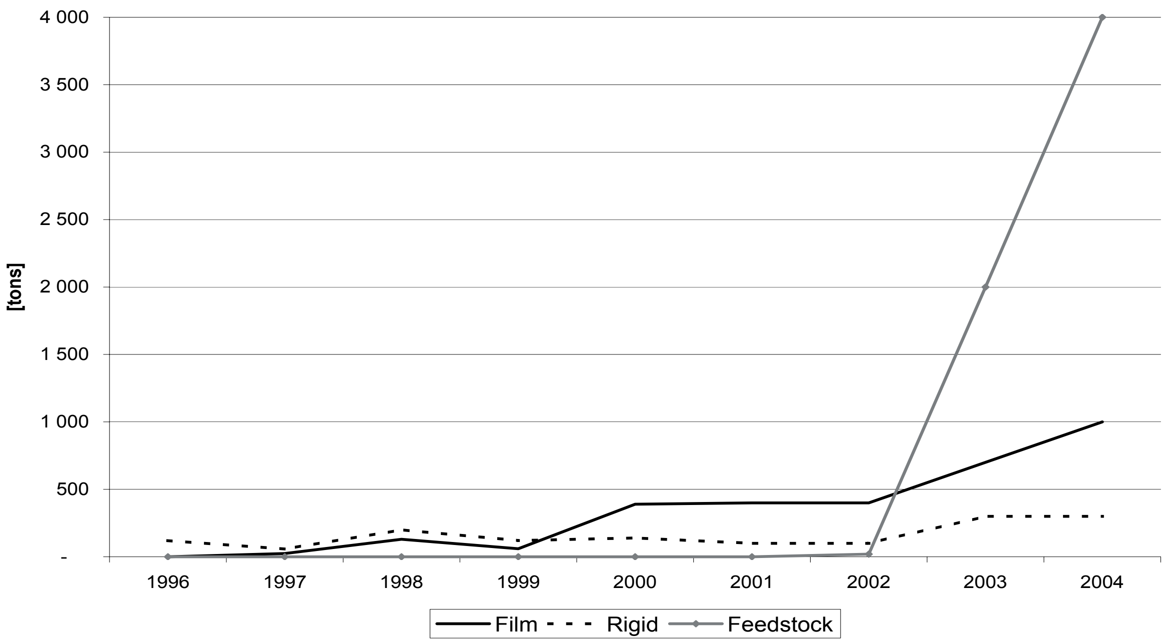


Figure 7.9 Recycled film and rigid plastic packaging from household, measured in tons

This is confirmed by Figure 7.10 which shows that the recycling ratios for film and rigid plastics are low, 1.4 % for rigid plastics, 2.5 % for film and 6.5 % for feedstock recycling in 2004.

The low recycling ratios can be explained by the efficiencies in Table 7.3. The collection solution is decided by the local authorities, and normally they select between a bring system and a kerbside system. The former might take two ways, either as collection stations in the neighbourhood, or as one of several fractions in municipal waste plants. The collection stations might be designed so that plastic packaging is collected as a separate fraction, or together with other materials increasing the need for sorting afterwards (Schefte 2004). This distinction also goes for the kerbside system. The experiences so far is that collecting plastic packaging in separate "clear" plastic bags in a kerbside system (120 litre) provides the best results (Schefte 2005, Plastretur 2005b, Plastretur 2005c). A critical factor as to the efficiency of the household collection of plastic packaging is how well the household actually source separate their plastic packaging at home.

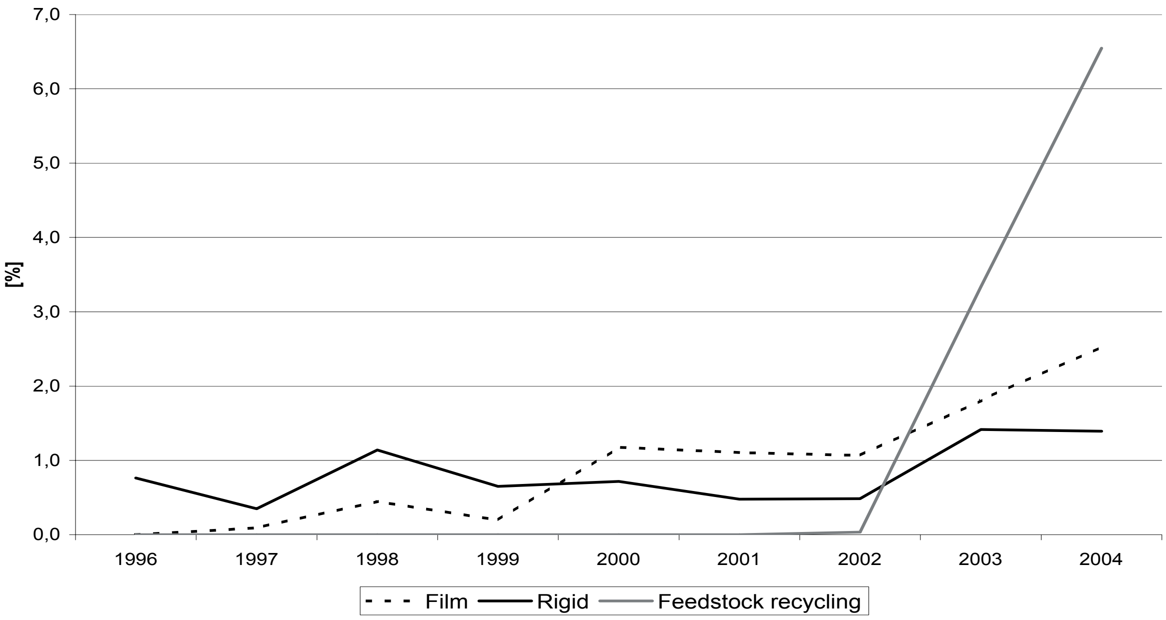


Figure 7.10 Recycling ratio for film and rigid plastic packaging from household

Plastic packaging in Norway is normally collected by waste management companies (WMCs). As for the household waste, this is either sent to 4 sorting plants for household waste or sent directly to feedstock recycling in Schwartze Pumpe in Germany. Since the start-up in 2002, around half of the separately collected household plastic packaging waste has been transported to Schwartze Pumpe in Germany for feedstock recycling. This fraction is accepted as material recycling for everything going above 22.5 % (NMoE 2003b), which is the mechanical recycling target within EU (EU 2001).

Table 7.3 Efficiencies for household, mechanical recycling (Schefte 2005, Gjester 2005).

	Recycling ratio	Sorting	Pre-recycling	Recycling	Collection
Film	0.025	0.3	0.8	0.8	0,13
Rigid	0.007 - 0.014	0.20-0.25	0.65 - 0.85	0.95	0.07

The collection efficiency is here given on national level, and one explanation to the low efficiency is that just half of all municipalities in Norway offer solutions for source separating plastic packaging. For instance, Oslo (the capital) does not have such solutions, but has decided to implement it in 2006.

The major differences between 'commerce and industry' and 'households' are found in the sorting efficiencies and in the collection efficiency for film. As for households sorting, this is far below commerce and industry both for film and rigid, indicating a poor source separation within the households, low-tech facilities in the sorting plants as well as a wider range of plastic packaging polymers in households. Losses of efficiency early in the recycling chain are very difficult to catch up with later in the chain (Solem, 2004) and several advocates that households should be given stronger incentives for sorting properly at home (Norwegian Competition Authority 2004, Walls 2004).

7.1.2.3 Discussion

The previous chapter showed that the collection efficiencies are the limiting factor for obtaining higher recycling ratios. The plastic packaging that does not go to material recycling, might either go as a fraction of source separated material for energy recovery or as a fraction in the residual waste. Figure 7.11 shows the amounts in energy fraction.

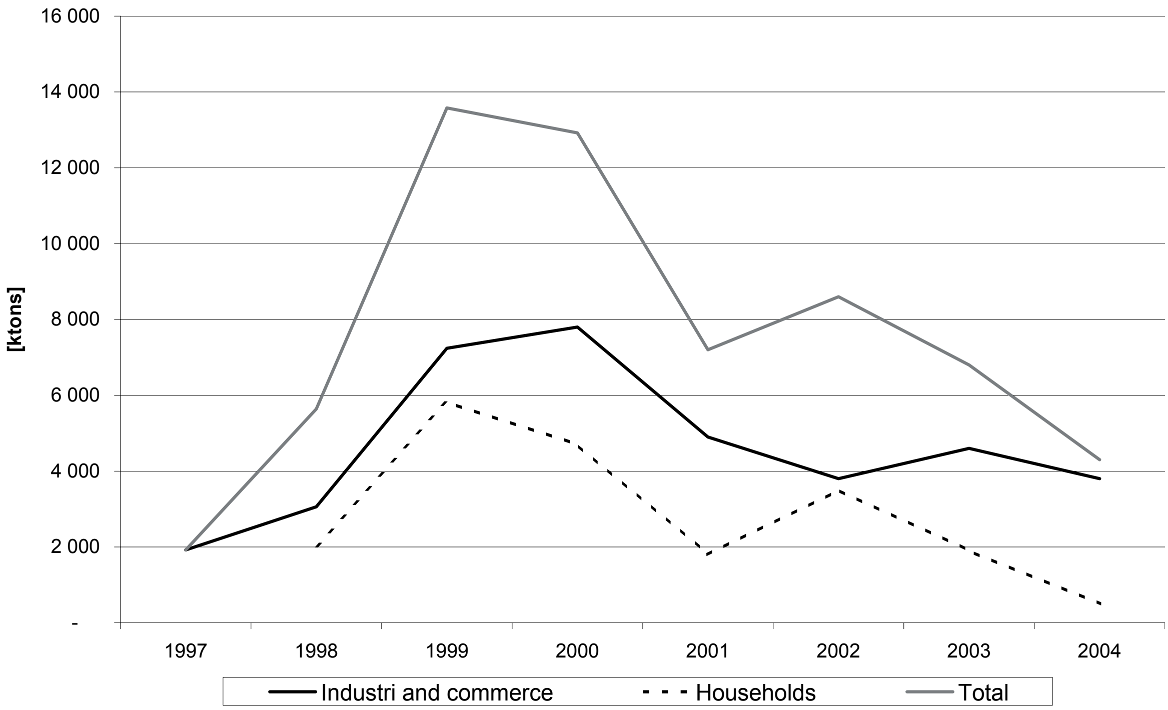


Figure 7.11 Amount of source separated plastic packaging in energy fractions

As seen in Figure 7.6, Plastretur is currently approximately 10,000 tons below the target. If all what is now sorted for energy recovery is 'transferred' to the material recycling fraction, this will only contribute to less than half of the required amounts for reaching the target. Hence, in order to reach the targets, parts of the plastic packaging following the residual waste flow must be redirected towards material recycling. This emphasis the need for strategies and measures directed towards the waste generators, both in commerce and industry and in households.

Looking at the improvement potentials within commerce and industry and households, we see from Figure 7.4 that the recycling ratio within industry and commerce has been fluctuating around 30 %. The film fraction within this market has a recycling ratio of 28

% in 2004, while the rigid fraction only has 4.9 % material recycling.

Table 7.4 shows the amount of generated waste for each market and each product and the corresponding material recycling ratio for these in 2004. Apparently, the potential for improvements are present in neither agriculture nor aquaculture because there already are high recycling ratios and the total quantity is low compared to the other markets. Hence, it is film and rigid plastics within 'households' and 'commerce and industry' we find the greatest potential for improvements.

Table 7.4 Total amount of generated plastic packaging waste (in ton), and the material recycling rate (in %)of this in 2004, as an example.

	Households		Comm & ind.		Agriculture		Aquaculture		Total	
	ton	%	ton	%	ton	%	ton	%	ton	%
Film	39,550	9.1[8]	32.500	28.0[9]	7200	75.0	0	0,0	79,250	22.8
Rigid	21,550	7.9	12.300	4.9	300	0	0	0,0	34,150	6.8
PP-bags	0	0,0	1.600	56.3	900	33.3	2.000	100	4,500	71.1
Reuse	0	0,0	1.200	41.7	0	0,0	0	0,0	1,200	41.7
Total	61,100	8.7	47,600	26.5	8,400	67.9	2,000	100	119,100	21.5

If the recycling ratio within the households increases to 25 % for both film and rigid plastics, the target will be reached. This is almost as high as for film in commerce and industry. Material recycling of household film is more challenging as it contains laminates, more dirty packaging (organic material) and a number of polymers that are not compatible in recycling processes (Hoyle and Karsa 1997) That said, the collection rate for the best municipalities in Norway is 55 % plastic packaging Raadal et al. (2001) with a total 15 % recycling ratio.

As shown in Figure 7.10, feedstock recycling counts for 6.5 % of the recycling results in households. This controversial type of recycling does not require the homogenous qualities as extrusion does, and might thus have a higher potential. That said, the feedstock recycling options in Germany is not stable options as the DKR that has subsidised these recycling plants might not any longer support them (Karras 2005), and this option for Plastretur then disappear. Moreover, feedstock recycling cannot be used for compliance up to 22.5 %, so Plastretur must anyhow find solutions for these first 22.5 %.

This analysis clearly shows the benefits of a material flow approach to study a system like this. It is here shown that material flow accounting on a detailed level will help the PROs to better manage and run the recycling systems, and that knowledge on detailed level is important to construct and improve the system. The analysis on this level does not, however, tell us about the quality of the recycled material. The next chapter will present and discuss the costs and cash flows within the Plastretur system, which will provide better understanding of both the efficiency of the system as well as the effectiveness when it comes to material quality.

7.2 Understanding the Plastretur system by studying the cash flows

Is there any correlation between the subsidies from Plastretur to the direct actors and the collected and recycled amount? What are the effects of increased subsidies? The basic idea with EPR-system like this on plastic packaging is to transfer money from upstream companies (cost) to waste management companies (income) making it economically more attractive to recycle. Below we will follow the cash flows in the Plastretur system. We will, however, not go into the particular company costs.

7.2.1 Overall picture

7.2.1.1 Income

The EPR system for plastic packaging is financed by the fee paid by producers of plastic packaging, by fillers and packers, by wholesalers and by importers. The producers of empty packaging for the packaging sent directly to the final consumer-use (plastic bags), packers and fillers. Retailers pay the fee for plastic bags. The fee is by a majority of the interviewees regarded as the same as a governmental fee, because both represent a cost, but in this case, the fee gets to the industry itself to organise a recovery system, and not to the government. The fee is paid to Materialretur, which is a financial coordinating PRO for all material companies like Plastretur. It was established in 1997, due to the potential synergetic effects in co-organising the fee collection and to reduce the number of free-riders (Guttuhaugen 2000). From 1st of January 2000 Materialretur has been the only actor in Norway that has licence to use the "Grüne Punkt". Companies that do not pay the fee, is not allowed to use this label, and Materialretur uses this actively to recruit new members (Guttuhaugen 2000).

There are basically two reasons for why the income from licence fee is lower than 100 %. First, through frequent audits Materialretur discovers that companies pay licence fee for less than they actually are using. For instance, packers and fillers have frequently not reported transport packaging, but only the inner-packaging. The second reason is that there are free-riders in the system. These are companies that do not pay the licence fee, but that despite this take the benefits of using the system. Being a voluntary system, Materialretur does not have the legislative authority in order to reduce the number of free riders, but must rather go through the market mechanisms. Figure 7.12 below shows the actual income as fraction of the potential income.

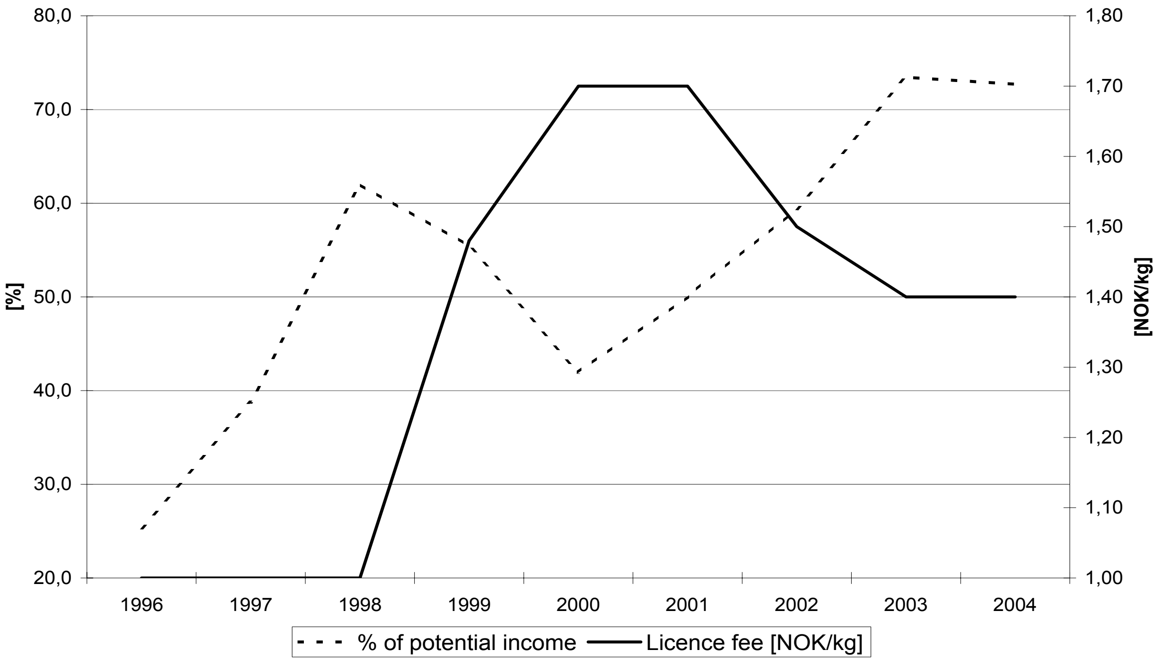


Figure 7.12 The licence fee per unit and fraction of total income to the potential income

7.2.1.2 Overall cost picture

Similar to the material flows we will look at the cash flows in the Plastretur system at various levels of aggregation. Given the objective of redirecting the material flows towards material recycling, the overall cost picture can be expressed as the total costs Plastretur actually has divided by the tons actually material recycled. Without any governmental interference or consequently any role for Plastretur, the material flows would have been entirely market-driven, as it was before the introduction of EPR in 1995. The costs of Plastretur can therefore be argued to be denoted entirely to increase the material recycling ratio. However, in addition the single companies have administrative costs connected to reporting, payment of the licence fee and other tasks that follows with this. We will not provide cost picture of these company costs.

While Materialretur is concerned about the income side, Plastretur is concerned about how to distribute the money to the recovery sector most efficiently. Figure 7.13 below shows the development of the total costs for Plastretur for the period 1996 – 2004. The total costs show a steady increase during the entire period. The main reason for this is the increase of running costs. The fixed costs have actually shown a reduction from 2001 and onwards). Fraction of fixed costs to the total costs is reduced during the last years, from 35.6 % in 2001 to 22.8 % in 2004.

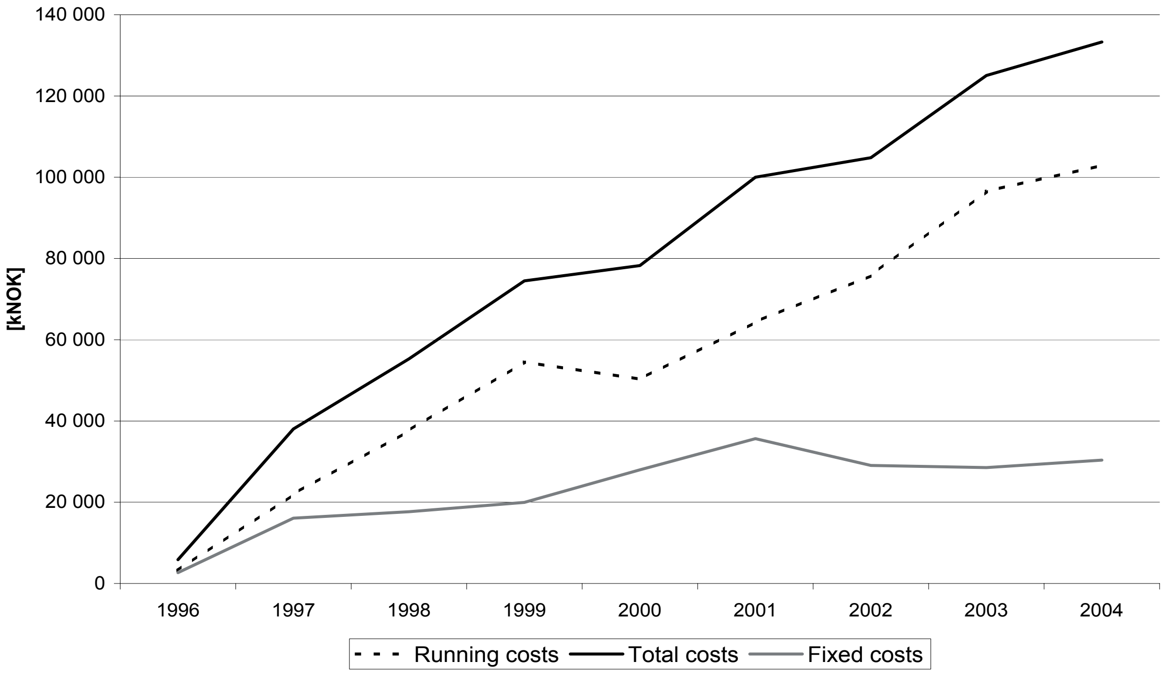


Figure 7.13 Total costs, running costs and fixed costs for Plastretur 1996 – 2004

Fixed costs are those costs that are not directly associated with the material flows (per ton) throughout the Plastretur system. In Figure 7.14 we distinguish between three types of fixed costs; i) projects, ii) administration and iii) communication. Projects are undertaken to improve the performance in certain phases of the Plastretur system, and to initiate new fields of particular interest for improving the quantity and quality of the material going to recycling. One example is the 'Quality Project' where representatives from Folldal Gjenvinning, the largest film recycler in Scandinavia, get paid by Plastretur to educate waste management companies how the plastic packaging should be collected and treated in order to obtain the highest input quality to the recycling process (Plastretur 2002b, Aursland 2002).

Besides the financial support paid to collectors, sorters and recovery companies, Plastretur use a lot of resources and money on information and communication in order to recruit more member companies, establish co-operation with municipalities, information campaigns and start-up-subsidies both within commerce and industry and within the household segment, all in order to make the recovery system more effective.

Indeed, running costs will increase with increasing amount of recycling, given the same technology and contracts. Consequently, the way these running costs can be reduced is to alter the contractual unit costs (commitment) or the financial mechanisms, for instance by reducing subsidies for energy recovery or by letting more being recycled in low-costs countries abroad. If we go into details here, we may disaggregate the costs into the various phases, in order to discover where the highest costs actually are, in sorting, collection, recycling, information etc. For instance, why are the unit costs increase every year from 1998 to 2004? Figure 7.14 below illustrates this on an aggregated level. Based on this, we may develop unit costs for the different markets and products.

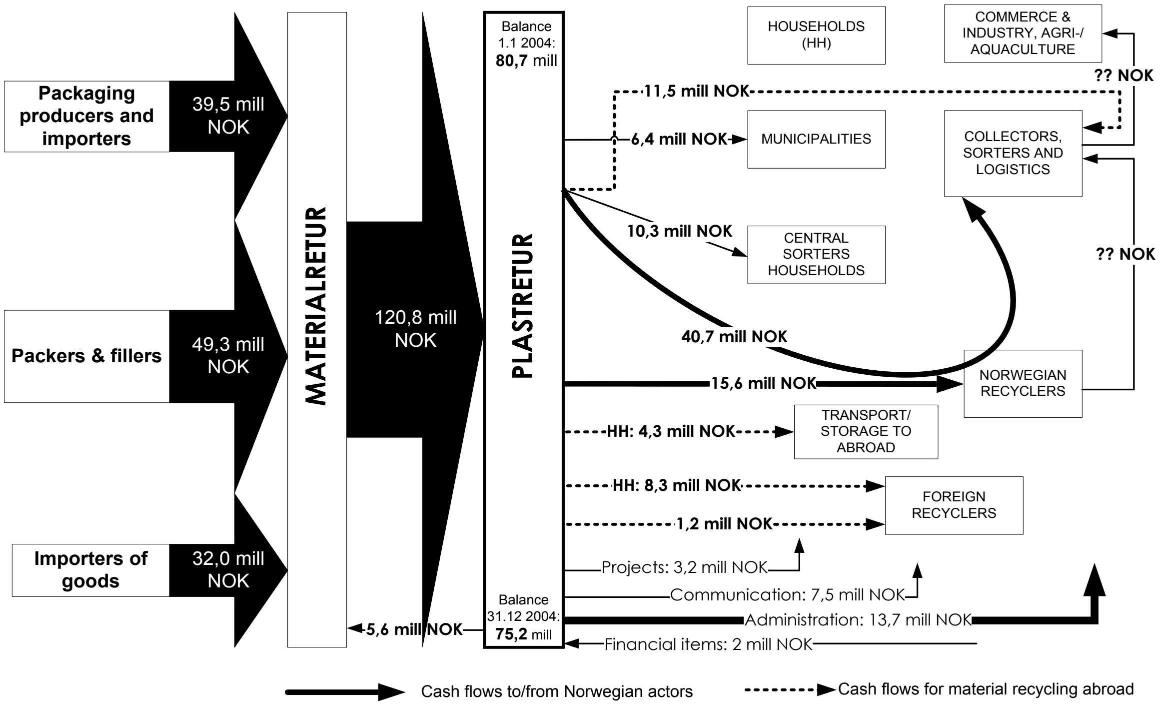


Figure 7.14 Cash flows through the value chain for 2004

7.2.2 Running costs

Figure 7.15 provides the overall running cost-picture for the period 1996 – 2004. The collection and sorting costs are the major contributor to the costs, with the material recycling costs following second, although these have dropped significantly the last years. This can be seen in connection with the growth of recycling activities abroad, see Table 7.3. During the same period, the transport and storage costs have increased because these are mainly connected to recycling activities abroad.

Figure 7.16 displays the distribution of running costs between the four markets. Commerce and industry is the market with highest total running costs, but household costs are increasing due to the increased efforts in that market the latest years. To get a similar picture as for the material flows, we will now provide information on running costs for 'commerce and industry' and 'households'.

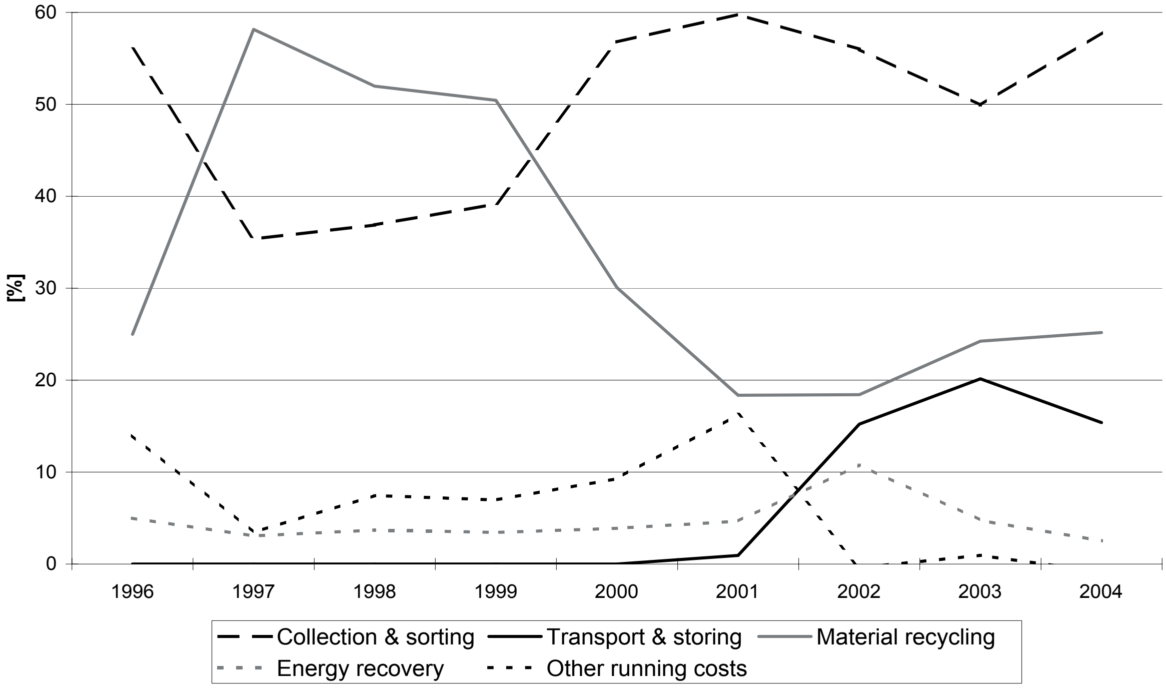


Figure 7.15 The total running costs fractions for various processes in the waste management system.

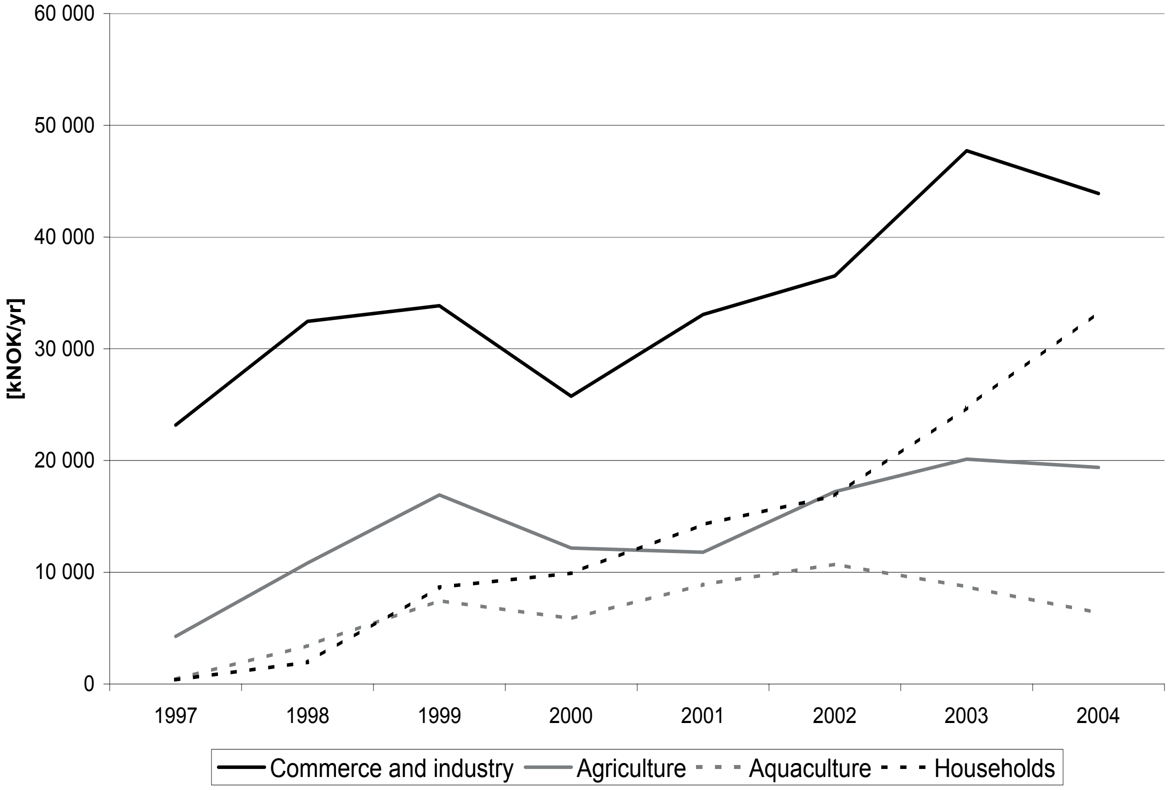


Figure 7.16 Total running costs for the four markets

Figure 7.17 illustrates the running costs for commerce and industry. The same trend as in Figure 7.15 can be observed. Collection and sorting costs are highest, with material recycling costs as second.

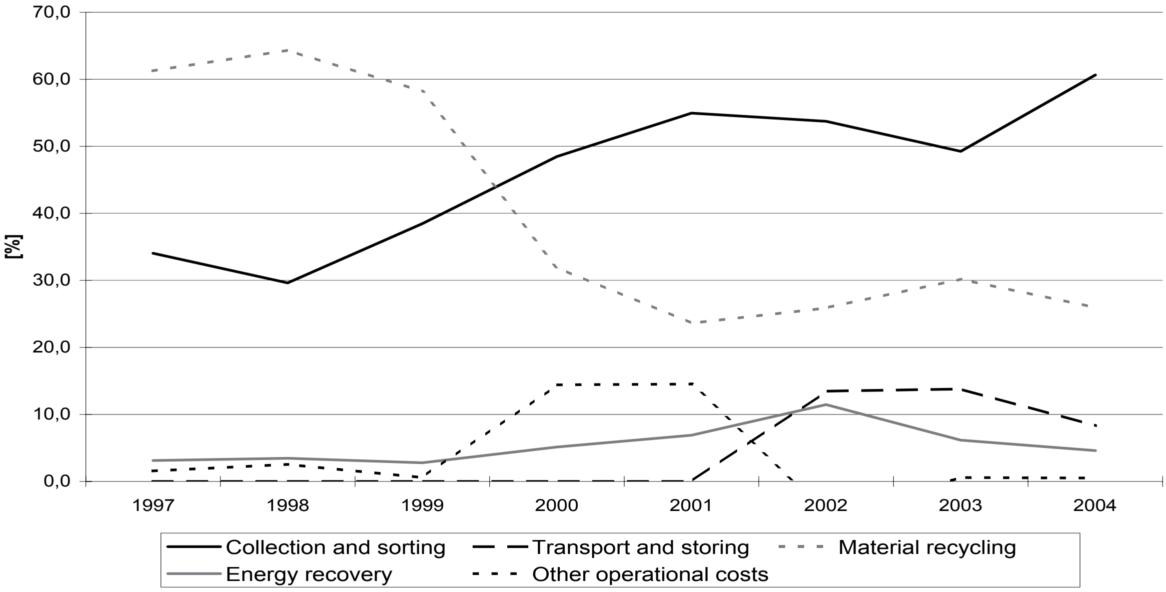


Figure 7.17 Running cost for commerce and industry

Figure 7.18 illustrates the running costs for households. We observe that the collection and sorting costs are relatively more dominating than the collection and sorting costs for the other markets. The reason for this is that Plastretur in addition to the subsidy for delivered sorted plastic packaging that all four markets get, also subsidies local authorities on collection and sorting from households.

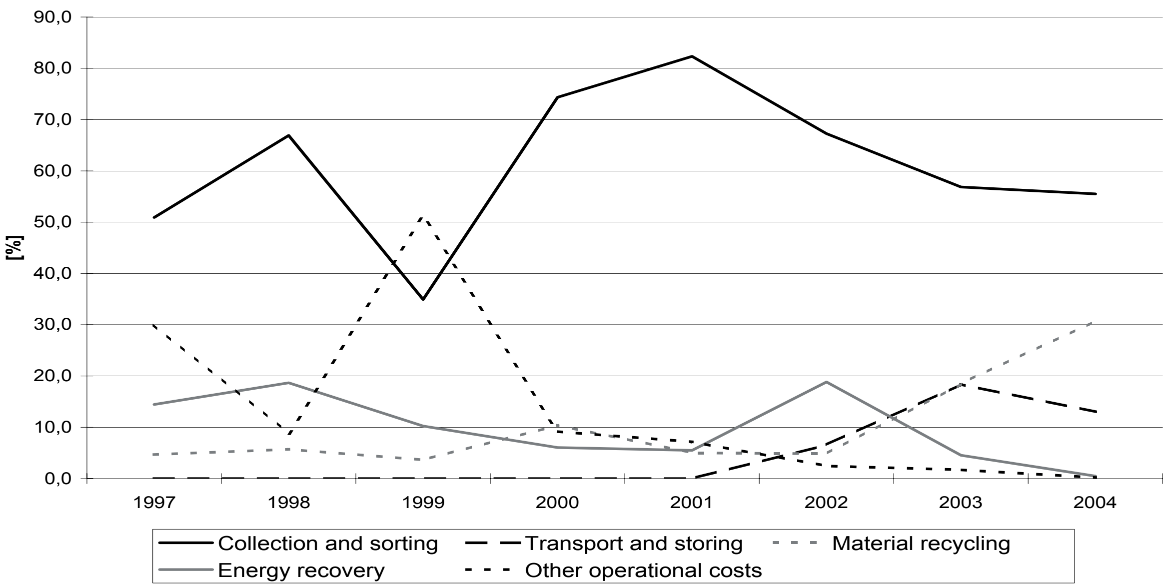


Figure 7.18 Running costs for households

In total we might say that all four markets show more or less the same trend with high collection and sorting costs and with material recycling costs following second.

7.2.3 Unit costs

Chapter 7.1 and 7.2 have so far provided information on material flows and cash flows. In this chapter we will, as outlined in Chapter 4, combine these in order to point out some interesting development trends with regards to efficiency.

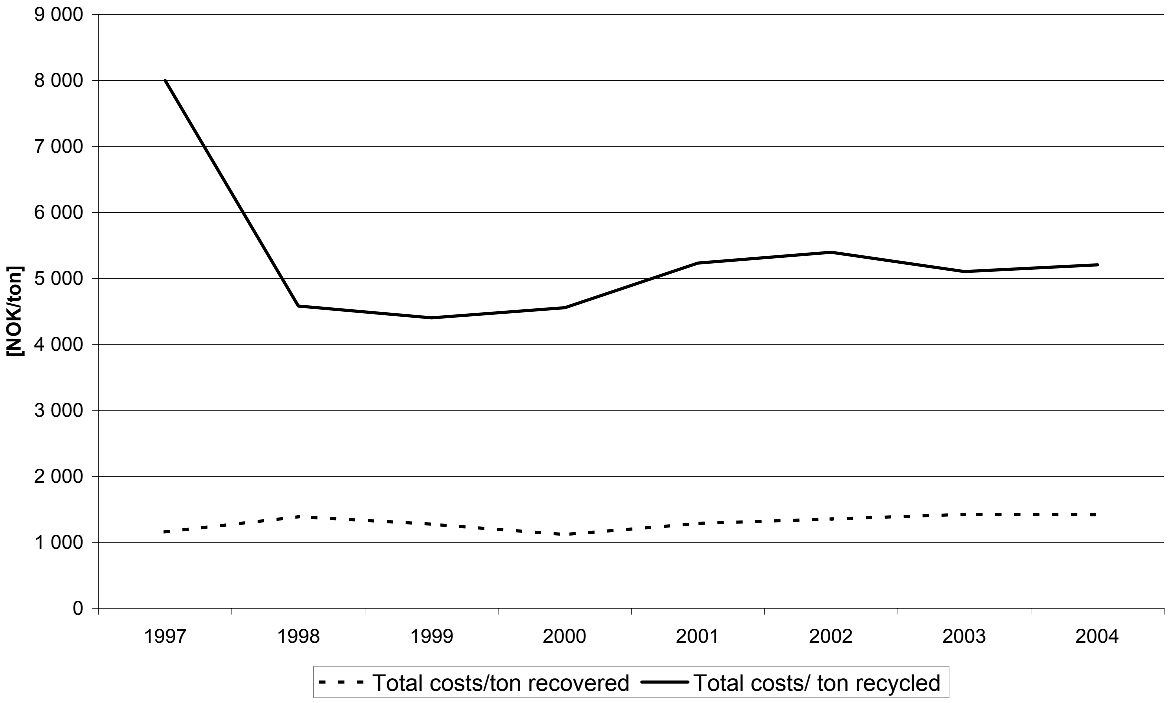


Figure 7.19 Total costs related to tons recovered and recycled, index 2004

The total costs per ton recovered are rather stable. The main reason for this is that the energy recovered fraction constitutes close to 70 % of total recovered amount. Plastretur does not pay for this fraction except from the transport to energy recovery in Denmark for the amount source separated for energy. The largest amount of energy recovered amount comes from residual waste from households which Plastretur does not subsidise. The unit costs per ton material recycled are considerably higher, being just above 5000 NOK/ton. The unit costs have increased slightly during the latest years, somewhat contrary to what might be expected given that systems will be more efficient by the time.

Turning to the unit costs based on *running costs*, Figure 7.20 shows the same trend; a relatively stable unit cost related to recovery, but a growth in the unit costs related to recycling. How can we explain this?

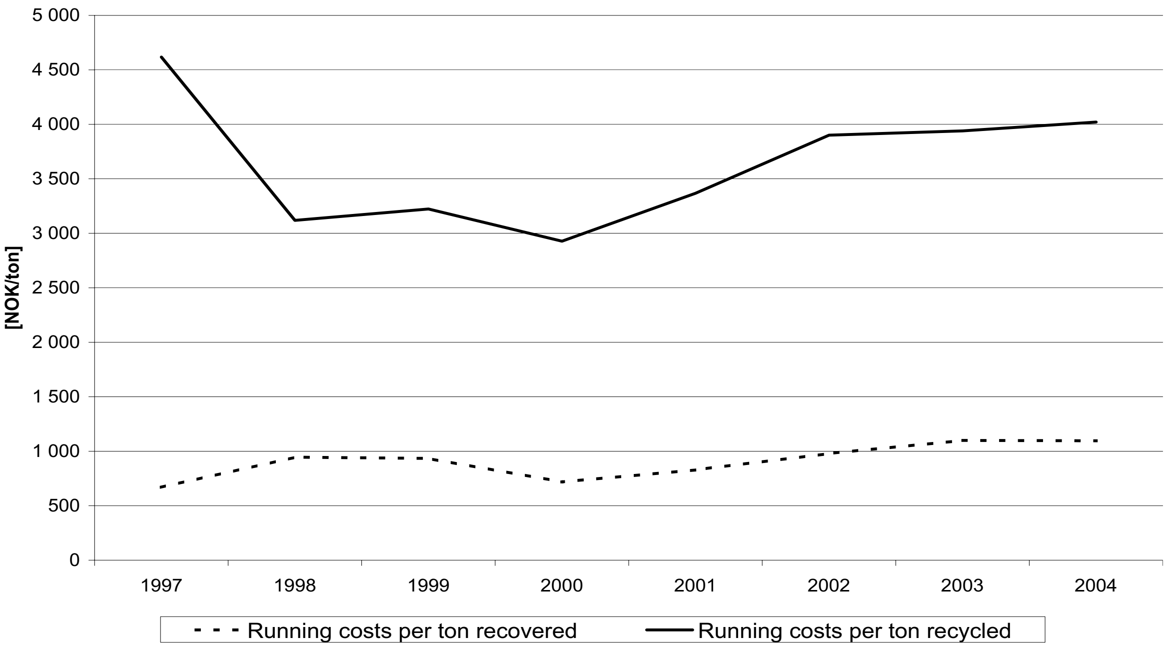


Figure 7.20 Running costs related to tons recycled and recovered. Indexed = 2004

One explanation to the rising unit costs is that in the beginning of the operative period of Plastretur EPR system (1996 – 1998) there was lots of reuse plastic packaging entering the system. Plastretur does not pay anything for this fraction, but it contributes to the actual recycling results. Since then, this amount has been reduced dramatically, and at the same time the 'cheapest' fractions when it comes to unit costs among film has been utilised already. In order to increase the recycling ratio even more, the more expensive fractions like rigid and household waste must be taken into account.

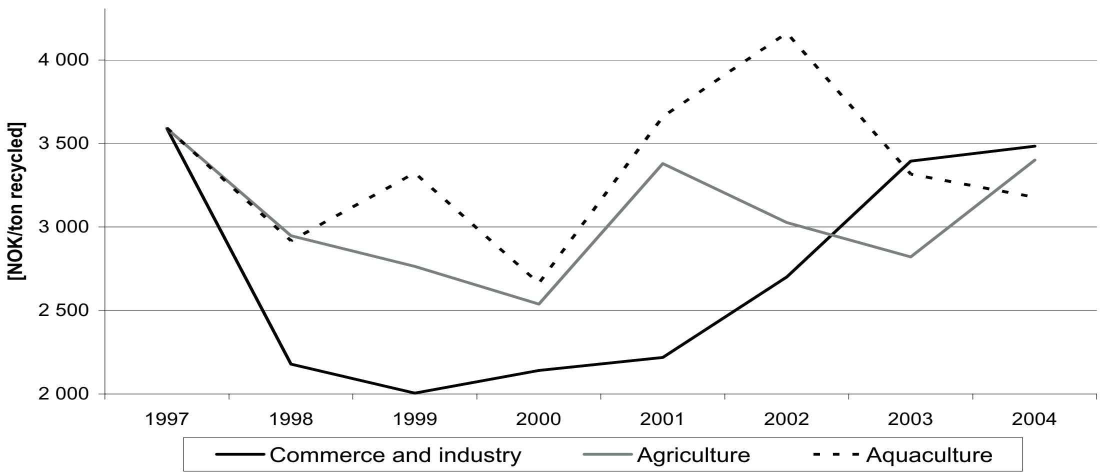


Figure 7.21 Running costs per ton material recycled in three markets. Indexed: 2004

Figure 7.21 clearly shows that the unit costs for commerce and industry have risen more than 50 % since 2001, which explains the trends in the previous figures. The unit costs for household packaging are shown in Figure 7.22. Obviously, the unit costs are many times higher than for the other markets, although the difference has decreased considerably the latest years, mainly due to the introduction of feedstock recycling. Figure 7.22 also clearly illustrates why Plastretur has not paid too much attention to household waste in the early years.

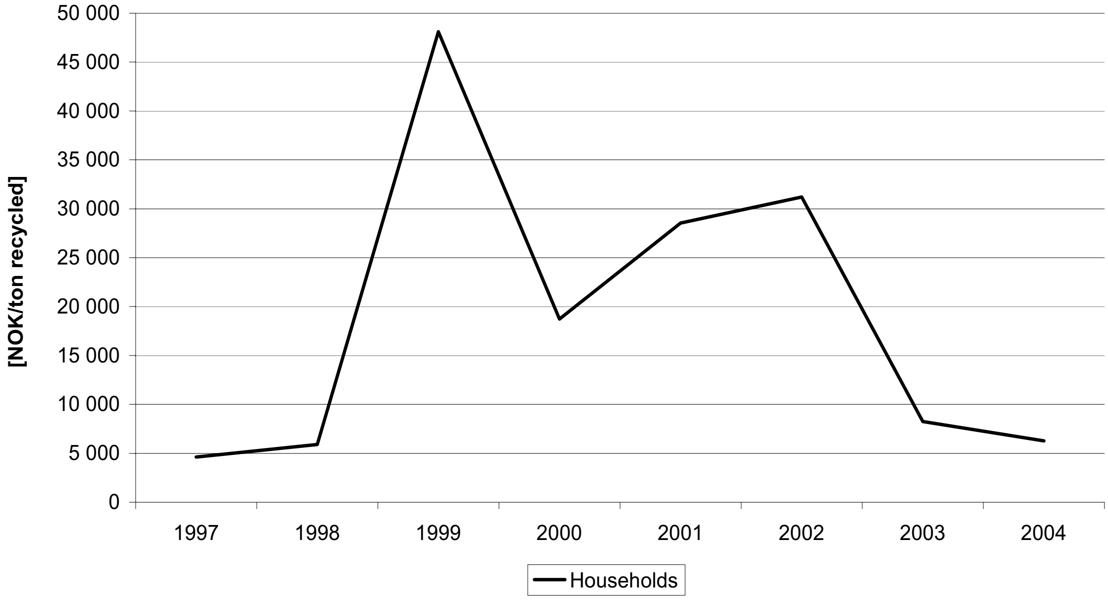


Figure 7.22 Running costs per ton material recycled in households

7.3 Interconnected actors – the market mechanisms

So far we have been looking at the flows of materials and cash *between* actors. In this chapter we will go more in detail into the direct and indirect groups of actors that constitute the Plastretur system, by discussing their roles and responsibilities in the system and how they relate to each other. Figure 7.23 shows the actors and their relative influence on the actual material and cash flow.

The direct actors are production companies, trading companies, packers and fillers, the industrial users of plastic packaging (aquaculture, agriculture, industry etc), private consumers (households), waste management companies (collection and sorting), recycling companies in Norway and abroad as well as secondary production companies that use recycled plastic packaging material in their products.

The most important indirect actors are Plastretur, Materialretur (PRO), Ministry of Environment, Norwegian Pollution Control Authority, the scientific communities and business organisations.

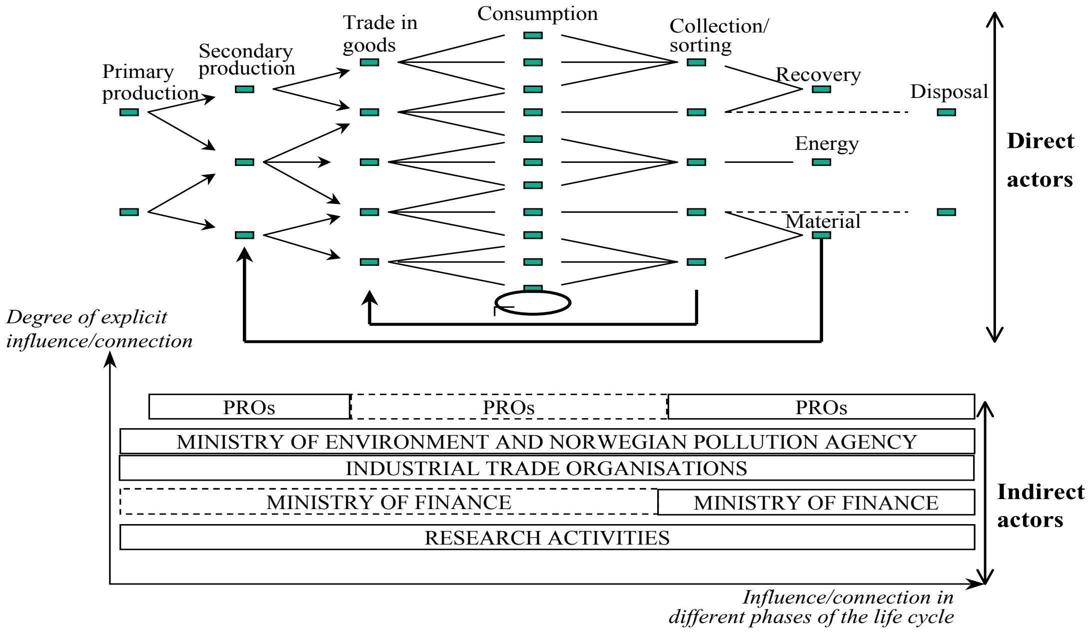


Figure 7.23 Direct and indirect actors in the EPR system of plastic packaging

In order to provide a picture of the complexity of the Plastretur system, Figure 7.24 shows the connection between the direct actors as far as the material, product and cash flows are concerned.

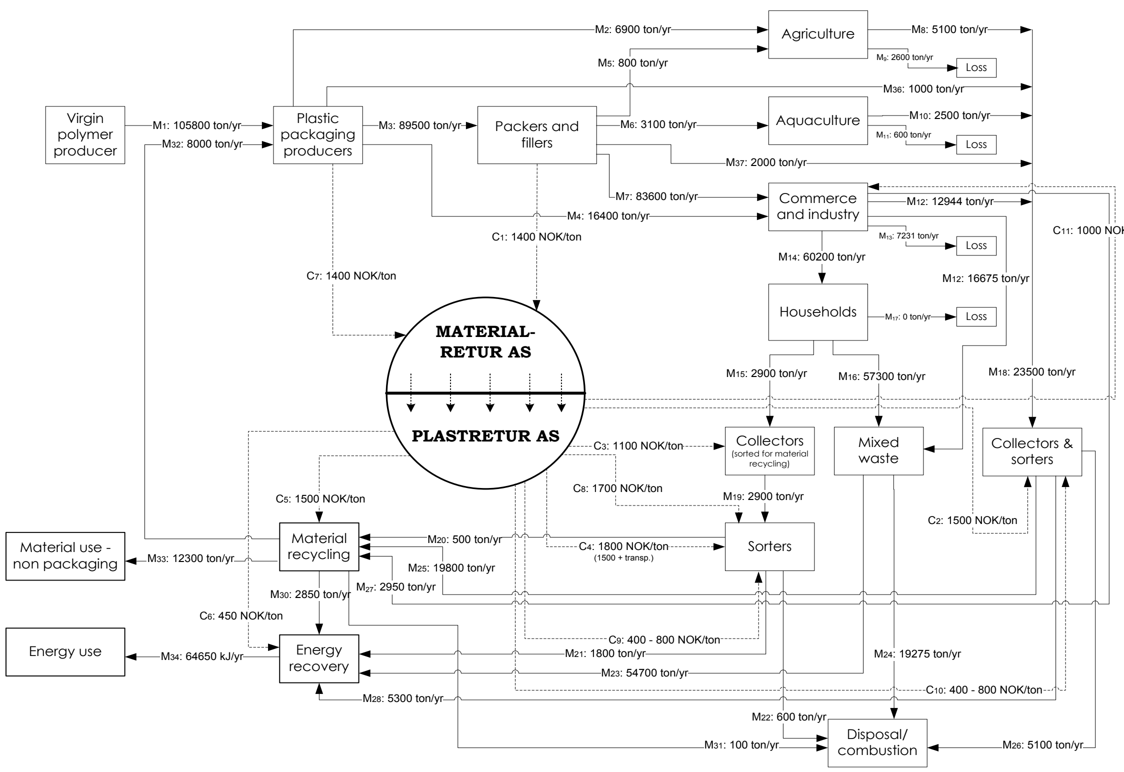


Figure 7.24 The actors, material flows and cash flows within the Plastretur system. Numbers from 2001

Figure 7.24 shows the flow of materials and cash between the different actors. The squares are the actors, the whole lines are material flows and the dotted lines are cash flows. The figure also shows the role of Plastretur receiving money from producers and packers and fillers (through Materialretur), and distributing these to the actors in the recovery phase to encourage recovery activities.

7.3.1 Direct actors

According to the analytical framework presented in Chapter 4, we distinguish between upstream actors, downstream actors and secondary use actors.

7.3.1.1 Upstream actors

The plastic industry comprises *virgin polymer producers* and *plastic packaging producers* as well as *plastics recyclers*. Their role in the Plastretur system is to 'contribute to recycle collected plastic packaging waste and to establish and develop markets for recycled plastic packaging' (Plastretur 1995), and this group of actors holds 1/3 of the shares in Plastretur. Virgin polymer producers do not pay licence fee to Materialretur except for the plastic packaging they use for protecting *their* products and packaging on imported goods. The plastic packaging producers are employing primary or recycled plastics for making plastic packaging products. This is traditionally a large and powerful industry with Stenqvist and Norfolier as the biggest actors, but recently they face very small margins due to high competition. These companies pay licence fee to Materialretur if they are producing plastic bags, building film, service packaging, agriculture plastic and plastic for market gardens and agricultural goods. The fee is usually included in the price of the product.

The *packers and fillers* are those who use the plastic packaging for protecting the 'real' product. Those companies that during their production *use* plastic packaging are those who basically pay the licence fee to Materialretur. These are represented in Plastretur through the 'Food Industry Association' both as shareholders (1/3 of the shares) and as board members. Both producers of goods within the secondary industry and service companies within tertiary industry are packers and fillers as long as they employ packaging during their activities. Importers of empty packaging are committed to pay licence fee as well, as shown in Figure 7.14. Currently there are around 1,800 fee payers to Materialretur and a majority of these are 'packers and fillers'. There are, however, just a handful of these that are participating actively in the organisation of the Plastretur EPR system, either through shares in Plastretur, board members in Plastretur or through 'The Industrial Packaging Optimization Committee' (NOC). It is mainly the industrial associations that represent the individual companies. Hence, the daily contact with Plastretur EPR scheme is not present and most often limited to the bimonthly date of licence fee payment (Fredriksen 2003, Kildal 2003)

The last group of upstream actors are those industrial and private actors that are the last link in the upstream packaging chain constituted by the wholesaler and the retailer business. In addition to being the last group of actors upstream, they are also part of the first group downstream, the waste generators. Obviously, all the actors presented above generate plastic packaging waste during their activities. Major waste generators are, as presented above, categorised in four markets. Within the commerce and industry, the grocery traders both as *wholesalers* and retailers are the most important actors. There are four large supermarket chains in Norway, having significant influence within the Plastretur system, both as shareholders (1/3) and as the customers to the major packers and fillers. The last point is significant as competition between suppliers and between the supermarket chains (Rommetvedt 2002), particularly since international supermarket chains establish business in Norway, is a key element in the development of the Plastretur system. According to the shareholder agreement, their role in the Plastretur system is to 'contribute to efficient control so that all their suppliers of goods pay licence fee in order to avoid free-riders' (Plastretur 1995, p 2). Obviously, the wholesalers have the power not to buy products from companies not paying the licence fee (Maldum 2003).

However, both wholesalers and retailers are significant waste generators mainly of clean and dry transport packaging of high quality. Due to finalisation tax introduced in 1999 and generally higher waste management costs for residual waste, it has become more expensive for them to deliver the plastics to the waste disposal sites than to collectors of plastic packaging waste. The collectors contracted by Plastretur are obliged to receive the plastic waste for free (Sundt 2002). However, some wholesalers utilise the commercial potential of their valuable plastic packaging, by demanding getting paid for their plastic packaging. At the same time they reduce their waste management costs (Langolf 2002). The multi-sided role of this group of actors, both being plastic packaging users, plastic packaging waste generators and controllers of their suppliers, emphases their significant position within the Plastretur EPR system.

Household plastic packaging constitutes the largest fraction within the Plastretur system. On the waste generation side of the consumers' activities, they are treating their plastic packaging waste according to the waste management system set up by local authorities (see Chapter 6 for more). Some argues that there are few economic incentives for consumers to sort packaging at source, and current source separation systems (*kerbside system* or *bring system*) invite the environmental conscious people to act accordingly, and not those who are acting mainly due to economical reasons (Bruvoll et al. 2000, Norwegian Competition Authority 2004). However, plastic packaging is just a part of the entire waste generation within households which local authorities must take into consideration in order to obtain an optimal system (Plastretur 2005b, Plastretur 2005c).

7.3.1.2 Downstream actors

In general, direct downstream actors are not a part of the agreement between plastic packaging industry and the Norwegian Ministry of Environment. The waste management business is an independent sector making profits out of treating waste in the most economic beneficial manner. Plastretur aims at influence this market through measures and strategies such as subsidies, contractual arrangements and information so that the competition between the market actors contribute to improved material and product flows towards loop closing.

Plastretur has contracted 120 waste management companies (WMC) in Norway. These companies guarantee to receive plastic packaging waste for free from waste generators at their sites, but can require payment if collected at the waste generators place. Plastretur guarantees that the WMCs have a place to deliver the plastic packaging waste. WMCs get paid, through the recovery companies due to quality control carried out by recyclers (see Figure 7.14). The payment depends on the type of polymer (e.g. film and rigid) and the quality of the plastic. The recovery companies can reduce the payment if the deliveries from WMCs do not comply with quality criteria given in the contract. Moreover, the WMCs choose themselves to what extent they sort the plastic packaging before sending it to recyclers. The largest waste management company in Norway, Norsk Gjenvinning, built in 2001 a sorting plant for increasing the quality of the plastics.

As seen from Figure 7.25, the recycling abroad has increased the latest years, and Plastretur has established an 'export storage' for quality control and joint transportation to recyclers, particularly in the Baltic States. Experiences show that the quality control is not as strict as by Norwegian recyclers, although they receive the same payment. Hence, major Norwegian WMCs claim that Plastretur prioritise quantity to quality (Kopstad 2003).

The *local authorities* are not part of the covenant on plastic packaging, despite the fact that they according to the Pollution Control Act are responsible for the plastic packaging from households. The municipalities thus claim that Plastretur and the other PROs on household packaging are 100 % financially responsible for the packaging comprised by the EPR regulations (Igesund 2004). Thus, they require payment for their actual costs connected to collection and sorting of this packaging, although the local authorities are by law imposed to collect and treat the household waste in the environmentally best manner. On the other side, Plastretur is responsible for achieving their recycling targets and are thus free to decide how to spend their financial resources in order to reach this as efficient as possible. However, the mutual interdependence between the local authorities (supplying packaging waste) and Plastretur (PROs) (demanding packaging waste) creates a close co-operation between Plastretur and more than 250 municipalities.

The municipalities are paid directly by Plastretur to create and distribute information material and for establishing collection points. They also receive NOK 1100 pr ton (2004) from Plastretur for plastic packaging going to the regional sorting companies which have the quality control of the collected plastic packaging.

During the latest years, combustion without or with poor energy recovery and landfilling have become more expensive due to the finalisation tax (and recyclables will be banned from 2009), and local authorities, like waste management companies, look for solutions that reduce their costs due to this. Recycling and recovery activities are in line with this. On the contrary, several local authorities own landfills that represent a substantial income for them due to these increased prices.

Recovered material of high quality is a main driver in the EPR system. If the quality is good enough, it is able to compete with virgin material in making new products. The material recovery companies and the sorters are guaranteed a minimum price from Plastretur. There are material recyclers both in Norway and abroad receiving plastic packaging collected from Norwegian waste generators. Folldal Gjenvinning is the largest Scandinavian film recycler with an annual capacity of 10,000 tons in 2004, increasing from 5,000 tons in 1998. The recyclers are allowed to refuse entire loads from WMCs or parts of it.

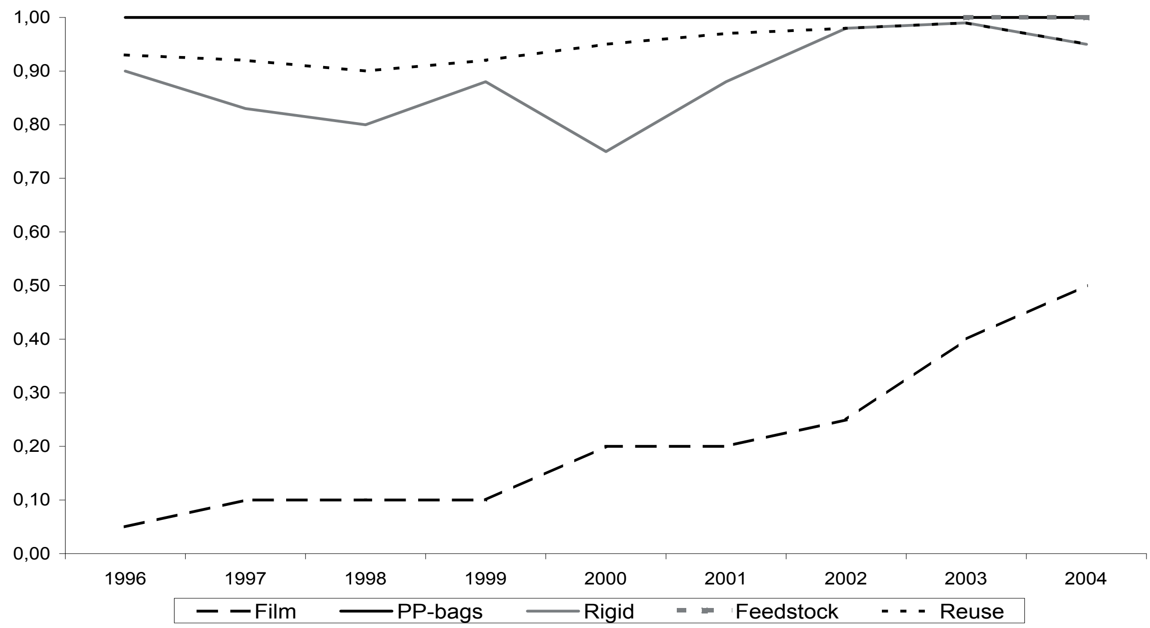


Figure 7.25 Fraction of plastic packaging recycled abroad

The general picture is that recyclers abroad offers better prices for plastic packaging waste than Norwegian recyclers can do, basically due to lower labour costs. Foreign recyclers have the capacity to sort an additional round before entering the recycling process. On the other hand, Norwegian recyclers are part of the Plastic Industry Association, which holds 1/3 of the shares in Plastretur. Due to this, there have been examples where the interests of these companies and not of Plastretur have been decisive for the conclusion made on issues such as how much of the collected plastic packaging shall be recycled in Norway. This is particularly relevant for film, as shown in Figure 7.25 below. The present situation is that Folldal Gjenvinning is guaranteed 10,000 tons a year in order to maintain their recycling capacities. During the first years of the Plastretur system, plastic packaging waste collected in Norway was recycled abroad due to lack of recycling capacities in Norway, but in the latest years, the cost aspect has also given incentives for increasing the export also of film.

The *energy recovery* of the rest fraction from household waste is mentioned above. This energy recovery counts for almost all the entire energy recovery in this EPR system (see Appendix C). The energy recovery at industrial sites, gets plastic waste from the sorted plastic of low quality from households and from the industrial plastic waste of low quality. In 1996 – 1999 the energy recovery was carried out at Norcem cement production plant in Brevik, Norway, or at Sande Paper Mill in Sande, Norway. Since 2000, there has been a tender and Plastretur has since then used Aalborg Cement in Denmark as the energy recover.

7.3.1.3 Secondary upstream actors

The recycled material must eventually be employed in new products, either packaging (closed loop recycling) or non-packaging (open-loop recycling). Recycled material is competing with virgin plastics, and must satisfy the similar criteria as far as quality, quantity and stability in delivery is concerned. There are some examples of Norwegian companies that have employed recycled plastic packaging material. The most important products are garbage bags, plastic bags and cable cover plates.

7.3.2 Indirect actors

7.3.2.1 PROs

Plastretur is, despite its key role in meeting the objectives in the covenant, basically an indirect actor in this EPR system. It does not own the material, except from the part of the system where plastic packaging waste is sent abroad to be recycled there. As shown in Figure 7.24, Plastretur is mainly occupied with the end-of-life phase, while Materialretur is dealing with income-related activities. Materialretur was established in 1997 by 6 ‘packaging’-PROs (plastics, corrugated cardboard, beverage cartons, carton, glass and metals) in order to coordinate all activities directed towards the licence fee payers and to prevent that confidential information from licence fee payers becomes available for competitors being involved in the PROs (Røine 2002). Plastics is a particular challenging material in this context as there is a high number of licence fee payers (~1800) compared to for instance beverage cartons with just a handful of fee payers.

EPR on plastic packaging in Norway is a voluntary scheme, and Materialretur must develop their strategies accordingly in order to avoid free-riders and underreporting. Of particular importance in reducing number of free-riders has been the 'control membership' (Sundt 2003, Røine 2003) Companies with such membership have committed themselves to make sure that all their suppliers are members of Materialretur. If not, they will not be allowed to sell to the controllers, making it a kind of 'green procurement' system. Another strategy that has proven successful is to concentrate recruitment efforts on specific business sector and motivate every (large) company within this sector collectively to agree that they will be members of Materialretur (Røine 2002). In addition, a new governmental procurement regulation requires that every company being supplier to the regulatory authorities and directives (NHD 2004). Moreover, Materialretur has exclusive right to use 'Die Grüne Punkt' and employ this as an argument to recruit new members. This is particularly relevant for importers and international companies[10].

However, there are barriers for participating: Firstly, companies might, on principal basis, not be interested in participating, arguing that this is a voluntary scheme. Secondly, companies might be frustrated by the complex reporting system, due to a wide range of products with no knowledge on the weight of the packaging. This is particularly relevant for importers of products that have only knowledge to the product and not the packaging. Thus, heavy administrative load and costs in addition to the actual licence fee might create free-riders. The covenants on packaging have stimulated the relevant actors to form different discussion fora, meeting places where experiences and solutions are exchanged. One example is that the packaging chains have established 'The Industrial Packaging Optimisation Committee' (NOC) that aims at cope with the packaging optimisation objective in the covenant (see Chapter 5.3). This was established in 1999 as a consequence of the first evaluation carried out on the EPR packaging schemes by Norwegian Pollution Control Agency (SFT), which claimed that the PROs were initiating too few efforts in order to cope with the challenges of waste generation (SFT 1998). To the extent it does not influence the objective of reaching the targets, Plastretur is not to deal with upstream activities, including waste reduction efforts (Skilhagen 2003).

7.3.2.2 Authorities

The roles of various authority bodies in the EPR schemes are diverse. Local authorities are already mentioned as a direct actor being responsible for household waste. Local authorities are also indirect actors as the administrator of the relevant regulations, in particular the Pollution Control Act, while the operative part of the local authorities' activities now to a larger extent is privatised. These are usually 100 % owned by the local authorities, competing with other private WMCs.

The central authorities are operating at different levels. The Norwegian Ministry of Environment is the signing part in the covenant and is basically making sure that the development of the EPR schemes goes in right direction towards the targets. For instance, in year 2000 NMoE did a large evaluation of the covenants on the packaging area (NMoE 2000, NMoE 2001b). They have a very limited role and shall not interfere with the industrial EPR system unless there is a need for clarifications and interpretations of the covenant not concerning the industrial implementation. Their only sanctioning mechanisms is related to introducing a tax instead of the covenant. However, since the NMoE has put a lot of prestige in these EPR schemes, and they consider this to be like a regulation (Hambro 2003), they remain silent as long as the targets are reached.

Lkewise, SFT is just receiving the annual report from Plastretur, and without capacity to control the numbers provided by Plastretur, they have limited role in the system. However, it was SFT that decided in 2004 that the measuring point for material recycling should be at the point of inflow to the recycling plant (Flow $X_{M3,9}$ in Figure 4.5), and not into the actual recycling process. The argument was that it should harmonise with EU standard. In this context, we should also mention that the central authorities are represented in every county through an environmental governor, which reports to SFT and has a major influence on the local environmental policy. These make decisions concerning emissions to water, air and soil. The strictness of these when considering an application for emissions, are traditionally to a large extendt varying throughout the counties. Thus, various regions face different strictness of enforcing the law.

In an IPP perspective as discussed in Chapter 3, NMoE also is the key actor that has implemented final treatment taxes and that prepare how to implement the EU landfill directive in Norway. These policies are also influencing the choice of waste management solutions among the direct actors. For instance, after introducing the finalisation tax in 1999, we saw particular two things happen; the export of waste for energy recovery in Sweden increased and more companies started to source separate their waste. Hence, various policies (the covenant and the finalisation tax) might point in the same direction and contribute to similar outcome.

7.4 Plastretur

Chapter 7 so far has provided insight into the material and cash flows that characterise the EPR-system for plastic packaging in Norway. It has also looked into the direct and indirect actors that, to a greater or less extent, have contributed to the observed development. As seen from Chapter 7.1, the tonnage of recycled plastic packaging has increased considerably since 1996, and so has the recycling ratio, although this has found a stable level just above 20 % the latest years. The questions are: How has Plastretur contributed to this development? What strategies and instruments have Plastretur employed that has turned out successful? And to what extent has Plastretur provided signals and feedback to upstream companies so that these incorporate considerations on recycling issues into their design process?

We will look into these questions below by first drawing a picture of the role of Plastretur, its position within the already existing market as well as some overall principles governing the activities (Chapter 7.4.1). Then we go through the entire life cycle and discuss the strategies and measures that Plastretur employs towards the direct actors (Chapter 7.4.2). Finally, we go beyond the administrative (management) and operational issues and look into the interactions between the owners, the Board and the Ministry of Environment in order to explore topics these actors meet (Chapter 7.4.3).

7.4.1 Objectives and governing principles

As mentioned in Chapter 5, the existence of Plastretur was 'decided' in the covenant from 14th September 1995. On 6th November 1995, Plastretur was founded as a non-profit company that on behalf of the owners ('the producers') should "develop, run, manage, monitor and organise collection and recovery of plastic packaging to meet the objectives of 50 % energy recovery and 30 % material recovery" (Plastretur 1995). As mentioned in Chapter 5, the EPR scheme took form as a 'communal voluntary work' since the EPR scheme was based on industry's own initiative and model for a producer responsibility. The common spirit of being a 'voluntary' framework seemed during the first year to motivate a majority of the 'producers' which to a larger extent than a regulation provided a good atmosphere for achieving results (NHO 1995, Maldum 2003, Sundt 2004, Bjerk 2005). However, there still are some companies that just relate to regulations and found this as not anything to take into account.

From the start in 1996, the main objectives were clearly stated:

1. Achieving the targets in the covenant
2. No free-riders
3. Lowest costs possible for Plastretur

The overall objective has been to reach the targets stated in the covenants in order to avoid sanctions and packaging tax from Ministry of Environment, which the owners of Plastretur themselves had proven was a far more expensive solution (NHO 1995). The second point is connected to the challenge of avoiding competitive advantages for free-riders. If not paying the licence fee, they would get reduced costs, but still take benefit from using the system, and thus reduced waste management costs as well.

Fair competition on equal basis is of high importance for commercial actors. The last objective is therefore about running the Plastretur system as cost-efficient as possible so that reaching the targets can be achieved at a minimum cost.

In reaching these objectives, Plastretur developed a model based on certain governance principles. Plastretur early decided to develop a market-based model that utilised already existing infrastructure and market actors. All WMCs in Norway that committed themselves to the requirements set by Plastretur, were allowed to sign standard contract with Plastretur. The number of WMCs increased steadily from a dozen in 1996 to 85 in 1998 and further to 120 in 2004. Every WMC gets the same financial condition, which intends to increase the competition between them and consequently make the system more efficient. WMCs own the material, but in order to get paid from Plastretur, they must pass the material on to one of those material recyclers that Plastretur has agreements with.

As a consequence of this Plastretur has been an indirect actor in the system by neither buying/selling plastic packaging waste, nor owning infrastructure or waste management facilities. Instead of ownership, the strategy was based on contracting waste management companies and recycling companies. Hence, Plastretur had basically two points in the end-of-life phase where interaction with the market occurred.

Basically, the contracts contained mutual commitments for both Plastretur and the direct actors. Plastretur guaranteed WMCs that they could deliver all collected plastic packaging waste, if fulfilling certain quality criteria, to those recyclers that Plastretur had contracted. The WMCs would then receive subsidies from Plastretur, through the recyclers as shown in Figure 7.14 and Figure 7.24. The contracts with recyclers guaranteed that Plastretur should subsidise these for the recycled plastic packaging *sold* to the market. However, Plastretur did not guarantee that the recyclers should get enough raw material to run their processes, but that they should work for increasing the collection and hence the supply of plastic packaging waste. The role as a guarantor is the main financial risk element for Plastretur, because if they could not find recyclers, they had the responsibility to finance an alternative, thus more expensive, treatment. Moreover, Plastretur did only finance operational activities and not investments in new equipment and process technology. Hence, the technology development of the waste management sector was primarily up to the direct actors themselves, but Plastretur has contributed with information and as initiator.

The subsidising principle was 'net cost coverage' which meant that Plastretur should financially support activities downstream to the extent that it became economically beneficial for actors to act so that more plastic packaging was directed towards material recycling. However, since every direct actor signed the same standard contract with the same level of subsidies, this principle was applicable on national level and not on company level. Hence, those being effective got a comparative advantage compared to their less efficient competitors. Being a market-based collective EPR system indicates that the Plastretur system is not based on full cost coverage (as in Germany), but rather on shared financial responsibility.

The design of the subsidising policy has since 1998 almost entirely been focused on increasing the material recycling. The energy recovery target was by then almost reached through incineration with energy recovery of household residual waste and source separated plastic packaging for energy recovery (Plastretur 1999).

Poor experiences from for instance Germany where there were lack of recycling capacities for large amounts of collected packaging waste, inspired Plastretur from the beginning to focus the recycling phase and developing markets for secondary use. The slogan was ‘planning from behind and forward’. However, after a couple of years it was realised that the large challenge was not related to the recycling phase but to the collection phase. During 1998 it was free recycling capacity and a high demand for collected plastic packaging waste as input to the recycling processes (Plastretur 1999).

As a consequence of the third objective mentioned above, a governing principle has throughout the period been to put the measures and efforts where the unit costs are lowest. As seen from Figure 7.21, this has primarily been within commerce and industry, and secondary within agriculture and aquaculture. Plastic packaging waste from households was due to high unit costs (see Figure 7.22) decided not to be the main focus area. However, in order to secure legitimacy, household waste has been prioritised among those local authorities that are ‘willing and able’ since 1999 (Sundt 2000).

From the very beginning the strategy was to improve the reputation of plastics and plastics waste through openness and transparency, high credibility and reliable statistics (Sundt 2002), resulting in comprehensive environmental studies and major efforts to decide the denominator (Plastretur 2002a)[11]. The communication strategies have been based on the principle that very specific campaigns should be directed towards the actors in the system, and not as general information campaigns to the public, like for instance Norsk Returkartong (EPR scheme on beverage cartons) did. One reason for this is that Plastretur first and foremost has been focusing on industrial actors and not plastic packaging waste from households. This is cheaper, but has the consequence that Plastretur and the Plastretur EPR system has not become a brand.

As for the scope, the main focus has always been related to direct actors in the end-of-life phase. Some attention was initially put in developing markets for recycled material, but few, if any, efforts where heading towards the primary upstream companies. The governing principle was that efforts and measures should all increase the recycling ratio, and actions towards upstream companies proved to be a too long way to go in order to see effects of the results. Measures towards upstream companies have been taken care of by NOC.

7.4.2 Strategies, measures and instruments towards direct actors

Plastretur has employed various types of instruments for influencing direct actors in order to achieve the recycling targets. We may distinguish between four different types of instruments: i) contracts, ii) financial support, iii) projects and iv) information.

By contracts we mean signing agreements with operators. This can take various forms; for instance signing standard contracts with all interested parties or invite to a tender competition. Usually a contract is guaranteeing the operator a certain minimum price per ton of output, as a subsidy to its business. The contracts are therefore often combined with economic incentives to stimulate the market and the material flows of plastic packaging.

The basic principle in Plastretur's subsidising policy is that payment is given at two points; i) to the collector (WMC) at the point delivered to recycler (or export storage) and ii) to recycler when the recycled material is sold to their costumers. In order to receive subsidies from Plastretur, WMCs must receive sorted plastic packaging for free from the waste generator, but they can charge for the transportation from waste generator to their plant. Moreover, the recycler must, in order to receive subsidies from Plastretur, guarantee to receive baled and sorted plastic packaging from WMCs and to process this into sellable material. However, if the quality is poor and does not comply with the quality criteria in the contract between WMC and Plastretur, the material recycler can decide to reduce the payment accordingly. Every transaction that releases payments from Plastretur requires communication from both parties confirming the amount (volume) agreed upon. This also serves as input to the statistical management tools of Plastretur.

The choice of instruments and strategies are indeed depending on how the roles and business models for your company are formulated. In this chapter we will discuss Plastretur's strategies for inducing changes on the material flows, and particularly look at the costs of these.

7.4.2.1 Upstream companies

As mentioned above, Plastretur employs few direct strategies and instruments on upstream companies. There is very limited interaction with these companies. One exception was in fact a seminar on design for recycling in 2002. The feedback from the upstream companies participating on this seminar was overwhelming, but still there have not been any similar seminars, mainly due to the fact that downstream activities were prioritised

(Braathen 2002). The basic contact with the fee-payers is through Materialretur, and the experiences are that it is difficult and time-consuming for Materialretur to explain the recovery system, financial mechanisms and the technological aspects related to recycling systems. Hence, the feedback loop from waste management system to upstream companies is very weak.

Plastretur is financing Materialretur's activities, both as the general financial support but also through projects particularly aiming at recruiting more members to Materialretur in order to reduce the number of free-riders. Total costs to Materialretur were 5.6 million NOK (19 % of fixed costs) as shown in Figure 7.14. The other indirect influence Plastretur has on the upstream companies is through financing a fraction of the activities within NOC. Beyond this, there is neither institutionalised nor random interaction between Plastretur and NOC, and consequently no knowledge transfer either. However, according to informants in Plastretur administration, there has been some one-way contact from Plastretur to NOC, but not the other way. Thus, the feedback loops from the waste management system (potentially brought by Plastretur) to the producers in order to influence the product design process, is non-existing. That said, as pointed out by Plastretur's chairman Steinar Skilhagen, 'the collective task is to reach the targets in the covenant. The task of 'waste minimisation' and 'packaging optimisation' is to a large extent an individual task that cannot be solved as a collective issue (Skilhagen 2002).

7.4.2.2 Waste generators

As identified in Chapter 7.1, a main challenge is to collect more of the plastic packaging from the waste generators. What have been Plastretur's strategies to cope with this challenge? First, Plastretur has during the entire period from 1996 – 2004 not subsidies any waste generators proportional to the amount of generated waste. The strategies have rather been *projects* and *information campaigns* directed towards key waste generators. Examples of these are shopping centres, retailers and wholesalers in convenience chains and building sites, and the scope has primarily been film, but at shopping centres there has also been focus on rigid plastics (bottles and cans).

Plastretur has run several projects at shopping centres from 1998 and onwards. In 1998, the average source separation of plastic packaging waste was 5 % at such centres, while it in 2003 was close to 80 % at those centres projects had been run (Bratterud 2003). Plastretur (2002c) argues that there is a potential of increased collection of close to 2,000 tons from shopping centres in the Oslo-region. Plastretur's strategy has focused on costs when 'selling' the message. The main point is that residual waste is the far most expensive fraction, and reducing this by source separation is a proper strategy. Secondly, transportation is costly and reducing the frequency of collection through compressing the plastic packaging. The racks are able to compress the packaging down to 1/5 of original volume. Finally, 'correct the first time' has been a slogan when approaching waste generators because this potentially creates more value than if for instance plastic packaging of non-compatible polymers are mixed into one bag. All these three points contribute to reduce the waste management costs and should be obvious for every industrial waste generator that pays relative to the amounts generated.

Practical drivers for successful plastic packaging collection at shopping centres are to visualise the economic potential for doing this, get the centre management engaged in this so that they can influence the entire centre, including sanctions if shops do not follow up, educate the employees in the shops and finally that there are racks with transparent plastic bags for source separation in every shop (Bratterud 2003).

These projects have, according to Plastretur, been highly successful, and Plastretur has through these cases produced a number of success stories, focusing on cost reductions. These are published at Plastretur's homepage, at seminars and meeting with direct actors, in media and brochures. The challenges, however, is to reach out to the vast majority of waste generators. Even in Norway, being a small and transparent country, advocating the message is difficult.

7.4.2.3 Waste management companies

The main instrument targeting waste management companies are standard contracts with guaranteed minimum prices for delivery to recycler, given that the batch satisfies certain quality criteria. Figure 7.26 provides the contractual unit prices for film, rigid plastics pure fractions, rigid plastics mixed fractions and rigid plastics mixed PP & HD. The film unit price has been stable around 1500 NOK/ton, while the rigid plastics have been more fluctuating. The higher prices on rigid plastics can be seen as a strategy for increasing the amounts. As seen from Figure 7.8 and 7.9 this might have caused the slightly increase in the recycled amounts of rigid plastics. The same figures show that film has increased significantly measured in tons, but more modest in recycling ratio. We can therefore expect that the increased recycling of film is due to growth in the quantity of generated waste and not due to altering guaranteed minimum prices from Plastretur.

Another strategy that targets waste generators indirectly is all information and 'education' of the waste management companies, so that these can bring this further to waste generators. The strategy has been to do the marketing work in close cooperation with the waste management network.

As can be seen from the unit costs in Figure 7.21, this has increased for commerce and industry the latest years. This is mainly due to three aspects. First, that the efforts on rigid plastics have increased and this fraction has higher negotiated costs than for film.

Second, rigid plastics are recycled abroad which increase the costs of transportation and costs to the export storage. Third, due to rising financial subsidies on this fraction, the collection has increased as well, making the total running costs higher.

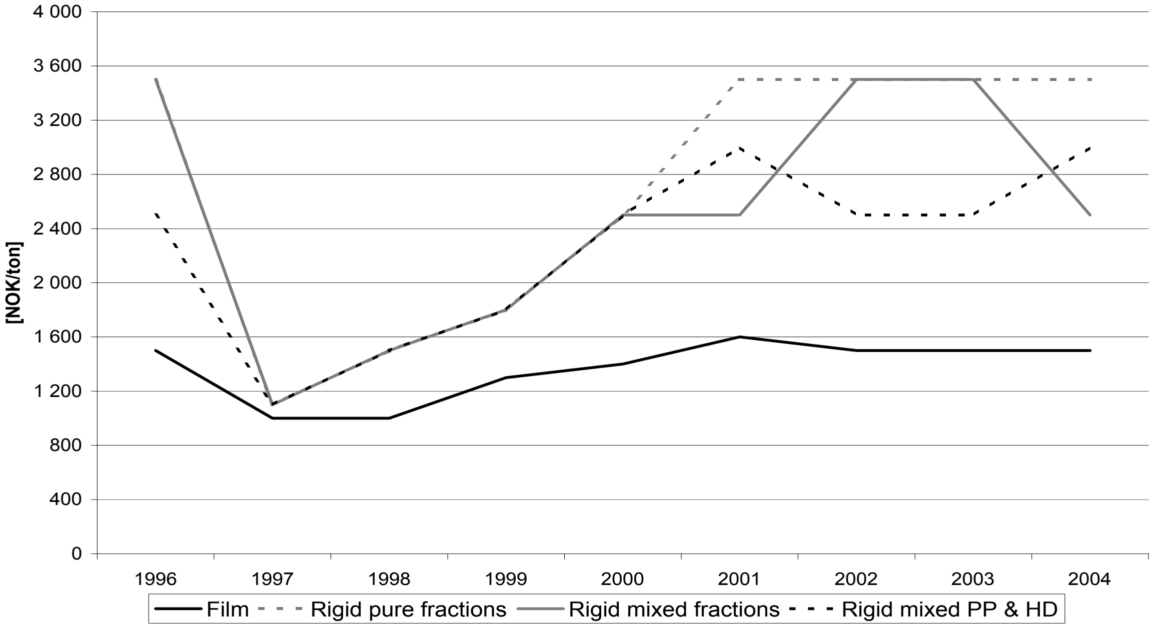


Figure 7.26 Guaranteed minimum prices for waste management companies for delivering film and rigid plastics to recyclers

Another project for increasing the quality of the input to the recycling process is the 'Quality project'. Plastretur pays two employees from Folldal Gjenvinning to visit waste management companies and educate these on how to collect from waste generators, how to sort at their waste management plants. Downstream actors and Plastretur are generally satisfied with this type of knowledge creation, and the project is considered to be successful. Folldal Gjenvinning argues that there are considerable improvements in the quality of their raw material coming from the waste management companies that they have paid a visit (Tamnes 2002).

That said, Plastretur does not provide specific incentives for the waste management companies to sort the collected plastic packaging. Since the payment from Plastretur is the same whether sending it to export or to domestic recyclers, WMCs often prefers not to increase the quality but rather send it to export instead. To counteract this, Folldal Gjenvinning has paid more for sorted plastic packaging, which comply with Norsk Gjenvinning's argument that increasing the quality should give higher prices.

Another issue related to waste management companies is that the large retailers and wholesalers (supermarket chains), as waste generators, has during the last years started to send plastic packaging directly to recyclers without going via WMCs. The quality of this plastic packaging is generally very good (Rogstad 2002) and the supermarket chains have argued that they should get the same price as the WMCs do (1500 NOK/ton) because it is similar or even better quality than delivered by WMCs. However, Plastretur has only paid 1000 NOK/ton. Plastretur has argued that if all large waste generators also shall get 1500 NOK/ton, then the market model is damaged. This model is based on the premise that the waste generators shall deliver for free, not to get paid for their waste. However, supermarket chains have been invited to sign contracts as a WMC, which include the requirement to receive plastic packaging waste from other waste generators as well so that every WMC is treated equally. This has been refused, due to the reasons mentioned above, by the supermarket chains.

7.4.2.4 Local authorities

Contrary to most EPR systems for plastic packaging in Europe, the Plastretur system includes almost all of the plastic packaging generated as waste in Norway, conf Table 7.1. This implies that Plastretur has a certain flexibility regarding where they will put most efforts and resources in order to reach the targets. Ever since the very beginning in 1996 the strategy has been to develop a cost-effective system where the 'cheapest' and easiest tons are first collected and recycled (Plastretur 1997, Sundt 2000). Obviously, the plastic packaging waste from household is much more diverse, dirty and, thus, more expensive to obtain high collection rates and high quality of the regranulates (conf. Chapter 6.2). Plastretur has therefore had a strategy that the efforts related to household waste are limited to those municipalities that are "willing and able". Since it is the responsibility of the individual municipalities to design the collection system for household waste (according to the Pollution Control Act, §30), only those municipalities that actually *want to* start source separation and that have the ability to do so (Schefte 2002), are invited to do so. The ability is related to the size of the municipality. The experiences were that it was almost equally time- and resource demanding to serve and assist a small local authority as a larger one.

The last years, Plastretur has intensified the priority on household waste, due to reasons of legitimacy and in order to increase the amount collected. The legitimacy is due to the fact that the plastic packaging becoming waste in households are to a large extent been subject to licence fee which then also would have expected to be recycled. It might however be argued that this is a consequence of the collective EPR system. If there should have been a guarantee that plastic packaging becoming waste also should have been recycled, then we are either entering a type of individual EPR system or a system like in Germany, with the consequence of being a far more expensive system. The licence fee in Germany has been ten times the fee in Norway for plastic packaging (Sundt 2004). Hence, for the packers and fillers the collective Plastretur system seems to be the cheapest model, while at the same time the legitimacy towards the consumers must be there.

Still the unit cost per ton recycled is very high compared to the other markets. First, Plastretur pays the municipalities 1100 NOK per ton collected (2004) and 1000 NOK per ton delivered to one of the four contracted sorting plants. The sorting plants get similar prices as for industrial packaging (see Figure 7.30) when received by the recyclers. In addition, however, they also get 2000 NOK per ton as a bonus. This bonus is intended to stimulate the sorting plants to do a proper job, because low sorting efficiency increase the unit cost of household waste considerable since Plastretur already has paid 2100 NOK per ton for the inflow to the sorting plant.

Plastretur started in 2002 to send plastic packaging to Germany for feedstock recycling instead of energy recovery. This avoids the sorting process, and becomes therefore much cheaper. The recycling ratio has increased considerably due to this strategy. However, due to uncertainty on whether this option will remain in the future, Plastretur has still long-term contracts with sorting plants in Norway. This has induced considerable investments at these sorting plants.

Finally, Plastretur has the latest years been more active in stimulating local authorities to start with collection of plastic packaging. They provide advice, information material and knowledge transfer to those deciding to start with this. Plastic packaging comprises approximately 50% on volume basis and 15 % of mass basis of the household waste.

Based on experiences from other local authorities, Plastretur recommends a kerbside system for plastic packaging, for glass and metal and for paper, as well as separating organic waste for the residual waste. This reduces the frequency of collections of residual waste from every week to every fourth week, and thus the overall costs. This has proven to be an effective way of increasing the collection of plastic packaging from households.

7.4.2.5 Material recyclers

The main strategy towards material recyclers is contracts including financial mechanisms. Film recyclers in Norway have got 1500 NOK per ton sold to the market, except from in the period 1997 – 1999, where the guaranteed minimum price was 2250 NOK per ton. If film is sent abroad for recycling Plastretur *receives* 1200 NOK per ton (in 2004). Although this price depends on the Platts index for virgin polymers, there is a considerable price difference between these two options.

However, costs connected to export storage and transport is close to 1000 NOK per ton, but still recycling abroad remains considerably cheaper. In 2004, Plastretur contracted Folldal Gjenvinning for a new five-year contract, intending to supply the material recycler with up to 10,000 tons a year. From an economic point of view, this is obviously not the most cost-efficient solution.

Approximately 50 % of all plastic packaging contributing to the recycling ratio is actually recycled abroad. There are basically two reasons for this. First, the Norwegian recycling industry does not have capacity and ability to recycle all collected and sorted plastic packaging, for instance PP-bags and rigid plastics. Second, the cost level abroad is lower than in Norway.

7.4.2.6 Secondary upstream producers

There has been limited focus on stimulating potential users of recycled plastic packaging to do so. Except from occasionally guidance to single companies contacting Plastretur to get advice on how to proceed on such an issue (Schefte 2002, Malthus 2002), a project was initiated, financed partly by Norwegian Research Council, in 2004 on this issue. The intention was to establish project groups with participants from the entire value chain from sorters of plastic packaging waste, via recyclers to secondary upstream producers and final users of products, with Plastretur as the coordinating body, and through this cooperation try to remove some of the present barriers for this. The interest of Plastretur in this project is that due to an increasing amount of recycled plastics on the market, with potentially limited range of products that might use this material, there is on a long term basis a risk for not having proper markets for recycled material. In that case, Plastretur as a guarantor for the WMCs to find a receiver for their collected plastic packaging waste runs a financial risk as the alternative of energy combustion or landfilling are more expensive and does not contribute to meeting the targets in the covenant.

7.4.3 Representing the producers – the Board and owners

So far we have discussed the flows of material and cash within the recycling system, the various actors who are part of or influence this system, and the role of Plastretur in achieving the recycling objectives. In this chapter we will look at a more strategic level as seen from the owners of Plastretur, the representatives for the 'producers' and how they have contributed to the obtained results.

The owners of Plastretur contributed in 1994 and 1995 to design "the industry's model" as an alternative to the packaging tax suggested by the government. They argued that their model would reach the same environmental objectives at a considerably lower cost (1/10). The fact that their model was accepted provided a common understanding of the actual responsibility and that all together now should contribute to achieving these targets. The feeling of contributing to a voluntary communal work was highly present and contributed significantly to the results during the first years (Sundt 2003, Maldum 2003). The first evaluation in 1998 initiated the foundation of NOC, while during the main evaluation in 2000 (NMoE 2000), showed that Ministry of Environment was basically satisfied with the development of the Plastretur system, although the targets were not yet reached within the 'deadline' by end of 1999.

The covenant was renegotiated during 2001-2003, and remained by large unchanged, except from two minor alterations. The term 'waste reduction' was substituted with 'packaging optimisation' and there was no requirement that the targets should be fulfilled by a PRO, only that the plastic packaging industry should make sure that there was an operative recovery system (NMoE 2003).

This time, it was in reality no negotiations (Maldum 2003) as the Ministry of Environment was committed to follow the instructions laid down in the declaration by the new government that took office in October 2001. That said, it was somewhat easier to accept the ambitious targets due to several reasons. Firstly, the industry did not feel 'the stick' of tax introduction so realistic since NMoE did not employ it when the first covenant expired without reaching the targets. The fact that Ministry of Environment had signed the covenant in 1995 and after that in practice left everything to the industry and at no point of time threatened with sanctions had made the owners of Plastretur more relaxed related to the targets. NMoE, though, claimed that the threat of economic instruments replacing the covenant is still there (Hambro 2003).

Secondly, companies argued that by voluntary it means that they can, in practise, do what they want. On the contrary, the covenant is considered by Ministry of Environment as a kind of regulation with in practice no time limits (Hambro 2003). The consensus is, thus, more based on the fact that this is the preferred solution to the agreeing partners, than that they both fully agree to the content of the agreement.

Thirdly, the plastic packaging industry argued that the EU level had lower recycling targets (22.5 %), and that there was no reason for Norway to have stricter targets than the competing countries. The industry, however, accepted the 30 % recycling target if the agreement also stated that the targets should be subject to 'socio-economically' evaluation during the period of the agreement. This was due to the fact that the industry is now more experienced with costs, operational arrangement and technological possibilities, and that the industry itself was in position to define what was an socio-economic optimal level of recycling (Skilhagen 2003). Thus, in 1995 the targets were accepted as the socio-economic optimal level, while in 2003, the targets were not considered to be absolute as the socio-economic optimal level might vary. In this sense it can be argued that the industry speculate in *not* achieving the targets, without taking the risk of being exposed to the whip.

This tendency was also reflected in the objectives and the governing principles agreed upon by the Plastretur Board. Prior to 2003, the main objective was to reach the targets in the covenant, while from 2003 onwards the main objective was to 'achieve the recycling objectives of the Board. The purpose of the covenant shall be the basis for deciding annual targets in combination with how to reach the targets' (Plastretur 2003b). Apparently, the Board found it legitimate to decide their targets themselves based on the purpose of the covenant to 'find socio-economic optimal solutions'.

This new interpretation of the covenant indicates that the business aspects of this EPR scheme have become more dominating. However, already from the start in 1995, the owners of Plastretur had particularly interests in how the strategies and subsidies from Plastretur were formulated. For instance, the major plastic packaging producer in Norway (Norfolier) owns Folldal Gjenvinning and use recycled material from Folldal in its production of plastic bags and garbage bags. The plastic packaging producers have since 1995 experienced an increasingly competition, particularly from foreign companies (Løvold 2003). This competition is particularly visible in retail segment and grocery trade where for instance 700 million plastic bags are sold annually. Norfolier is necessarily interested in that subsidies to Folldal Gjenvinning are as high as possible or that long-term contracts can create predictable conditions for the supply of recycled material to their own production. In this sense, it can be argued that through this recycling system, the plastic industry is paid by others (packers and fillers and consequently the consumers) since the system provides cheaper raw material to their productions, making this a major contribution to their survival in the tough competition.

Another example is the supermarket chains that are large waste generators and, as mentioned above, argue for getting paid as much as possible for their plastic packaging waste. They had 1/3 of the shares in Plastretur and was thus in the position to influence the guiding principles for payment to waste generators. The intolerable situation occurred that the administration in Plastretur argued against its owners, while the Board was somewhat paralysed, unable to take a position. The situation turned out even more complex when the supermarket chains argued heavily for a fusion between all the various PROs for packaging materials. The packers and fillers joint this position after some time as the supermarket chains, after all, were their main customers. A basic principle when establishing a PRO for each material was, however, to avoid disturbing the competition between these materials.

That said, the convenience chain was the only actor involved in all the other material companies (except the PRO for glass) and argued therefore for making the EPR schemes more effective through a fusion. During the following process there was no arguments saying that a fusion would make it easier to reach the targets, but rather rhetoric arguments such as 'it is now time to move on' (Leiro 2003), and threats to establish their own PRO if the packaging producers did not agree to this solution. The next move was that the supermarket chains carried out changes in the articles of association in Norsk Returkartong, the PRO for beverage carton, stating that this company now were allowed to treat plastic packaging as well. Although Norsk Returkartong was considerably smaller than Plastretur when it comes to financial turnover, material flows and complexity, the plastic packaging producers were now squeezed against the wall. However, in order to agree upon a fusion, and through this loosing its decisive role in the new company, they got a long-term contract for Folldal Gjenvinning securing their existence for five more years. Part of the deal was, however, not to merge Plastretur and Norsk Gjenvinning, but to outsource all the operative activities, including all employees, to a new PRO, Emballasjeretur.

These two examples illustrate the trend that can be observed throughout the period from 1995 – 2005. The pendulum has gone form the voluntary communal work for reaching the targets set in the covenant, towards employing these EPR schemes as part of business strategies for being better prepared for competition. There was few, if any, arguments presented during the merging process that convincingly showed that this would be beneficial for reaching the targets.

(Endnotes)

1 From 2005, there is online registration making the system considerably more efficient (Skjervold 2005)

2 We will here employ four main product groups; i) film ('soft' film normally of low density polyethylene (LDPE) or polypropylene (PP)), ii) rigid plastic packaging ('hard' bottles and cans of high density polyethylene (HDPE), polystyrene (PS) or PP), iii) PP-bags (woven bags of PP particularly in use in agriculture and aquaculture for feed and fertiliser) and iv) reusable plastic packaging (usually like rigid plastic packaging). The reason for making a distinction between rigid plastic packaging and reusable plastic packaging is threefold. Firstly, reusables have life time longer than one year, contrary to rigid (and film and PP-bags) plastic packaging that is reckoned here to have a lifetime of less than one year, with, hence, no accumulation. Secondly, reusable plastic packaging is included in the official, obtained results for material recycling, but is not subject to any financial support (subsidy) from Plastretur. Finally, reusable plastic packaging is a separate category in Plastretur's statistics and is therefore convenient to treat as a separate fraction.

3 Other significant products are fertilisers used on the crops land and food for animals is usually packed in bags of pp. Moreover, cultivating flowers and vegetables are also within the agricultural sector, and finally, solar collector film used for protecting particular vegetables on the field, e.g. strawberries, turnips cabbage and cabbage heads, are also included in the product spectrum for agriculture that Plastretur is responsible for.

4 First, the efficiency of how well the waste generator actually is sorting in various fractions are important, high efficiency here means that a high fraction of plastic packaging is sorted for material recycling, without taking into account whether this fraction contains various products (e.g. film, rigid, PP-bags or reusables) or polymers (e.g. LDPE, HDPE, PP or PS) that have to be separated later on in order to be recycled. This

8. EPR ON PLASTIC PACKAGING IN NORWAY – COMPANY LEVEL

In Chapter 7 we presented the EPR system for plastic packaging with a main focus on Plastretur as the key organisation. Obviously, the covenant has proven successful in increasing the recycling level for plastic packaging. These results are, however, not only dependent on how well Plastretur performs, but also to a large extent how well the direct actors within the plastic packaging system are able to contribute to the recycling results. How powerful is the covenant to stimulate direct actors to act according to the intentions in the covenant? More concrete, which incentives does EPR provide to initiate change processes in first generation upstream companies, in second generation upstream companies and in downstream companies in the waste management system? How does this contribute to i) increase the recycling, ii) optimise the packaging and iii) influence the overall environmental performance in the company, also related to non-packaging issues? The focus in this chapter will be on explaining the efficiencies accounted for in Chapter 7, by looking at underlying interests and driving forces for technological and organisational change and innovation.

Employing the networks of actor's perspective, we will provide insight into the various actors, their interests and driving forces and how their interactions constitute the actual outcome we observed in Chapter 7.

8.1 Technological change and innovation (TCI) – a survey in the plastic packaging sector

One important aspect of the industrial implementation is related to the actual changes in the products of the companies. This is the core of the companies' business and the disaggregated fundament for the observed trends on a sector and society level. Hence, studying technological change and innovation on company level is imperative when analysing the industrial implementation of EPR. Moreover, it is important to discuss the factors influencing technological change and innovation (TCI) in companies in order to understand the mechanisms (Fagerberg 2004).

To gather statistical knowledge on these issues, we have carried out a web-based survey among these companies. The survey was primarily developed to get statistical evidence on the influence of the covenants on TCI. As a secondary aim, the survey should show the main driving forces for the observed development in TCI. For more information, see appendix D for details about the questions and answers.

This survey was part of another study on TCI in the plastic packaging industry and electric and electronic industries in Norway (Røine and Lee 2006). The anonymous, web-based survey was sent to 431 people in 291 Norwegian companies within the plastic packaging efficiency is depending on how easy it is to source separate at the actual place where the plastic packaging waste is generated or the 'infrastructure' at the site where the waste is collected by the waste management company, for instance outside single shops, shopping centres or at the sites for bring systems in households. Second, the efficiency of 'collection' also depends on what the waste management company actually do when they collect the fractions: Are these mixed or are they kept separated when transported to the sorting and pre-treatment site. However, fractions can obviously be transported together without actually being mixed which make them still 'sorted for material recycling', and, hence, the efficiency is not reduced due to this jointly collection.

[5] The waste management company (WMC) has usually three options for dealing with the fraction meant for material recycling; i) sending it directly to material recycling after baling (no sorting), ii) no sorting at WMC site but sending it directly to a more specialised sorting plant or iii) sorting at their own sites. The first option gives an efficiency of nearly 1 since no activity, and consequently no loss of material, is happening. However, there might be weight differences between inflows and outflows due to water run-off, but this will also influence the size of the inflow and no change in the amount of plastic packaging is the consequence. The efficiencies for the two latter options depend on the quality of the inflows with respect to diversity of qualities, on the degree of dirt and unwanted items and qualities and on the level of advanced sorting technology.

[6] Some waste management companies sort in the residual waste, but only to get hold of bigger items or larger fractions. However, this is regarded as marginal here. We therefore just measure the inflows of plastic packaging collected for material recycling.

[7] This is an average, pure fractions like plant cases are close to 1.0 in efficiency, while blended fractions are around 0.5.

[8] These numbers include feedstock recycling, and we have calculated the distribution between rigid plastics and film based on the denominators (64 % film and 36 % rigid). If not including the feedstock recycling the recycling ratios for film and rigid plastics from household would have been 2.5 % and 1.4 %, respectively.

[9] 100 tons to feedstock recycling is included| in the film fraction.

[10] From 1 January 2006 Materialretur change name to "Grønt Punkt Norge" [Green Dot Norway].

[11] See http://www.plastretur.no/research-development.html for more information on the research and development activities that have been carried out.

chain with 95 respondents, providing an answering rate of 32.6 % (companies) and 22.0 % (people). However, the e-mail addresses for 314 of those receiving the survey were provided by The Norwegian Packaging Association (DNE) and it is likely that some of these have their main focus on non-plastics packaging issues, making these irrelevant for the survey and we could therefore not expect replies from them. Moreover, 21 of the 431 did not receive the message due to incorrect e-mail addresses. Taking into account that one company generally does not provide more than one answer, we might assume an answering ratio of close to 40 %. Out of 95 responses, 93 were valid, and the majority of replies were from upstream actors compared to downstream actors, 60.2 % (N=56) and 37.6 % (N=35), respectively. The remaining 2 valid replies were from a research institute and a PRO and were held outside the statistical analysis because they are not direct actors, but are included to define the total number of respondents (N=93). The receivers of the survey were primarily contact personnel for the EPR system on plastic packaging (downstream) and for packaging issues (upstream). Table 8.1 shows the distribution between the various actors.

Table 8.1 Distribution of respondents to the survey

	Frequency	Percent
A Norwegian producer og plastics or plastic packaging	15	16,1
A Norwegian user of plastic packaging (packer&filler)	26	28,0
A wholesaler or retailer in Norwegian tertiary sector	8	8,6
A industrial organisation or PRO	2	2,2
A waste management company	26	28,0
A sorting or waste treatment company	5	5,4
A recycler company	4	4,3
An importer of plastic packaging	7	7,5
Total	93	100,0

Aggregating Table 8.1 into upstream and downstream categories[1], we end up as shown in Table 8.2.

Table 8.2 Categorisation of upstream and downstream responding companies to the survey

	Frequency	Percent
upstream	56	60,2
downstream	35	37,6
other	2	2,2
Total	93	100,0

Technically, we asked three types of questions. Firstly, a multiple choice question from which only one answer could be ticked. Secondly, a multiple choice question from which one or more answers could be chosen. Finally, the survey included open questions where the respondents could freely formulate the answers.

8.1.1 Results

While the complete results from the survey are found in Appendix D, we will here highlight the main outcomes. The overall picture is whether technological changes have been carried out or not. Table 8.3 below shows a difference between upstream and downstream companies in this respect. 75.0 % of the upstream companies and 48.6 % of the downstream companies have conducted technological changes the last 10 years that have reduced the environmental impact, summarising to 64.5 % in total.

Table 8.3 Have you conducted changes in plastic packaging or related processes during the past 10 years that have reduced environmental impact?

	Have you conducted changes in plastic packaging or related processes last 10 years?		
	Not answered	Yes	No
upstream	,0%	75,0%	25,0%
downstream	5,7%	48,6%	45,7%
Total	2,2%	64,5%	33,3%

Equally fundamental is the role of environmental aspects when carrying out these changes. Table 8.4 below illustrates this, indicating that environmental issues have been important for the respondents, although relatively more important for the downstream companies than for those upstream. This difference may be explained by how these companies methodologically interpret the question. A downstream company working with the actual flows of plastic packaging waste can state that the process improvements (efficiency) directly provide environmental gains, while product development upstream to a greater extent involves other arguments such as consumer functionality and product protection. Environmental aspects might be considered important by the respondents if the changes involve a win-win situation. Moreover, it might be that the environmental aspects have been considered, but were not powerful enough in contributing to the actual solution selected.

We find that 38.1 % of those upstream companies (75 %, ref Table 8.3) answer that they have conducted changes in plastic packaging or related processes during the past 10 years consider environmental issues to have been very important when making the changes. 54.8 % state that it has been 'somewhat important, but not among the most important ones'. The corresponding numbers for downstream companies are 64.7 % and 35.3 %. Thus, more upstream than downstream companies have carried out changes, but the environmental argument seems more important for the latter. In total, of those answering that they have conducted technological changes in the past 10 years that have reduced the environmental impact, 46.7 % say that 'environmental issues have been very important' when making the changes, while 48.3 % said that 'environmental issues had been somewhat important' when making changes. Only 5 % argued that environmental issues were not important.

Table 8.4 Have environmental issues been important when carrying out technological changes?

	Have environmental issues been important when carrying out technological changes		
	Yes, very important	Somewhat important, not among the most important ones	No, not important
upstream	38,1%	54,8%	7,1%
downstream	64,7%	35,3%	,0%
Total	46,7%	48,3%	5,0%

Turning to the type of changes, Table 8.5 demonstrates the distribution of answers. In general, there are more changes upstream than downstream. The most important changes downstream are 'increased suitability for material recycling' (28.6%), followed by 'reduced waste generation in production phase' (17.1%). Interestingly, 26.8 % of the upstream companies denote that they have increased the suitability for material recycling.

Table 8.5 Type of changes

[%]	upstream	downstream	total
Reduced consumption of materials	62,5	2,9	38,7
Elimination of toxic substances	39,3	0,0	23,7
Substitution of substances	21,4	8,6	16,1
Reduced energy consumption in production phase	17,9	2,9	11,8
Reduced waste generation in production phase	39,3	17,1	30,1
Changed functionality	17,9	2,9	11,8
Increased suitability for material recycling	26,8	28,6	26,9
Generally increased efficiency in the processes	28,6	8,6	21,5
Other changes	7,1	11,4	8,6

Explanations for this might be several and some are pointed out in the answers to the survey. First, respondents upstream might consider paying the licence fee as increasing the suitability for material recycling. Second, reducing the material consumption (dematerialisation) might also be a part of this. Third, some argue that increasing the homogeneity of the packaging is an example of increased suitability for material recycling. Forth, internal source separation is stated as contributing to increased suitability for material recycling. Thus, without making it technologically easier to material recycle, respondents can argue that they contribute to increased suitability for material recycling.

The most important changes for the upstream companies are related to 'reduced consumption of materials' (62.5%), 'elimination of toxic substances' (39.3%) and 'reduced waste generation in production' (39.3%). Interestingly, out of the 75 % upstream companies saying they have conducted technological changes the last 10 years, 92.5 % state that they contribute to reducing the amount of waste. Hence, most of those making changes, contribute to dematerialisation. For the upstream companies, eliminating toxic substances has also been important (39.3%), although this is not directly a part of the covenant. In order to display the influence of EPR polices on the technological changes, Table 8.6 shows that 'continuous changes on several types of plastic packaging' are dominant both for upstream and downstream companies.

Table 8.6 Frequency of the changes

	What is the frequency of the changes?			
	Once on several types of plastic packaging	Once on one type of plastic packaging	Continuous changes on several types of plastic packaging	Continuous changes on one type of plastic packaging
upstream	5,4%	8,9%	60,7%	3,6%
downstream	14,3%	,0%	20,0%	2,9%
Total	8,6%	5,4%	45,2%	3,2%

More than 60 % of the upstream companies carry out continuous changes on their product. An obvious explanation for this is that more than 27 % of the upstream companies are 'producers of plastic packaging', and these will necessarily carry out continuous changes. Moreover, additionally 46 % of the upstream companies are packers and fillers and these are also dependent on developing the packaging continuously according to costumer requirements (survey).

Another aspect of these changes is when they are carried out. Table 8.7 shows clearly that for upstream companies, the changes happen all the time, although with a peak in 1998 – 2000. This correlates with the implementation of EPR. In general we see that upstream companies are, to a larger extent than downstream companies, making continuous changes. As for downstream companies, the changes seem to be rather evenly distributed from 1998 on.

Table 8.7 Timing of the changes

	When were these changes in general carried out?				
	1995 - 1997	1998 - 2000	2001 - 2003	All the time	Not able to specifiy
upstream	3,6%	17,9%	7,1%	46,4%	5,4%
downstream	,0%	14,3%	17,1%	11,4%	5,7%
Total	2,2%	16,1%	10,8%	33,3%	5,4%

Turning to the main drivers for these trends, Table 8.8 presents the key results. Overall, 'cost reductions' (49.5%) and 'environmental consciousness in the company' (41.9%), as well as 'the covenant on plastic packaging' (28.0%) are those alternatives answered by most respondents.

Table 8.8 Drivers for observed changes

[%]	upstream	downstream	total
The coventant on plastic packaging	32,1	20,0	28,0
Other Norwegian environmental regulations	8,9	5,7	7,5
Environmental regulations in EU	10,7	5,7	9,7
Other Norwegian 'non-environmental' regulations	10,7	0,0	6,5
Cost reductions	60,7	34,3	49,5
Pressure from market	37,5	8,6	25,8
Pressure from competitors and suppliers	23,2	17,1	20,4
Environmental consciousness in the company	44,6	40,0	41,9
Pressure from media, NGOs	7,1	8,6	7,5
Other contributing factors	3,6	2,9	3,2

'Cost reduction' is the most important factor upstream (60.7 %), followed by internal environmental consciousness (44.6 %), pressure from market (37.5 %) and the covenant (32.1 %). In addition, a number of respondents wrote in the open questions that 'consumer functionality' and 'product attractiveness' are two significant drivers for changing the packaging. Although these can be placed under the categories 'pressure from market' or 'pressure from competitors and suppliers', this illustrates an important point, namely the fundamental role of packaging to both protect the main product and to sell the product. These remain the main drivers for change. One respondent wrote:

> *"It is not pressure from the authorities that constitute the greatest driving force in these questions. I have worked in various companies, and will argue that it is the determined willingness to orient towards optimal solutions, including the environmental aspect, that continuously contributes to the choice of materials".*

However, this questionnaire does not discover how strong the drivers for change actually are. The interviews and in particular company studies are to reveal this. Table 8.8 indicates two main drivers downstream; cost reduction (34.3 %) and environmental consciousness in the company (40.0%), supporting the upstream results that these are the major drivers.

According to these results, the covenant has obviously had an influence on the observed changes, on 32.1 % of the upstream companies and 20.0 % of the downstream companies. 28.6 % of the upstream companies have both reported that they have carried out changes in the last 10 years and that the covenant was a driver for this. The difference between the covenant on the one hand and the other policy measures on the other is however striking, and this might be explained by the explicitly stated focus on the covenant in this survey. Indeed, R&D support, tax levels and other policy measures have influence on the degree of technological change as well.

There are basically two main barriers for carrying out technological changes as displayed above. Firstly, the cost savings are too low to be economically beneficial. Secondly, the demands for environmentally friendly packaging from costumers are generally weak, making it an uneconomic argument to change packaging according for these reasons. Table 8.9 illustrates this.

Table 8.9 What were the main reasons why changes were not carried out?

[%]	upstream	downstream	total
Too high development costs	14,3	2,9	9,7
Too low cost savings	21,4	20	20,4
Lack of incentives from the covenant	3,6	11,4	6,5
Lack of incentives from other EU and Norwegian regulations	5,4	5,7	5,4
Lack of demand for env friendly packaging	28,6	17,1	24,7
All others in the sector produce the same making no difference	12,5	5,7	10,8
Other factors preventing changes	21,4	20	20,4

Several respondents argue in their written answers that 'competing interests' when developing packaging is preventing the changes that, ideally, should have been carried out if the intentions in the covenant had been completed. This will be a key point to investigate further in the particular case studies later in this chapter.

We also asked what would be decisive factors for the respondents to make environmentally friendly changes in the future, see Table 8.10. Overall, increased pressure from customers is considered to be the key driver for this, particularly for upstream companies. Still on the market side; increased demands for cost reductions are also important, while on the regulatory side, stricter environmental regulations in both EU and Norway will stimulate changes. Interestingly, only 4.3 % believe non-environmental regulations to be significant for carrying out changes. This can be interpreted in at least two directions. First, there is a need for stricter, *mandatory* measures for the industry to develop environmentally friendly solutions, and consequently that voluntary measures are too weak to do so.

Second, the respondents do not grasp the effects non-environmental policies might have on their actual environmental performance.

Table 8.10 What will be decisive factors for your company to make environmentally friendly changes in the future?

[%]	upstream	downstream	total
Changes in the covenant	19,6	25,7	21,5
Stricter Norwegian environmental regulations	37,5	25,7	32,3
Stricter EU environmental regulations	33,9	20,0	28,0
Stricter non-environmental regulations in EU/Norway	3,6	5,7	4,3
Increased pressure from costumers	80,4	31,4	60,2
Increased demand on cost reductions	35,7	48,6	39,8
Increased pressure from competitors and/or suppliers	26,8	17,1	22,6
Increased environmental consciousness within the company	35,7	20,0	29,0
Increased pressure from NGOs and media	16,1	17,1	16,1
Increased knowledge on environmental impacts & solutions	35,7	17,1	28,0
Other factors	10,7	11,4	11,8

8.1.2 Discussion

Given the results from the survey, we will now look further into the various companies to find support for our preliminary conclusions.

8.1.2.1 Methodology

The respondents say what they believe are the most important factors. Ticking an alternative indicates that a factor has been influential, but not how strong it has been and the relation to the others. Thus, all might have ticked 'the covenant', but no one might find it the most significant factor. Therefore, interviews must be carried out to discover the strength of these drivers.

The questions on changes and environmental importance (e.g. Table 8.8) can be understood in various ways. Firstly, environmental issues can be considered as an initiating factor for making changes. Secondly, environmental issues might have been considered during the innovation process, but not necessarily with significant impact on the end result. Finally, the question can be understood as that environmental issues had a major influence on the end-result, for instance that the most environmentally friendly solution was selected, although it was somewhat more expensive or did not provide sufficient attractiveness to the consumer. Another methodological aspect is what type of environmental issues are regarded as important. For instance, reducing the amount of waste can easily be argued to represent an even stronger economic driving force than elimination of substances actually does. Low response on the question concerning barriers might indicate that they do not have a conscious picture of these factors or that the pre-defined answering options provided in the survey did not cover the actual response needs. This is supported by the fact that more than 20 % have marked for 'other factors'.

8.1.2.2 Empirical results

The written comments show some interesting aspects. One of these is related to the fact that we did not obviously cover the broader product development and the primary function of the packaging – to protect the main product and to make it more attractive to the consumer. Hence, when consumers are buying products, they should find these attractive and interesting, and the degree of environmental friendliness, particularly related to recyclability, is primarily not relevant. However, if it is discovered that the product is unnecessarily over-packed or that the packaging in other ways is not optimised, the opinion might turn away from the product. That said, it might seem that the covenant has some influence on the changes carried out. 32.1 % of the upstream companies state the importance of this.

The upstream companies constitute a particularly important group of actors as they are those actually being responsible for meeting the targets in the covenant. Theoretically, EPR may influence upstream companies in several ways. First, the covenants invite them to take responsibility by paying the licence fee and by being involved in the return systems. Second, EPR might be an incentive for optimising the packaging solutions along various dimensions; within its own production and processes, in relation to the consumers and in relation to the entire life cycle including design for recyclability. Finally, EPR might influence companies to think in an industrial ecology direction also on other non-packaging 'environmental' issues such as energy, transport, waste generation, emissions to water and air from production, as well as organisational changes. By identifying the internal change mechanisms on these issues we are to a larger extent able to analyse the significance of EPR to the observed changes.

More than 1800 companies pay licence fee to Materialretur for their use of plastic packaging. To grasp the underlying mechanisms and driving forces for the significance of EPR to these companies, a number of structured interviews have been carried out, including Tine Norske Meierier, Lilleborg, Brødrene Sunde, Baca, Toro, Friele, Rosenlew and Stenqvist. Tine Norske Meierier is subject to a thorough study, while the other companies are employed as controlling cases for the main TINE-case.

8.2 TINE Meieriene/ TINE Norske Meierier

Tine Norske Meierier BA (Tine), a dairy cooperative, is by far the biggest Norwegian food production company. Prior to April 2002, the dairy cooperative in Norway consisted of 10 independent dairy companies, called Tine Meieriene (TM), with altogether more than 60 dairy processing plants and a coordinating, sales and marketing company, called Tine Norske Meierier, 100 % owned by the 10 dairy companies. The TMs were owned by more than 20,000 milk-producing small-unit farmers in Norway. The role of the dairies was, and still is, to collect and process the milk into a wide range of products, while Tine Norske Meierier coordinates and supervises these dairies and carry out product and process development, in addition to sales activities and marketing campaigns. The annual turnover in 2001 was 10.5 billion NOK and there were 4,378 employees in the 10 diary companies and 681 in Tine Norske Meierier. Appendix E provides some key figures about the organisation[2]. Moreover, the sources of information to this chapter is primarily taken from annual reports (Tine 1996a – 2005a), environmental annual reports (Tine 1996b – 2005b) as well as from interviews with key personnel, see Appendix B.

Following the material flow approach identical to the previous chapters, Figure 8.1 schematically provides the raw material inputs, utilities, product outputs and emissions related to Tine.

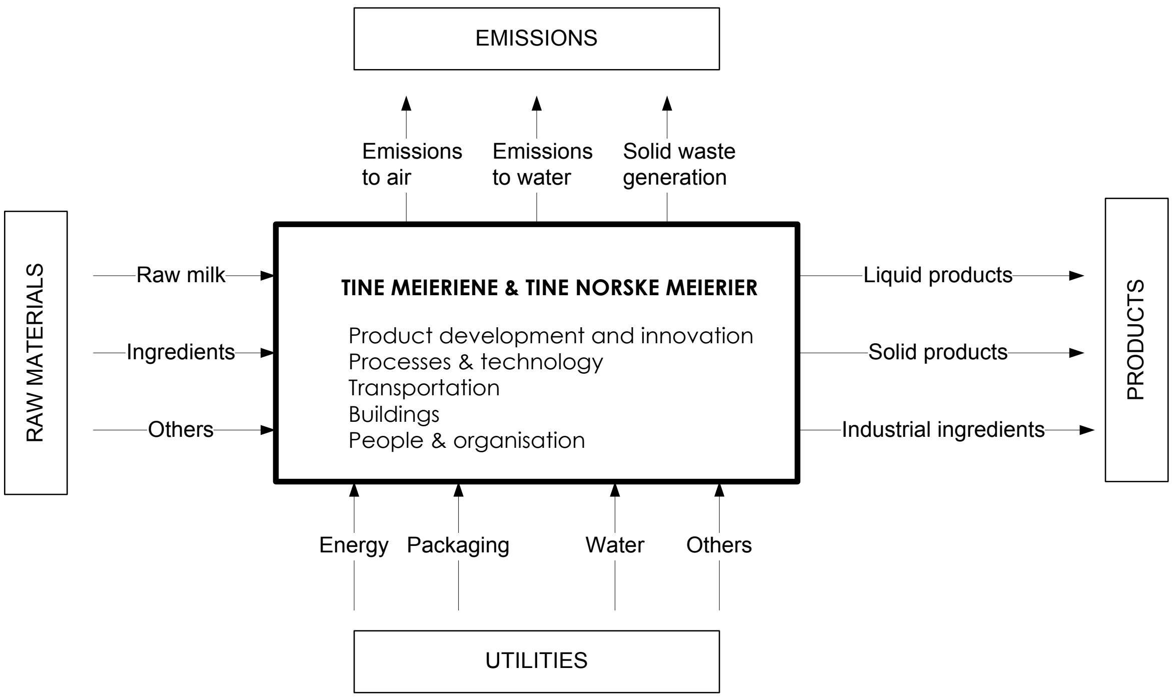


Figure 8.1 A schematic material flow approach to Tine Meieriene and Tine Norske Meierier

We will primarily look at packaging as the key utility and will analyse how efforts to incorporate EPR have been realised in the entire organisation. The most important raw material is milk, having in 2004 a throughput of 1.47 billion litres of cow milk and 20.0 million litres of goat milk, producing main groups of dairy products like milk, cheese, yoghurt and butter. The throughput has been reduced every year for the last 10 years. The market share of Tine for these products in Norway are generally very high (between 85 % and 98 % in 2000), although there now is a decreasing trend for some products due to increased competition. The large wholesalers and retailers in grocery in Norway are the major customer of Tine, in addition to institutional households, typical service companies such as hotels, airlines and restaurants as well as to other food industry companies[3].

The annual indexed costs have been rather stable at around 5 billion NOK.[4] For instance, in 2000, the distribution of costs was: personnel (30.9 %), packaging (24.2 %), transport (16.5 %), maintenance (6.8 %), administration (6.4 %), commercials (5.1 %), depreciation (7.3 %) and energy (2.8 %). Packaging represents a major cost for Tine, approximately 1.3 billion NOK in 2000, accounting for around 25 % of the total costs in the period 1996 - 2004. The main packaging materials are liquid carton (63 %), cardboard (20 %) and plastics (15 %), measured on a weight basis.

Up until the mid-90's, Tine had in reality monopoly on producing and receiving raw milk and on producing dairy products. Due to EU competition laws, to negotiations in GATT/WTO and a general trend of increased industrial competition, other Norwegian companies were from 01.01 1997 allowed to produce dairy products, and Tine as a market regulator had to supply these and other companies in the food sector with raw milk based on certain rules[5]. Moreover, during the 90's Tine faced the challenge of decreasing milk consumption in Norway, and one declared objective of Tine has been to reduce the rate of decrease of the consumption. Another trend is that 90 % of the processing plants, mainly the small ones, have been shut down during the last 20 years, resulting in increased centralisation and longer transportation distances (Johansen 2001a). In addition, Tine is, as is the majority of the companies in the food industry in Norway, protected by high tariff rates on imported food[6]. All these elements made Tine realise that the cooperative was not organised in an optimal way to meet these new challenges. Consequently, Tine was reorganised into a traditional industrial group in 2002.

In our context, the key interest is the development in the packaging solutions and how EPR schemes have influenced this development. Below we will present results on this.

8.2.1 Packaging consumption and intensity

Being an upstream company, Tine can contribute to the targets in the covenant through their key activities in (at least) three ways: i) reduce packaging consumption (dematerialise),

ii) increase own source separation of solid waste generation, iii) design for recycling. In addition to this, they can contribute by paying licence fees to the PROs. Table 2 in Appendix E illustrates some key environmental indicators for Tine 1995 – 2004.

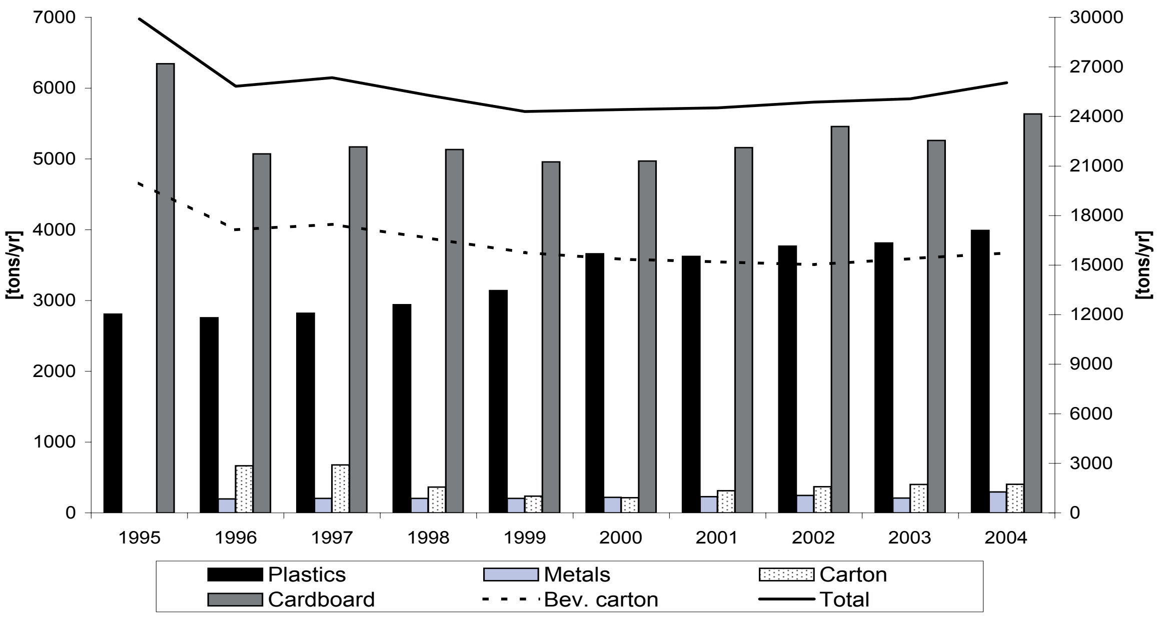


Figure 8.2 Packaging consumption in Tine Norske Meierier 1995 – 2004. 'Beverage carton' and 'total' is shown on the secondary y-axis (on the right hand side).

Figure 8.2 shows the development of key indicators related to packaging consumption in the period 1995 – 2004. This is the input of packaging as a utility for bringing products onto the market, see Figure 8.1.

The total use of packaging was reduced by 18.0 % from 1995 to 2001, while from 1996 to 2004 the total packaging consumption has increased by 0.91 %. From 2001 to 2004 the packaging consumption increased by 6.2 %. The total use of packaging is at the lowest level in 1999 and 2000. As for plastic packaging, the consumption seems to follow a growth trend, increasing by 29 % in 1995 – 2001 (~4 % annually), by 44.8 % in 1996 – 2004 (~5% annually), and by 10 % in 2001 – 2004 (~2.5% annually). Hence, the growth in plastic packaging consumption has been reduced during the last years, but the total consumption is still increasing. The big jump from 1999 to 2000 is mainly because 395 tons of transport packaging was included in the 2000 number, but not for the previous years (Eide 2001). This, in addition to more precise measuring methods, makes the numbers from recent years more reliable than those from earlier.

Taking 1996 as the starting point, the fraction of plastic packaging consumption to total packaging consumption has developed from 10.7 % to 15.3 % in 2004. This indicates a transmaterialisation towards plastics or a change in product segments. The liquid cartons constitute the largest packaging fraction, being 66.4% in 1996 and 60.4% in 2004.

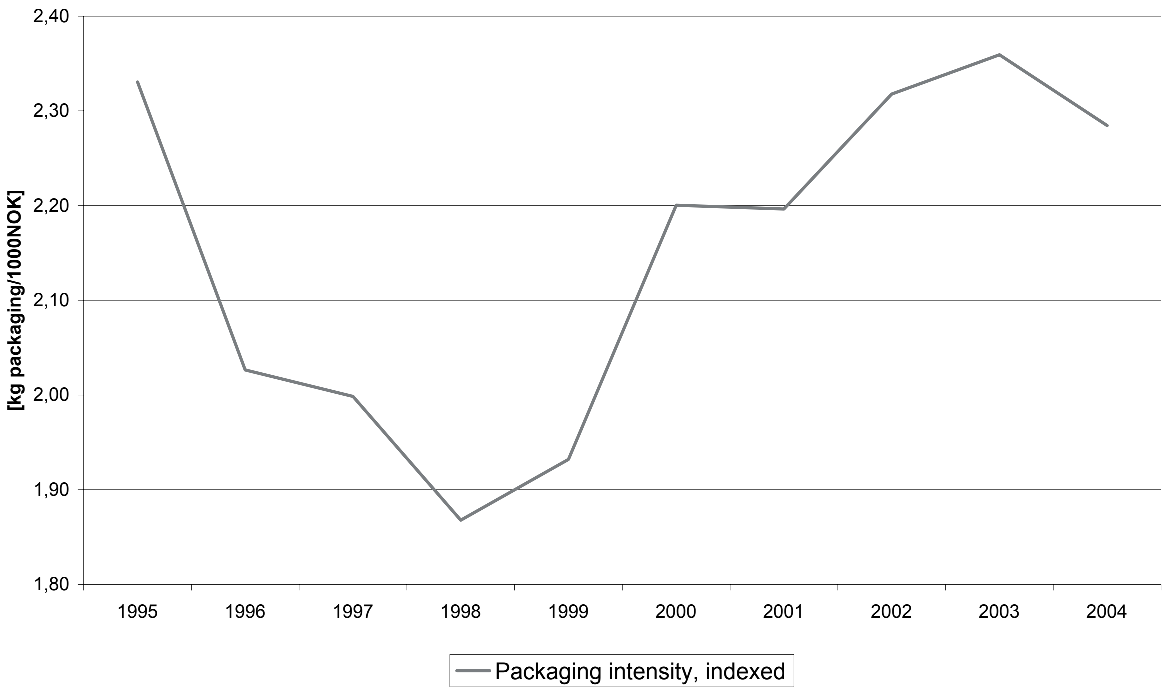


Figure 8.3 Overall packaging intensity for TINE. Indexed for inflation with 2004 as reference point

The inflation-adjusted indicator on packaging intensity is shown in Figure 8.3 and indicates a slightly reduction from 2.33 in 1995 to 1.87 in 1998 and up to 2.28 in 2004. This is a reduction of 2.15 % from 1995 – 2004, of 19.7 % from 1995 – 1998, but an increase of 21.9 % from 1998 - 2004. In the period 2000 – 2004, the packaging intensity rose by 3.63 %. However, the 1995-number is methodological unreliable and most probably too high (Eide 2005), and the packaging intensity during the period 1996 – 2004 shows an increase by 12.3 %.

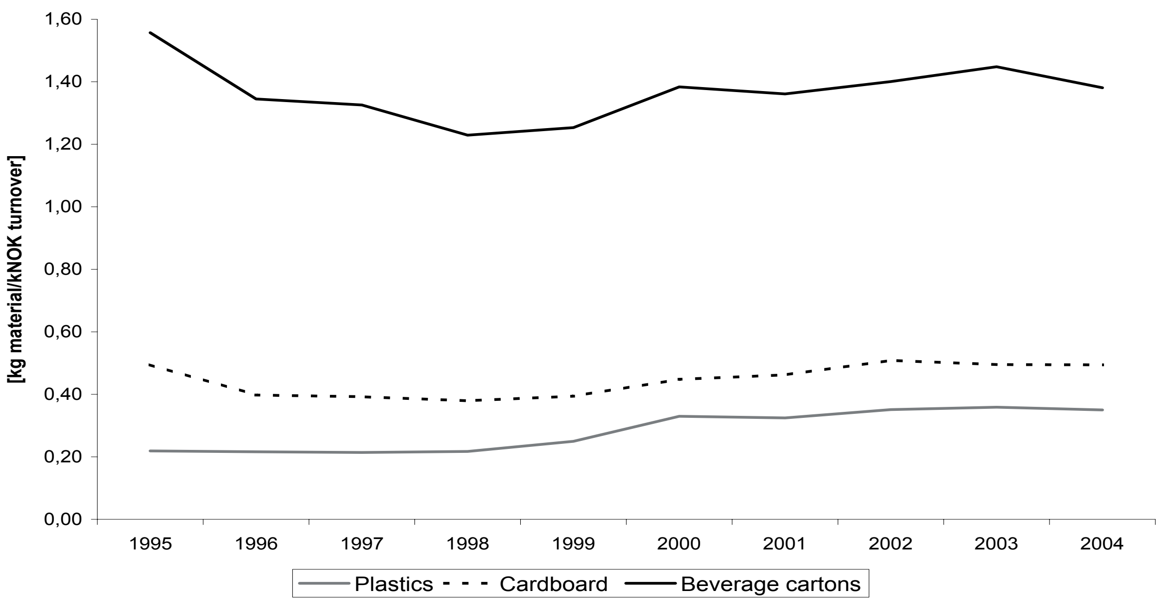


Figure 8.4 Packaging intensity for plastics, cardboard and beverage cartons. Indexed 2004

Figure 8.4 disaggregates the overall packaging intensity into the various materials. As far as the beverage cartons are concerned, they show a relatively stable trend during 1996 – 2004, but with a drop in 1998 – 1999. As for plastic packaging, the packaging intensity has increase more or less over the entire period, from 0.22 in 1996 to 0.35 in 2004. The drop in packaging intensity in 2004 is mainly due to the relatively high increased turnover that year.

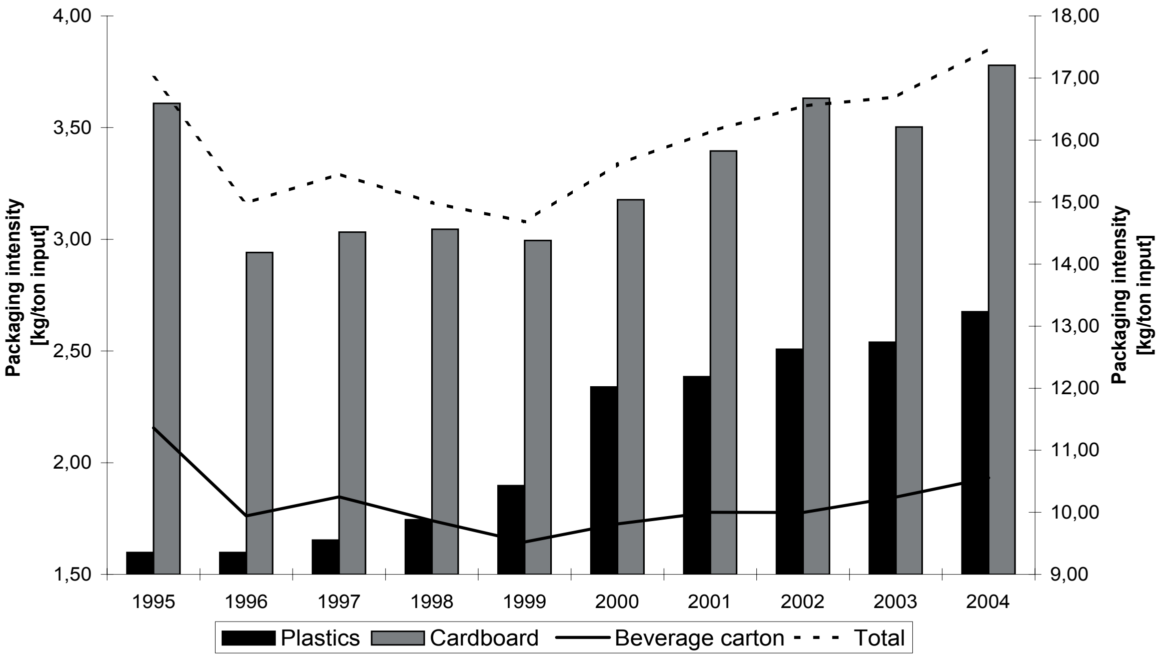


Figure 8.5 Packaging intensity based on packaging consumption and input of raw milk for selected materials. 'Beverage carton' and 'Total' relate to the secondary y-axis (right)

Another way of expressing the packaging intensity is to compare the packaging consumption in relation to input of raw milk and output of products on weight basis. This indicator is not, in general, dependent on the price levels and other economic factors, and might therefore, to a greater extent, express the technological development than the packaging intensities in Figure 8.3 and Figure 8.4. The packaging consumption in relation to input of raw milk is given in Figure 8.5, while the packaging consumption in relation to output of products is displayed in Figure 8.6.

We observe the same developing trend over the period 1995 - 2004, namely that more plastic packaging is employed per input of raw material and output of products, rising from 1.60 in 1996 to 2.68 in 2004. The same applies to cardboard, while for beverage cartons the packaging intensity was at the lowest level in 1999 and 2000 and since then it has increased again.

Moreover, the packaging intensity based on output of products shows the same trend as the packaging intensity based in input of raw material.

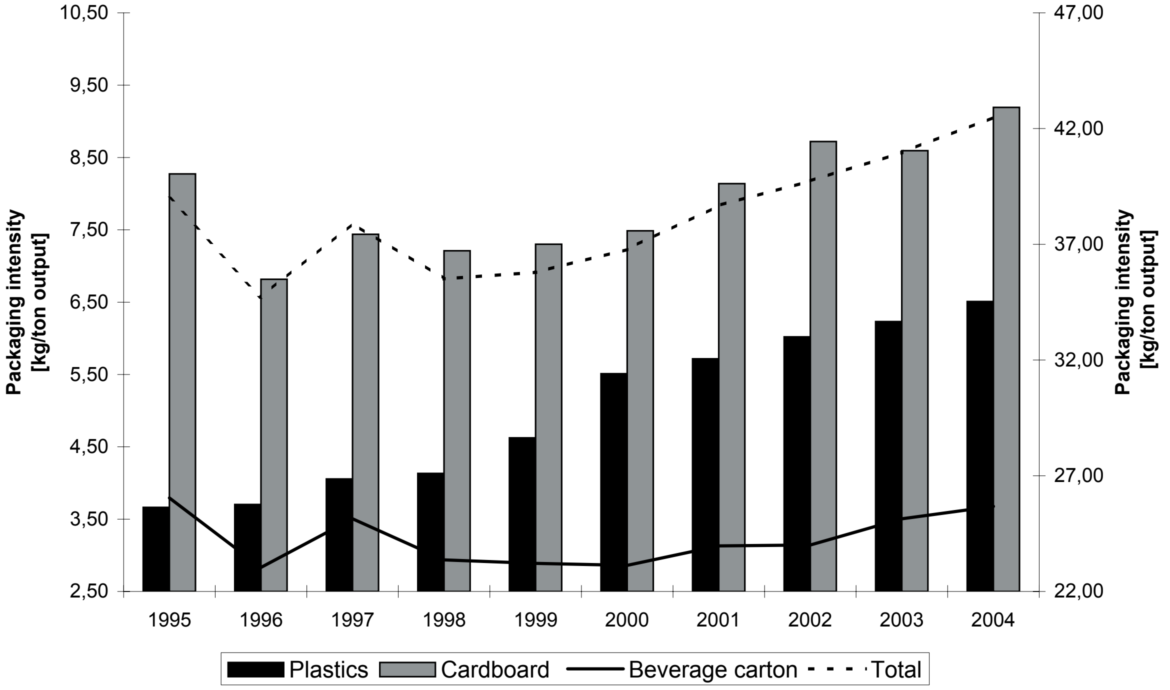


Figure 8.6 Packaging intensity based on packaging consumption and output of products for selected materials. 'Beverage carton' and 'Total' relate to the secondary y-axis (right)

Turning to the actual costs in order to comply with the covenant, we see from Figure 8.7 that the total licence fee costs (around 24 million NOK in total) is declining in relation to total packaging costs, from 2.2 in 1996 to below 1.5 in 2004.

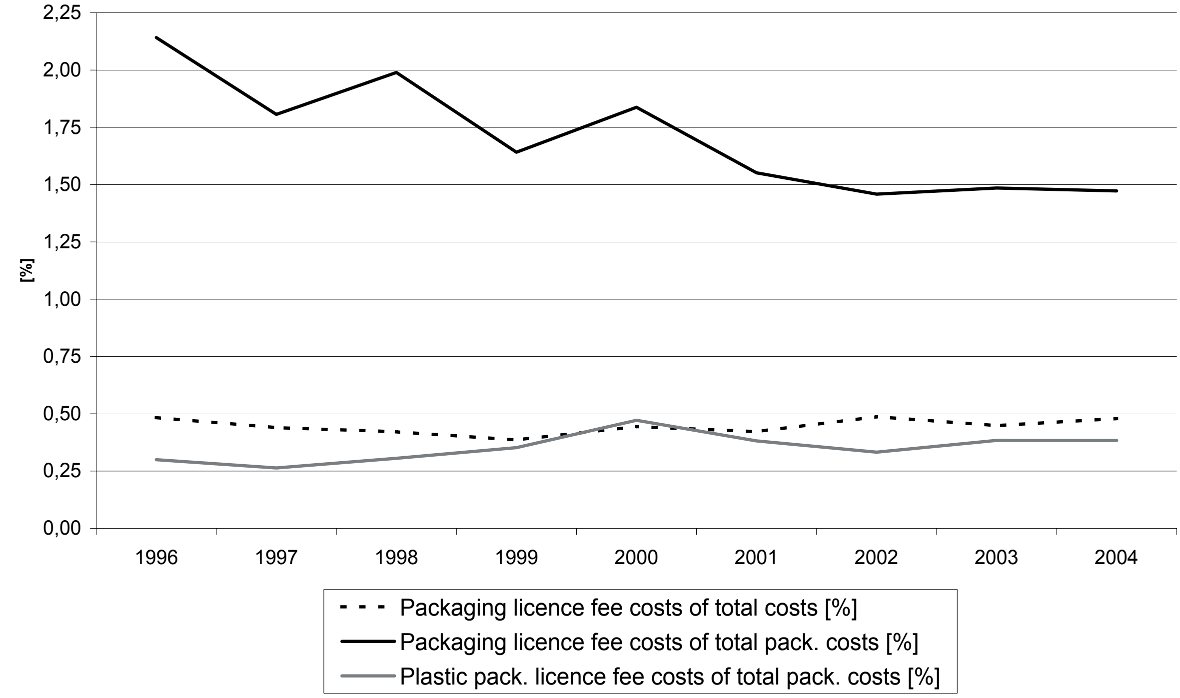


Figure 8.7 Relative packaging licence fees – in total and for plastics

Thus, the relative importance of the licence fee to total packaging costs has been reduced. The total licence fee is just below 0.5 % of total costs. Moreover, the plastic packaging costs are pending around 6 million NOK, being close to 0.40 % of total packaging costs. For comparison, the packaging costs of total costs have during this period been approximately 24 % on average. The modest increase in plastic packaging costs from 1999 to 2000 can be explained by purchase of reusable packaging and updated measurement methodology (Solgaard 2005)

8.2.2 Analysis

In order to understand the trends observed above, we now move into the box "Tine Meieriene and Tine Norske Meierier" in Figure 8.1. We will start by seeking explanations for the trends by looking into particular examples of packaging changes[7]. These changes are the outcome of internal processes within Tine. The role of EPR as one potentially contributing factor will be discussed in relation to other factors suggested.

8.2.2.1 Packaging improvements and optimisation

Packaging improvements and optimisation are at the core of the covenants[8]. This analysis will distinguish between two different types of packaging improvements and optimisations; i) improvements in existing products and ii) packaging optimisation in new product development projects. In Table 8.11 the most important packaging reducing efforts during the years 1995 – 1999 are listed.

Table 8.11 Some packaging reducing efforts

Year	Efforts	Reduction [tons/yr]	Material
1996	Removal of bottom plate in goat cheese	33	Metal
1996	Change in lid in yoghurt-cup	39	Plastics
1997	Reduction in beverage carton	425	Beverage carton
1997	Removal of outer cover in 4-pack milk	392	Cardboard
1997	Weight reduction in 175 ml yoghurt	10	Plastics
1997	Weight reduction in lid of yoghurt	26	Several
1998	Reusable case for maturing of cheese	1093	Cardboard/ plastics
1999	New yoghurt-packaging	87	Plastics
	Total	2085	

As seen from Figure 8.2, the packaging reductions were approximately 2000 tons from 1997 to 1999, and Table 8.11 explains how this has occurred. Our informants in Tine brought up four areas where substantial packaging reducing efforts have been carried out, as indicated in Table 8.11: i) Various changes to the yoghurt packaging, i) reusable case for maturing of cheese, ii) removal of outer cover in 4-pack milk and iv) reduction in beverage carton. The two first examples are related to plastic packaging, and we will discuss below how these changes came around.

The packaging of different types and sizes of yoghurt has gone through several improvement steps during the last ten years, with a major 87 tons a year reduction in 1999 (Tine 2000b). This packaging has changed considerably from previously being a complex packaging solution with a number of different materials, into a simple mono-material packaging of plastics only. This reduced the purchase costs considerably as well as reduced transportation costs due to lighter packaging and formation of the packaging during the filling process. This required investments of 30 million NOK. The yoghurt example resulted in both de- and transmaterialisation and a packaging solution that was obviously easier to recycle, but was the covenant the driver for this?

The improvements on the yoghurt packaging started in the early '90s when Tine experienced an increasing pressure from environmental NGOs and consumers (individuals/schools) concerning the 'God Morgen'-yoghurt. These raised important environmental questions, particularly the lack of return systems for beverage cartons, and the use of too much packaging in the 'God Morgen' yoghurt. Tine was at a loss for good answers, and decided in 1992 to start studies based on life cycle assessment (LCA). This created an extended collaboration between Tine and its packaging suppliers, to gather better knowledge of the environmental performance of their products, and particularly the packaging (Solgaard 2001). These LCAs were very important to how Tine reacted to the pressure from the market. Thus, this example shows that external pressure from NGOs and consumers were major factors for the packaging changes in 'God Morgen'-yoghurt. During the interviews, everyone brought up this as the most representative example of major packaging improvements[9].

The reusable maturation cases for cheese substituting corrugated cardboard is the most significant contributor to dematerialisation through less packaging (see Table 8.11). This transmaterialisation partly explains why the amount of plastic packaging has increased during the late '90s while all other packaging materials show a decreasing trend (Sylte 2002). Previously, corrugated cardboard was used for maturing the cheese within Tine. In 1998, this was substituted with reusable plastic cases, and consequently the packaging consumption and the packaging costs were dramatically reduced, 1,200 tons and 15 million NOK, respectively. Interestingly, the taste of the cheese also improved (Solgaard 2002).

TINE had previously developed a unique corrugated cardboard case that was reused several times. The EU Directive on food hygiene prohibited this practice, stating that everything returnable to food processing production sites should be washed. Moreover, the four large supermarket chains in Norway started to request cheese in unit weight forms, which was easier conducted by plastic cases than corrugated cardboard cases (Sylte 2002). Finally, TINE started using plastic pallets instead of wooden pallets, making the cleaning process of these also much easier. All these factors contributed to the development of new maturing cases. The role of the covenants for this packaging improvement was expressed by the project leader:

> *On a general basis, the covenants make it even more important to reduce amount of packaging. They indirectly influenced the development of these cases, but the directly contributing factor for this was the demand from the supermarket chain to have unit weight cheese which the plastic maturing cases in plastics were a lot easier to conduct.*

Hence, the change towards maturing cases based on plastics was driven both from the customers and the authorities, but it turned out to have 'unintended' positive consequences for TINE as well through reduced costs, improved product quality and reduced amounts of waste[10].

These examples of packaging improvements involve dematerialisation and transmaterialisation, based on modifications of existing packaging solutions without changing the actual product. The packaging consumption and packaging intensity depend, however, also on innovations related to new products and new packaging solutions. These solutions might be based on new process and material technology, or on existing technology but with a different shape and appearance. Quantifying the reduction in packaging consumption is impossible since no reference points are available. Thus, instead we must go into the actual development process to analyse the significance of covenants on this.

In 2002, Tine developed a new packaging solution for the product sold at schools through a "school milk agreement". 55 % of all pupils in compulsory schools in Norway have this agreement. In order to attract the pupils and to reverse the declining trend of milk consumption, a new type of screw top packaging was developed. A comparative LCA between alternatives concluded this to be one of the poorest solutions, environmentally speaking (Solgaard 2002). Moreover, it did not fit into the standard transport packaging for Tine and a new cardboard-based tray was developed, causing an additional waste problem for the schools. Moreover, this is an example where the aspect of design for recycling is not taken into account, since more materials are present. This type of decisions and arguments might be an explanation for the trends of increased packaging consumption displayed in Figure 8.3. However, Tine argues that this packaging can be recycled as a traditional beverage carton, since the screw cap in plastics are removed together with the remaining plastics in the beverage cartons and combusted with energy recovery.

8.2.2.2 The role of EPR

The examples above provide some explanations for the packaging trends within Tine, and indicate a limited role of EPR in these trends. To some extent this runs contrary to the results from the survey where 32.1 % of the upstream respondents indicated that the covenant was a driver for the packaging changes. However, we argued above that a methodological weakness with the survey is that it does not include the strength of these drivers. The question is therefore: Can we find evidence for the role of EPR, and its relative importance to other influencing factors?

Generally speaking, the design changes that might come along as a consequence of the covenant are related to dematerialisation, to design for recycling and to reuse of recycled material. The survey indicates that dematerialisation is the most frequent type of changes (62.5 %), while increased suitability for recycling is marked by 26.8 % of the respondents, see Figure 8.5. 21.4 % answered that they had 'substituted other substances', and this included the use of recycled material. How reliable are these results if tested on Tine? Moreover, the pressure from EPR might either come through Plastretur, through Materialretur, through the Industrial Packaging Optimisation Committee (NOC), through the market and their commitments in the covenants or through the covenant itself as a cognitive understanding of (the moral) responsibility (Ehrenfeld 2000b).

There is no doubt that Tine has participated in the EPR schemes. Tine is the largest licence fee payer in Norway for plastic packaging and beverage cartons and has organisationally been involved in the EPR systems through ownership and board members in the PROs[11]. Complying with the legal commitments downstream is, hence, no problem. The interesting question is, however, to what extent this has influenced Tine's daily activities. Below we will discuss more thoroughly how Tine has been influenced by the covenant, not only as licence fee payer, but beyond this, trying to find evidence for the question of to what extent the covenant contributes to technological change and innovation and changed behaviour.

<u>Dematerialisation</u>

Packaging is a substantial cost (~25 %, Tine 1997a – 2004a), and efforts to reduce the use of packaging, reducing the weight of packaging resulting for instance in reduced transport costs, have always been an important issue for Tine (Johansen 2001b). The covenant has provided an additional cost load of 0.4 % (see Figure 8.7) and represents a much weaker incentive than reducing the cost of purchasing packaging.

Why is cost reduction a more significant driver for carrying out dematerialisation than the covenant? First, Tine has since the mid 90's faced an increasing competition along the entire value chain due to the deregulation of the Norwegian market in 1997

(Rommetvedt 2002). As one informant in Tine put it:

> *"The competition intensified, both due to other cheese making companies, and from abroad and from other non-dairy products like water and lemonade. In addition, the pressure from the authorities increased (agriculture policy) and the consumer behaviours changed into new habits (one-person households and food on the run), resulting in an entire new focus in our industry. We had to think differently, both related to marketing and internal cost reduction. Obviously, cost reduction is very important and I think that environmental measures with high costs not will be implemented".*

Another explanation to the increased focus on cost reduction is the significant pressure from the four major supermarket chains. More than 80 % of Tine's sale is through these (Tine 2005a). The supermarket chains are under a big pressure being focused on reducing costs (Rommetvedt 2002, Borch and Stræte 1999). One way of doing this is to press their suppliers to accept lower prices for their products. Hence, the food industry has relatively poor cards on their hand, and the supermarket chains are constantly strengthening the demands on their suppliers. This has been the trend for several years, making Tine realise that the organisation did not provide optimum conditions for meeting these challenges (Tine 1999a). A new organisational model was the consequence, established in 2001. Moreover, the supermarket chains are to a larger extent selling their own brands, making the market less for the traditional companies (Borch and Stræte 1999).

The on-going discussions within World Trade Organisation (WTO) on reducing the tax barriers on agricultural products, and the EU's new competition directive (EU 2004), have additionally strengthened the political framing conditions, making Tine "more exposed to harder competition in the market" (Tine 2004a, p 9). To meet this, Tine argues that they need to "create growth through innovations and new-launching" (Tine 2004a, p 33) and on both volume products and niche products. This increased focus on innovation and the increased competition can be illustrated by the fact that in 1999 15 new products sent to the market, while in 2004 more than 50 new products were introduced (Selmer-Olsen 2005).

Finally, another cost reduction factor is that the subsidy from Ministry of Agriculture has been reduced during the last 15 years, meaning that Tine must improve their efficiency in order to maintain the milk price pr litre to its owners, the farmers. This has also resulted in a cost-effective centralisation of production capacity, reducing the number of plants from 800 in 1980 to 53 in 2004. Another way of explaining this centralisation is that the technology development, with high degree of automation, resulted in larger, more expensive machines where the packaging is formed inside the filling machine. This also reduces the transport costs of the packaging from packaging producer to Tine since the packaging is not longer preformed and less 'air' is transported. On the other hand, the centralisation causes more transport since the distance from farmer to plant to consumer is longer.

The packaging trend in Tine is that the potential for packaging reductions on existing packaging is overall utilised (Refsholt 2002). This is confirmed with the development of packaging consumption as presented in Chapter 8.2.1. Now the focus is on standardising the packaging for optimising the transportation and for standardising the appearance in the supermarkets. The supermarket chains are demanding in this respect, by for instance requiring smaller product units due to a tendency of smaller families (more single persons) and food-on-the-run. Moreover, the packaging consumption has increased also due to increased intermediate transport because of fewer dairies and hence longer transport distances.

The influence of EPR compared to these factors can be assessed in at least two ways – directly from the covenant so that Tine perceives the content of the covenant as stimulating for changing own practice or through the work done by Plastretur, the other PROs and NOC. As for the latter, Plastretur did not focus on stimulating upstream companies to design for recycling or to optimise their packaging (Sundt 2000). Moreover, since the covenants do not inhibit specified targets on waste reduction, the pressure from this was not that strong either. NOC was not founded before 1999, and could not be influencing the observed developments in Table 8.11. Being involved in negotiations and in PROs increase the attention/focus on this, but only to the extent of establishing the return system, and not on doing changes to the input to this system (Solgaard 2002).

To sum up, although the packaging improvement examples correlate with the EPR system, there were other more significant explanations than the covenants to why these changes occurred. Dematerialisation efforts have mainly come forth as a result of cost reduction. Cost reduction has become increasingly important due to tougher competition and reduced subsidy. As noted by general director “there is no single signal from the covenant or the intention behind the covenant that makes a force on Tine” (Refsholt 2002).

Design for recycling? – On Tine’s packaging strategy

When turning to the second aspect of EPR, the incentives for producers to design for recycling (Ehrenfeld 2000b, Lifset 1993), we must understand the role of the recycling aspects to other aspects in the product design process. Does EPR alter the strength of this role?

Design for recycling means that the product, e.g. the plastic packaging, is designed so that it will be easier to recycle, including all steps in end-of-life phase (collection, sorting, transportation and recycling). Obviously this has to do with the actual recycling system present, but we can put forth some general measures that can be taken to improve the design for recycling. First, the packaging can be marked with instructions on how the consumer shall source separate it, how to clean it, compress it and so on[12]. Second, reducing the amount of non-recyclable materials, for instance laminates, would make it easier for all actors in the end-of-life phase, including consumers, collectors, sorters and recyclers. Finally, another measure is to reduce the number of materials in the packaging, making it more homogenous. Of the examples provided so far, only the God Morgen Yoghurt can be defined as a design for recycling project. No examples of the other categories are found. New packaging solutions are important factors for success (Tine 2004a, p 7), but with an average of 15 major new packaging solutions annually, no one of these have paid particular attention to waste management issues (Solgaard 2005). How can we explain this?

Tine's packaging strategy is to develop and choose packaging that i) are recoverable and ii) can enter the return systems organised by the PROs (Solgaard 2002). These criteria are both easily fulfilled. When the energy recovery target is present in the covenants, it is literally no packaging from Tine that cannot be recovered. Second, the packaging chosen can necessarily enter the return systems because there are return systems for all types of packaging material in Norway. For example, the new packaging for school milk containing a screw cap in plastics and thus increases the heterogeneity in the packaging making it more difficult to material recover, but still it is recoverable and can still enter the return system.

The responsibility for the EoL phase is outsourced to Plastretur (and the other PROs on packaging materials). No one of the interviewees mentioned design for recycling as part of the optimisation term, rather that "we optimise along the value chain until the product is consumed" (Solgaard 2001). Since improvements in the design for recycling are not rewarded with reduced fee, there is then no incentive for doing so. The covenant is not representing any driving force concerning packaging optimisation (Refsholt 2002).

A second explanation to the lack of focus at design for recycling is that the packaging solutions are optimised for the purpose of attractiveness, food safety and consumer-functionality (Sverdrup 2001). Attracting consumers through exquisite packaging appearance and through functional solutions that make the product last longer and less product is lost, are areas with larger focus the latest years. "We have to be attractive in the few seconds a consumer decides what to buy" (Solgaard 2005).

In order to better understand how environmental issues are dealt with during product innovations, we need to look into these processes. Groups with representatives from various departments in Tine (sales, product, packaging, purchase and process) representing different aspects of the product development process are set up to run the developing process[13]. The core task of the group is obvious; developing a popular product for the market to maximise the profit for the company. In doing this, a number of aspects, in addition to the actual product, is taken into account; the existing production process and the available equipment and technology for this, the packaging to be used and the way it should be used for marketing, the logistics from production site to consumers, the potential environmental harm caused by the production process and the packaging, the costs of the production and the raw materials (Nagle 2001). Indeed, TINE has made huge investments in production and processing technology, which may lock in other potentially better solutions (Johansen 2002). The final product will always become the result of balancing these different factors, and the environmental issue is consequently only one out of many factors. The question is: How are the environmental arguments weighted in the decision making process?

The person representing the technical packaging aspect in the product group is also appointed the environmental responsible. This group in the R&D department has consisted of 2-4 persons, during the last years even fewer (Sætra 2002). He expresses his organisational position as:

> *I am the environmental leader, but am on the third level in the organisation, with consequently limited impact or decision making authority. The environmental responsible must be lifted to a higher level in the organisation.*

He has advocated the environmental aspect, potentially also the design for recycling issue, but within the project groups there are clearly different priorities between the various departments, as expressed by one informant:

> *The discussions are usually between the department of purchase and the others because the former is very focused on reducing costs. This is often in contrast to the priorities of the market department and the R&D department. Moreover, the market department argues for packaging that is attractive to the consumers, which often is contrary to an environmental argument. And finally, within the R&D department there are also various aspects to take into account, for instance environmental issues and product durability.*

Those speaking the environmental voice have necessarily various points to assess. For instance, the relative environmental load of the main dairy product to the packaging is 1:10, meaning that spill of the main product are far more environmentally necessary to avoid. The packaging must therefore be made in such a way that it maintains and protects the main product in a healthy and secure way. This is an argument for packaging optimisation, and not packaging minimisation or design for recycling. Within the area of packaging, EPR emerges just as an additional factor, making the decision-making process even more complex. In this discussion, both the environmental argument in general and the design for recycling argument in particular (that does not provide any economical profit) become weak. If the product is not sold, optimising for recycling is indeed irrelevant.

That said, during these processes, the dairy products are the major issue, while the packaging is one necessary condition for attracting consumers and for protecting the product. The consumer does not have a strong incentive for selecting the product with the most environmentally friendly packaging. Tine is obviously more concerned about the product than the packaging, and it is argued that the packaging will never be more than a factor supporting the main product. Other factors like production processes and existing process technology, utilities like energy, transportation, consumption and end-of life aspects are subordinate to developing the actual product. Obviously, the role of the covenant in this is non-existing as it does not provide any incentives. During the interviews it became clear that very few knew of the covenant and its content. Those knew of it argued that "this is something taken care of by Plastretur".

Environmental consciousness – reputation or reality?

Given the discussion above, it should be relatively clear that the covenant, or any internal or external actor that tries to advocate it, has minor influence. However, EPR is said to be forcing designers to think differently. Can we find evidence for this in the Tine-case? Has the general environmental consciousness become stimulated by the covenant?

The informants argue that Tine is an environmentally conscious company. To what extend this awareness actually is included in the product development processes is more uncertain. There is an observed uncertainty on how the environmental awareness should be included and taken into account in practise. And if an life cycle assessment (LCA) shows that one solution should be preferred to another, the most economical beneficial solution, in shorter or longer perspective, is always chosen (Eide 2001).

The new packaging on school milk is a good example. LCAs on variants of the new school milk packaging showed that the selected packaging is performing less well than other alternatives. Those speaking the 'environmental case' have nevertheless accepted that the choice is taken and the point is then to make this as good as possible (Solgaard 2002). Another example is the centralisation process, which has been carried out, despite the fact that this increases the transport distances, and is not environmentally preferable. There are other arguments than the environmental ones, which are stronger and more powerful to that discussion.

Tine has been awarded the best environmental company in Norway eight years in a row. All informants in Tine mention this position as important for Tine to keep. Moreover, this is also used as an internal argument proving that Tine is an environmental conscious company. One major reason for this is said to be the fact that milk dairy products are based on pure and healthy raw material, and Tine's identity and reputation is related to this fact. Since Tine is within the food industry, careful attention to safe and hygienic production and packaging is an absolute necessary condition for the products.

Another consequence of the increased environmental focus in society in early 90's in general and in Tine in particular, was that Tine in 1994 published their first environmental report. During the latest years the environmental reports have been subject to major improvements with respect to the number of indicators and the overall perspective. Tine was awarded the best environmental report in Norway in 2004. The environmental reports were reviewed by an auditing company, which in 1998 suggested that Tine should develop a system for mapping and controlling their materials and energy flows, primarily within the diaries, but also throughout the value chain. This has resulted in a database and an environmental accounting system, where all the diaries shall update the database on a number of indicators concerning the production of diary products, of transportation, of the further use of by products and so on. The informants could report that this has created an increased interest in environmental issues, and at the same time a better knowledge of the process and product system they are a part of.

Despite an initial impression of Tine as an environmentally conscious company, this empirical study so far indicates that this does not materialise into the real decisions where there are other aspects that are weighted far more. Consequently, the design for recycling argument is to some extent present, but not decisive.

Understanding the resource perspective

Based on the previous paragraphs we might conclude that the covenant has neither contributed significantly to the dematerialisation processes of packaging nor to the design for environment. It thus seems that the environmental consciousness of the company is not a key characteristic of the organisational culture. EPR has not, consequently, influenced the basic values and beliefs concerning environmental issues. "The environmental issues are dealt with those four persons in R&D", one interviewee stated, and this statement was confirmed by others during a company presentation[14]. To test this hypothesis, we will briefly investigate the activities within non-packaging areas related to environmental issues. We will focus the discussion on primarily two issues; i) internal waste management and ii) overall resource management.

As mentioned above, the internal waste generation and source separation in TINE is also contributing to the efficiency of the plastic packaging EPR system since we can assume that a majority of the waste generated within TINE is packaging, being directly relevant for the covenant. According to Appendix E, the amount of generated waste has increased with 55 % from 2000 to 2004. In the same period, however, the absolute amount going to landfill is reduced by 8 %. The explanation for this can be found in the amount of source separation in TINE, either for energy recovery or for material recycling, going from 51 % of generated waste in 2000 to 63 % in 2004. According to Selmer-Olsen (2001), TINE started systematic source separation of internal waste in 2000, and more dairies start separating their waste.

It seems that an internal pressure combined with a pressure from Plastretur and other PROs through illustrative examples are key factors for why these systems have come along, and of course combined with the cost reduction potential. However, not starting before 2000, more than 6 years passed by without utilising the direct connection between the EPR systems and Tine's own waste generation and waste management.

Second, the overall resource management will be discussed in relation to the extent which process innovations are carried out on existing plants and processes. There are basically two major issues to deal with; reduction of border milk and utilisation of ingredients in the whey. Emissions from border milk are the major source to water, representing a main environmental problem for a number of plants. 40 % of the plants do not comply with the concession limits set by the authorities (Eide 2001). Border milk is the rest of the milk present in the tanks after processing the raw milk to drinkable milk in batch operations. Hence, it will always present, but reduction is possible if the process is optimised (Selmer-Olsen 2002). The amount of border milk decides the need for purification plant, and traditionally there has been a trend towards these plants instead of optimising the processes. The border milk case is indeed an environmental challenge as it is presented here, but on the other hand, the solutions to the challenge might also cause economic benefits. This is an example of motivation being strengthened by economic prospects and not environmental consciousness.

The whey problem has been subject to lot of research (Selmer-Olsen 2001). Previously, the whey was sold to pig farms as 'liquid' animal feed. Now, the protein is separated from the whey, dried and processed into being an ingredient in diet additions. Other parts of the whey is also utilised as ingredients in other food industries. The main reason for this change is argued to be the altered focus from milk being the product towards milk as containing a number of substances. This has been driven by the economic rationale that by utilising the raw material better, the economic bottom line will improve (Selmer-Olsen 2005).

According to Selmer-Olsen (2002) there is now a change in the way Tine is looking at the milk as the raw material in their production. Previously, the milk was the starting point for processing it into being a drinkable product for consumers. This has slightly changed into considering milk as containing a number of substances, protein, sucrose, minerals, fat and so on, all being ingredients for use in food processing industry. Separating these from the milk production is regarded as an economically very interesting path for the future. This will indeed reduce the emissions to water and it will represent a potentially increased income. This improved resource efficiency/utilisation thus has an equally important economic aspect as an environmental aspect. As noted by several, the economic argument is indeed more attractive to those making decisions about what to do within the problem.

8.2.3 Concluding the Tine-case

The informants say that EPR has played an important role in creating the systems for collection and recycling for plastic packaging, and that this is important according to the social responsibility of TINE and the environmental profile the company wants to express. EPR has to some extend contributed to a generally increased environmental awareness within the company, but in general very few within product design and packaging department reflected more on this than that this was a downstream issue. Some secondary effects, partly due to EPR, can be observed, for instance participation in packaging based discussion and interest groups (e.g. NOC), environmental reporting and database for mapping the material and energy flows in Tine, and sharp focus on providing reliable information through annual environmental reports. There are, however, several other factors than EPR that has contributed to this.

Some of the factors are the increased competition, economical reasons (reduced costs) with environmentally friendly consequences, the top ranking in the MMI's investigations (which seems to be more important for the environmental motivation than EPR), the need to avoid skeletons coming out of the cupboard since the company is regarded an environmentally conscious and responsible one and the pressure from different external actors. Without EPR nothing would have been done in the end-of-life phase, but packaging reduction by TINE would have happened anyway. Tine's reputation as a social responsible company is here important to protect[15].

All the factors mentioned here contribute to cost reduction, and EPR has minor significance in these processes. The main point is that there are basic economical reasons for doing this, and environmental reasons are of secondary concern. "We are not selling environment, but products", an informant said. Luckily, there is often win-win situations, and the efforts are both economical and environmental favourable for the company. "There is no problem fulfilling environmental goals when this at the same time reduces costs", another informant said.

It seems obvious that the covenants act as sleeping pillows for Tine. Other companies (Plastretur and Norsk Returkartong) are carrying the responsibility for Tine in end-of-life phase and it does not seem to stimulate Tine to carry out product and process innovations in order to make this job easier. As far as the reputation is concerned, they can always argue that this is taken care of by these companies.

Although Tine is perfectly aware of the need for being an environmentally conscious company, it seems that they have not taken the big steps to do a systematic evaluation of the environmental problems at hand, and the core idea of industrial ecology, namely that there are often economic benefits connected to preventive approaches. Although, Tine is slowly turning towards this by looking at milk as consisting of a number of ingredients, the covenant has neither inspired to think preventively (cognitively), nor to give sufficient incentives (legislative) for the producers to act preventively in this process.

8.3 Other upstream companies and organisations

Can we find support for the conclusions in Tine within other upstream companies as well? We have interviewed 9 upstream companies and three industrial associations, see appendix B. The biggest polymer producer in Norway, Borealis, argues that there are strong driving forces for making more specialised polymers adjusted to a more demanding market. Borstar® is an example of a new polymer that is very strong and that makes it possible to for instance produce thinner film when extruding this quality. This will then lead to dematerialisation since less material [in kg] is used to fulfil the function (Skilhagen 2002). The cost savings related to these is usually divided between the polymer producer and the plastic packaging producer (and the 'packer and filler'). On the other hand, Folldal Recycling argues that this strong polymer is making their recycling process more difficult, troublesome and expensive to carry out, in line with other type of contaminations like nylon, strap bonds and EPS. In general, the ability of the virgin polymer producers to manufacture almost any specialised polymer demanded makes it even more difficult for the recyclers.

For packaging producers the trend is consequently thinner, stronger and cheaper packaging products in order to be competitive through better quality and lower prices. The margins are very small and supermarket chains put a strong pressure on the plastic packaging producers (Kildal 2002). Key characteristics of the Norwegian plastic industry in general are high costs, small home market, long transport distances and an enormous technical development making the plastics more diverse. The sector is to a large extent facing international competition, which have been clearly more visible during the last 10 years. Thus, there is a fight within the plastics industry to survive with very small margins. Although the majority of the plastic producers and plastic packaging producers confess to EPR, the overall focus is to survive and 'nice to do' points must be left more unintended (Flesland 2001). Thus, the focus on source separation is a direct consequence of companies focus on reducing costs.

> *We did not need to have a covenant to obtain source separation in companies. The covenant might have been increasing the focus on this, but not more (Kildal 2002).*

Interviews with packers and fillers support the findings within Tine. The main focus is primarily to protect the product "since this is what the consumers buy" (Friele 2001), and, secondary, to reduce material consumption (see Figure 8.5) in order to reduce the costs (see Figure 8.6), while the influence from the covenant is marginal (Havre 2001, Friele 2001).

The industrial associations (e.g. NHO) consider the packaging covenants as successful.

> *"More than 70 % is recovered, at a considerably lower cost than the suggestion by the authorities. The only problem is number of free-riders, which brings along a continuous discussion on whether to have a regulation or a covenant. The main argument for having a regulation is that this induces a public control instruments" (Fredriksen 2002)*[16].

NHO also considers the covenant to be successful in relation to packaging optimisation (Fredriksen 2002, 2005). The main activity has been to establish a methodology for measuring material consumption (Hanssen et al 2003) and to employ this for mapping the development. Packaging optimisation is defined as

> *continuous improvements throughout the value chain that maintain sufficient protection to the product with lowest resource consumption and environmental impact as possible (SfA, 2001, p 5)*[17].

However, the value chain stops at the consumer, leaving the recycling aspect outside the definition of packaging optimisation. Hence, even SfA being established to stimulate preventive actions within upstream companies, omit the EoL aspect of packaging. Examples of design for recycling efforts cannot be found in the annual reports from SfA. Consequently, the signals from the covenant to the product designers are weak.

This definition of packaging optimisation is supported by the 'Industrial association for wholesalers and retailers' (DMF). This organisation is very active both in Plastretur and in NOC. The main focus is to optimise the packaging from producer to retailer. This includes optimal utilisation of the pallets in order to reduce transportation costs. Improvements have been made among the largest companies, but still the pallet utilisation is just above 70 %. Since the supermarket chains are large waste generators as well, DMF wants to increase the value of this waste by demanding payment from Plastretur (see Chapter 7.3). DMF also argues strongly for a bring system where all the household packaging waste is collected in one bag and sorted afterwards (Maldum 2003).

As mentioned in Chapter 7.3, the supermarket chain Coop has switched their attention towards making money out of plastic packaging waste, see Figure 8.8. The basic idea is to redirect the clean and dry transport plastic packaging waste from 'Coop-retailers' and 'other retailers' towards 'Coop wholesaler/storage', instead of sending it to waste management companies (WMC). Coop argues that they will achieve a higher collection ratio than the WMCs (Coop 2003). Hence, there is a strong competition between WMCs and Coop on this. According to Coop (Langolf 2002), the potential is 3000 tons a year, only from the Midt-Norge district. The net effect of this is however lower as the amounts sent via WMCs to Folldal Recycling will become lower.

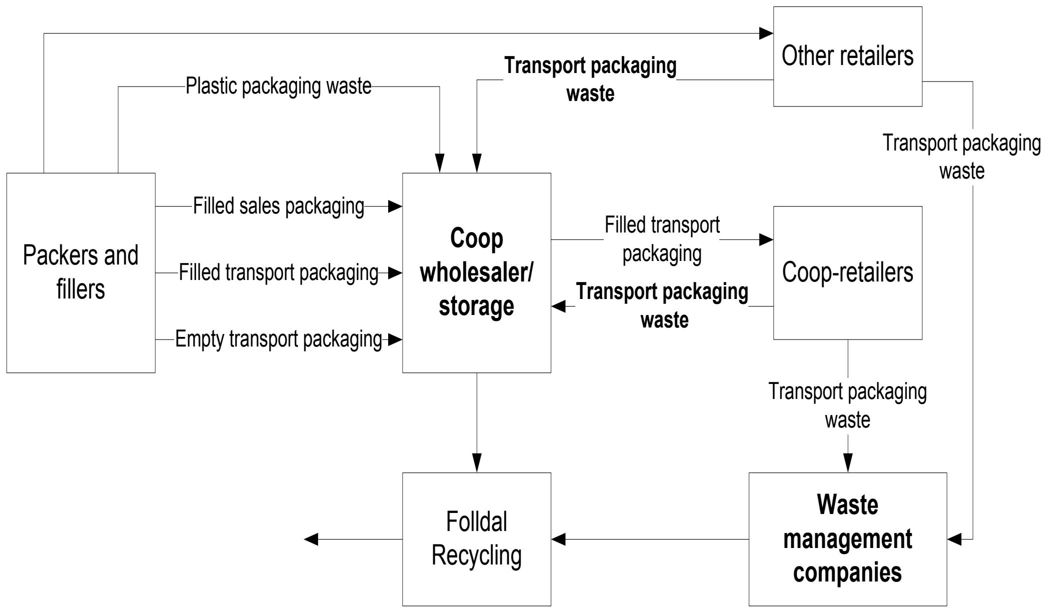


Figure 8.8 Flow of plastic packaging related to Coop collection and sorting centre

8.4 Waste generators and downstream companies

The efficiencies calculated in Chapter 7, is a consequence of the actions by the direct actors. In this chapter we will present some results and viewpoints from these actors. Fourteen comparable waste generators (retailers and wholesalers) and eight comparable waste management companies, all contracted by Plastretur for receiving plastic packaging from commerce and industry, were interviewed.

8.4.1 Waste generators and waste management companies

All waste generators we interviewed started with source separation during the period 2000 – 2001. The main reason for this was mainly the introduction of the final treatment tax in 1999 which made it more expensive to generate residual waste. They sorted primarily film, while some had an energy fraction. But no one was sorting rigid plastics. On average the waste generators assumed the contamination in the film fraction to be less than 5 %. As for the residual fraction, some argued that less than 5 % plastic packaging waste, while the other reckoned the amount to be between 30 – 40 %. Hence there was either large variation in the sorting quality or variation in their actual estimates.

As shown in Chapter 7, there are several examples of waste generators that have started to source separated, and saved money because they can deliver these fractions for free, instead of paying 1000 NOK per ton in disposal fee. Why is it so that not every waste generator prefers source separation if this is more profitable? First, we have found that educating both the management and the personnel, which within the supermarket chains or specialised trades often are relief counter hands, is very difficult and not prioritised in a hectic daily routine. The products in the store are the main focus and dealing with waste does not get first or second priority. Second, they are not specialised on plastics and cannot separate one type of polymer from another, which can explain why it is difficult to source separate correctly the first time. Third, often the buildings are often small and not designed for treating a number of source separated fractions.

For instance, IKEA has close to 15 different fractions that the employees are obliged to source separate. Fourth, the waste generators are usually subject to long-term contracts with waste management companies and respondents argue that 'there is no incentive for doing differently as long as the prices and framing conditions are already set'. Waste generators also argue that the waste management companies are used to handle large containers with residual waste, and earn money on this. Neither waste generators nor waste management companies are experts on plastic packaging, and this, together with the factors mentioned above can explain why Folldal Gjenvinning gets various qualities from their suppliers.

No one of the waste generators had ever received any feedback from waste management companies to improve their source separation. This support the general impression from the interviews with the waste management companies that these were very satisfied with their own activities. "There is not much more we could do, given the current prices and framing conditions", one informant said. Moreover, it was a common understanding that their waste management plants were not designed to treat clean fractions, except from corrugated cardboard and paper. This seems to be a major obstacle in order to obtain an efficient collection and sorting system that can contribute to increase the recycling ratio. In order to fully adapt one self to handling plastic (packaging) fractions as well, investments are needed. None of the interviewees dealing with industrial plastic packaging waste had adjusted to the new reality of separated fractions. One exception is the specialised sorting plants of Norsk Gjenvinning in Larvik and at Gardermoen. These produce high quality, sorted plastic packaging waste.

The collected plastic packaging that is already separated by the waste generator is usually not treated by the waste management company, but sent directly to the 'export storage' or to another recycler. The tendency is that the export storage has been less strict, although this was not the intention in the quality assurance (Gjester 2003) and that the waste management companies because of this have preferred to send their collected plastic packaging to them instead of sending it to domestic recyclers. The waste management companies are somewhat still in a waste regime and do not educate the waste generators on how to do this correctly. Experiences show that if Plastretur go directly to the waste generators rather than via waste management companies, this has far better effect (Bratterud 2002).

The problem, however, is that Plastretur (or any other PRO) cannot run specific project targeting any large waste generator. It is the waste management companies that have the primary contact with these and should therefore be the one to carry out this education. Moreover, it runs contrary to the market model if Plastretur in a too large extent does projects targeting waste generators since waste management companies are one of two primary points of contact within the waste management system for Plastretur.

The waste management companies want Plastretur to be supportive, and contribute with knowledge, solutions and subsidies. This is different from the traditional industrial thinking where those in the field are the knowledgeable actors, and those in offices do not understand what is needed out there. Plastretur tends in this sense to be a sleeping pillow for the waste management companies which do not look for new possibilities and solutions.

8.4.2 Sorters

As mentioned above, it is only the largest Norwegian waste management company, Norsk Gjenvinning, which runs a specialised sorting plant for plastic packaging. It started in 2001, and the intention was to improve the quality of the plastic packaging from the waste management companies before sending it to recycling. They found it economically interesting to start this activity.

The result is that the amount of quality 1 sent to Folldal Gjenvinning is much higher than before, evidently improving the quality out of the recycling process. Folldal Gjenvinning gets 70 % of all their natural raw materials from NG. The supermarket chains provide mainly the rest (Rogstad 2002). Table 8.12 shows the deliveries in 1998 and 2002 of various qualities as input to recycling process.

The main reason for this improved performance is the sorting plant in Larvik. Previously, Norsk Gjenvinning experienced that lots of high quality foil waste sent to energy recovery due to bad sorting, and lots of low quality foil went to material recycling due to bad sorting. 80 % of all plastic packaging collected by Norsk Gjenvinning goes through the sorting plant. With 45 % of the market share, Norsk Gjenvinning is the most important supplier to Folldal.

Table 8.12 Deliveries of plastic packaging in tons from Norsk Gjenvinning to Folldal Gjenvinning in 1998 and 2002. Source: Bjørn Kopstad (2003)

	1998	2002
Natural (quality 1)	48	1714
White (quality 2)	252	252
Blend (quality 3)	1003	1256
Not accepted	155	103
Sum	1458	3325

The value added due to improved quality of the plastic packaging is, however, not reflected in Plastretur's subsidies. Plastretur does not pay more for better quality. According to Kopstad (2003), Plastretur have changed the boundary conditions since Norsk Gjenvinning decided to build the sorting plant. The export storage has been established making it more attractive for waste management companies to deliver there instead of improving the quality through sorting and sending it to material recycling at Folldal Gjenvinning. According to Kopstad (2003), Plastretur prefers quantity to quality, and argues that other waste management companies get similar subsidy from Plastretur without providing the same quality. This hinders a real competition. In normal market situations, the market price for a good is reflected in the quality of it.

8.4.3 Recyclers

In the plastic packaging industry, Folldal Gjenvinning, producing re-granulates from low density poly-ethylene (LDPE), is an important case. It was established in 1994 through a governmental subsidy of 40 million NOK. This was given partly due to a recent close-down of a corner-stone company in the local community and partly because of the coming covenant (Løvold 2003). Since then, the company has gradually improved its products, but mainly as a result of higher quality and quantity of their raw materials, and not as a result of technological innovations (Rogstad 2002). Their existence entirely depends on the EPR schemes, both for reasons of raw material supply and subsidies.

Table 8.13 shows the development of the various recycling qualities at Folldal Gjenvinning. As mentioned above, the fraction of natural quality has increased steadily. According to Rogstad (2005) the supply from Norsk Gjenvinning only contains 2-3 % contaminations, while the supply from COOP is fed directly into the production process. Previously before Norsk Gjenvinning started sorting and supermarket chains started to deliver their plastic packaging, the input quality was not very good. The agricultural film was often dirty and sandy and contained a lot of water. Contaminations from other polymers with different melt index than LDPE, in particular PP, EPS, PVC and nylon cause problems in the production line. This has resulted in high costs due to shutdowns and damaged equipment. This emphasis the importance of proper sorting before the polymer enters the extruder. During the latest years, the new cross-chained polymer Borstar®, developed by Borealis, cause problems for the machines and the production.

Table 8.13 Distribution of outflow qualities from Folldal Gjenvinning

[%]	1998	2001	2002	2004
Natural (quality 1)	4.7	0	12.0	28.0
Off-white (quality 2)	0.0	15.7	9.4	16.0
Colored (quality 3)	36.8	12.8	9.2	50.0
Blend	58.5	67.7	68.4	6.0

The prices on these products are depending on the qualities. 'Natural' varies with the Platts index and is normally around 60 % of virgin material. Blended is more constant.

8.5 Secondary upstream companies

In order to close the loop, the recycled plastic packaging must be employed in new or existing products. If not, the entire recycling process is just a long energy-demanding way around to final treatment. We might therefore ask: How has the covenant stimulated companies to employ recycled plastic packaging material and to create a market demand and not only a market supply? And what are the experiences with using this material in new production? We have briefly looked into several companies that have employed recycled plastic packaging, and we will provide a short glimpse of the results.

The main markets for recycled plastic packaging are carrier bags and refuse bags (Gjester 2003). Norfolier, as the largest owner of Folldal Gjenvinning (45 %) employs recycled plastic packaging from Folldal Gjenvinning in refuse bags, in order to reduce the costs and increase the margins (Løvold 2003). In this aspect, the covenant has contributed to improve the competitiveness of certain companies. The quality demands of the recycled material are relatively low for refuse bags.

If we turn the attention towards carrier bags, the situation is somewhat different. Another plastic carrier bag producer, Stenqvist in Trondheim, Norway, is a key actor in the plastic packaging loop in Norway. First, the company is a major licence fee payer to Materialretur, because they have approximately 40 % of the market in Norway for carrier bags. Second, they spend recycled material from Folldal Gjenvinning in their carrier bags.

According to Buhaug (2002) it is challenging to employ regranulate in extruding processes. The main problem lies in the fact that the supply of recycled material is rather unpredictable and unreliable and "it is hard to know what you actually get". If breakdown occurs due to poor quality, production is lost for some hours and the potential profit for using recycling material is lost. Their customers demand 80 percent regranulate, but according to Buhaug (2002) this is impossible due to existing technology and variability in the input material. The economic calculation has to include a number of elements: i) the reduced costs when employing recycled material instead of virgin material, ii) the extra costs involved, for instance as a consequence of more often breakdowns, more wear and tear on the equipment as the regranulate is polishing the equipment, iii) more time has to be spent on maintenance, iv) refusal and reduced income from the customers due to poor quality and v) increased material use as thicker products is required to remain the same strength. In total, the costs of employing recycled material are not 60 percent, but closer to 80 percent. All these factors increase the financial risk connected to the usage of recycled plastic packaging. According to Buhaug (2002) it is primarily the market that demands this type of products. We have, however, not studied whether the covenant has had a significant role in this market pull.

Another case study might throw light upon this question. Rosenlew Industries (at Geithus, Norway) used to produce poly-ethylene-based carrier bags and refuse bags. Since the 1960s, refuse bags with recycled PE had been produced. In 1997, Rosenlew introduced a carrier bag consisting of 65 % recycled PE. The question is: Why did Rosenlew launch this environmental carrier bag in 1997 and not before?

It seems to be several reasons to this, and we will present these by looking at the situation as it appeared to Rosenlew in 1994 and 1997. By doing this we will be able to explain the different boundary conditions Rosenlew was facing, and that had influence on their decision-making processes.

In 1994, two major external relevant factors happened. First, the Folldal Gjenvinning had recently been established with substantial economic support from the NMoE. The major plastic packaging producers in Norway own Folldal Recycling, and Rosenlew is one of the owners. The support of NMoE was mainly due to the forthcoming implementation of extended producer responsibility and a precondition was that material recycling should happen in Norway (Løvold 2003). During the first year of operation, the quality of the plastic produced or recycled at Folldal Gjenvinning was not that good. Rosenlew was the third biggest fee-payer to Plastretur in 1996, meaning high costs to them.

Despite this, in 1995, Rosenlew continued to use only virgin material in their production of carrier bags. There were, according to the company itself, no triggering factors that could act as a catalyst for starting to use recycled poly ethylene. This catalyst appeared in late 1996. Rosenlew's biggest customer, Hakon-gruppen merged with the Swedish supermarket chain ICA. They had an outspoken environmental profile, with for instance an environmental carrier bag in their stores. The merged company explored the possibilities of introducing a similar carrier bag for the Norwegian market as well. The main argument for this was economic; they wanted a cheaper bag. Improving their environmental performance was of secondary concern (Riksen 2000). Rosenlew, due to close relations to the merged company, was involved in these discussions, and quite quickly presented a draft plan for how to produce such a bag on their production site. All the reasons so far have been external, or boundary conditions, for Rosenlew. What about the internal reasons for the company to engage in this in 1997?

First, their major customer demanded this bag, and in order to maintain and even tighten the bonds to this company, Rosenlew needed to follow up. Producing cheaper bags due to lower raw material prices would make them even more competitive, although this would give a technically less flexible and more vulnerable production and the economic margin would be lower. Secondly, Rosenlew had a 'sister company' in Sweden, with experience from producing such carrier bags. Rosenlew could therefore draw benefit from their experiences, making the test period and technical adjustments quicker and cheaper (Andersen 2000). Further, in 1997 the efficiency of the collection and sorting system of plastic packaging had improved, and Folldal Recycling produced recycled PE with substantial higher quality than in 1995. Rosenlew could have bought used PE from abroad, but since the market demand was not there, they did not. Of course, Rosenlew could have made a strategic choice saying that they would contribute to create such demand, but they did not. Thus, the main driving force for these changes was the demand from the market, while factors like the covenant, the existence of Folldal Gjenvinning and the sister company in Sweden were only premises being advantages that were present, but were in themselves not single reasons for Rosenlew to use of recycled material.

The examples so far are characterised by using extruding technology and LDPE as the main polymer. A greater potential for recycling is, however, found in moulding technology where polymers like HDPE and PP to a larger extent are employed. There are some examples in Norway on this. First, the office chair producer HÅG employs a combination of recycled ketchup bottles and car bumpers to produce a component in one of their models. The supply of recycled material is from Sweden while the moulding process is done in Norway. The key challenge was to establish deliveries of stable quality and quantity (Kviseth 2002). The driving force for this was the wish to use ecological arguments in the marketing, as an active environmental strategy differentiate them from their competitors. The covenant seems not to have contributed in this development.

Two other examples confirm this. First the reverse vending machine company Tomra employs recycled HDPE and PP as part of their environmental profile, in order to close the product loop (Saugen 2004) while Malthus, making utilities for construction sites, employs PP in their form elements (Hatlestad 2002). Common for these examples are, besides the environmental motivation and potential cost reductions, that they have experienced difficulties in finding proper supply of plastic packaging from Norway, and that they have to get abroad to find proper quantity and quality, at stable deliveries (Hatlestad 2002) This is to some extent confirmed by Figure 7.7, which indicates that the recycling ratio for rigid plastics are low. The role of Plastretur is mainly to be a coordinator in the market, with excellent overview of the actors and a source of information for those interesting in employed recycled material. That said, the secondary producer project outlined in Chapter 7.3, indicates a more active role of Plastretur, that eventually might contribute to a similar signal effect to other potential user of recycled plastic packaging as intended with the waste generator projects.

(Endnotes)

[1] Upstream companies are 'Norwegian producer of plastics or plastic packaging', 'packer & filler', 'importer of plastic packaging' and 'wholesaler or retailer in Norwegian tertiary sector. Downstream companies are 'waste management company', 'sorting or waste treatment company' and 'recycling company'. 'Industrial organisation or PRO' is defined as 'other'.

[2] At the annual general meeting in April 2002, it was decided, after more than three years of preparations, to merge Tine Meieriene and Tine Norske Meierier into one company based on a traditional industrial group organisation structure where the group management has decision-making authority over the dairies and Tine.

[3] In 2004, the diversion of sales income was grocery retailers (51.1 %), wholesalers (26.1 %), institutional households (9.4 %), industry (7.0 %), export (5.1 %) and others (1.3 %) (Tine 2005a, note 1 page 21).

[4] This is exclusive the cost of the raw milk. The costs of raw milk are around 5.5 billion NOK. This cost is calculated based on the sales income per year and the corresponding costs. The difference, in 'normal' companies being the net profit, is paid back to the farmers, who also are the owners of TM.

[5] Their role as market regulator meant that they have to receive all raw milk produced in Norway (Norwegian Competition Authority 2004, p 15).

[6] The ongoing WTO negotiations may alter this, which indeed might influence Norwegian farmers and Norwegian food processing industries.

[7] Methodologically spoken, these packaging improvements constitute the overall development displayed above, but explaining the actual development, not only from a technical packaging point of view, but to a greater extent 'independent variables' contributing to the development. We can assume some contributing factors; the total amount of throughput in TINE and the total amount of end-products, the composition of products, for instance smaller or bigger units of the main product (for instance small boxes of butter versus bigger boxes), specific packaging improvements causing potential dematerialisation in existing packaging solutions, and, finally, changed processes in processing/refining raw milk into various products. In this part we will focus on actual packaging improvements and leave the other explanatory factors for the analysis in the next chapter.

[8] As mentioned in Chapter 6, "Packaging minimisation" (NMoE 1995a) and "packaging optimisation" (NMoE 2003c) are employed as terms for the second target area in the covenants.

[9] This was at the same time as the White Paper on waste management and indicated a turn in the governmental attitude to waste giving more responsibility to industry, creating an incentive for Tine to be proactive. In 1993 Tine contacted the Norwegian Ministry of Environment (NMoE), with the intention of starting a working group elaborating on the issue of establishing a producer responsibility on beverage cartons. This was also because NMoE were talking more loudly of a packaging tax of 1 NOK pr unit. If such a tax would pass through, this would mean an increase in Tine's costs of hundreds of millions of NOK. This was the starting point and ended up with the establishment of Norsk Returkartong in May 1994 for creating a return system for beverage cartons.

[10] Interestingly, TINE initiated a project for employing plastic cases for transporting cheese from production plant to the grocery stores, but this failed due to resistance among grocery stores because of increased working load with return-logistics (Sylte 2002).

[11] Tine owns 20 % of Norsk Returkartong (NR), and had previously the chairman of NR and the vice-chairman of Materialretur.

[12] Plastretur and the other PROs have established LOOP for providing information to consumers on how to sort, but this is more about what kind of collection systems that are in all Norwegian municipality, including type of fractions. What is missing, however, is information on particular inner packaging and how this shall be sorted. Given the wide diversity of polymers, the regular consumer cannot know what are plastics and what are not. Further, within plastics there are various types of polymers that obviously cannot be recycled together (laminates and HDPE) and hence should not be collected together, remembering the slogan by Plastretur: 'Correct the first time'. Hence, the communication between the producer of the packaging and the developer of the collection and recycling system is not present although there are some weak attempts through for instance LOOP. Moreover, the Tur-Retur bulletin is also something that might be related to this information demand, but it is not yet at that path. In concluding, the situation would have been improved if the packers and fillers had given instructions on the packaging as to how this should be sorted and collected. For beverage carton, TINE has done this, but not for plastic packaging.

[13] The market is responsible for the costumer side (both the final consumer and the grocery shops), 'product' is developing the actual product; packaging is dealing with various solutions for packaging and is also, traditionally, ensuring the environmental perspectives. Purchase is those being in contact with the actual suppliers of packaging and finally, the process people is dealing with how the new product and selected packaging is fitting into the existing process technology within the company and how to optimise this production.

[14] Company presentation held by Kjetil Røine 10th December 2001 at internal meeting for entire Tine R&D, Kaldbakken, Oslo.

[15] This reputation was strongly challenged in late 2004 and early 2005 when Tine was accused for paying high 'remunerations' to one supermarket chain for holding one of the competitors, Synnøve Finden, outside this supermarket chain.

[16] If certain substances are to be removed from the industrial society, then regulations/bans are required to

obtain goal efficiency. The covenants that in fact are not juridical documents, aim to instead of authority power to stimulate market power and freedom under responsibility. We may ask, as seen from the individual company point of view; what is gained when using voluntary approach in preference to regulation. The term voluntary can in this respect be defended to be used since the covenants are not juridical binding documents and it is thus voluntary for the companies to participate in the collective systems or not. The actual covenant is, however, a result of negotiations between representatives from industry and industry associations and the environmental authorities. In this respect, the covenants are negotiated and not voluntary. Seen from the governmental point of view, it is to a large extent regarded as a regulation, although it does not include any sanction points to be used towards the individual companies. One key aspect of a regulation is that it is juridical binding for individual companies. In a regulation one cannot put up targets for the entire country, but it must be related to the individual companies/actors.

[17] SfA is the abbreviation for ”The Committee for reduction of packaging waste”, and is the former name for the organisation now known as “The Industrial Packaging Optimization Committee” (NOC).

9. KEY CONDITIONS FOR SUCCESSFUL EPR IMPLEMENTATION

As seen from Chapter 6, the recycling ratio has improved during the period 1996 – 2004. What has contributed to this and what can be considered as barriers to even higher recycling ratios? Moreover, Figure 6.8 in Chapter 6 shows that there has been a relative dematerialisation in the Plastretur system, while there is no absolute dematerialisation. How can this be explained?

9.1 Key conditions for successful EPR implementation downstream – loop closing

9.1.1 Correct sorting by waste generators

In Chapter 7 we identified low sorting and collection efficiencies by the waste generators and this phase turned out to be the place with largest loss of quantity. In the same chapter we also discussed successful projects among waste generators, improving the efficiencies considerably (e.g. from 20% to 80 % in some cases). This indicates that there is a large improvement potential by the waste generators and that specific projects targeting these actors might contribute to release this potential. A key condition here seems to be the necessity for direct information and guidance to the waste generators. This has been initiated and carried out by Plastretur, which through material flow analysis has identified waste generators in general, and shopping centres, retailers and building sites in particular as places with obvious potential for improvements. Another key condition is thus to employ a material flow approach to identify where the potential for improvements is highest.

Plastretur has put a lot of efforts in educating the waste management companies based on the assumption that these will distribute this knowledge and offer solutions to the waste generators as they have more frequent and a broader contact with waste generators. However, in Chapter 8 we showed that the waste management companies only to a limited extent have entered the recycling regime, and still mainly are within the residual waste realm. Due to lack of knowledge and awareness among the waste generators and a general limited competition on source separation solutions among waste management companies, Plastretur has been 'forced' to take a key role in educating waste generators.

The Plastretur slogan 'Correct the first time' is in line with an industrial ecology way of thinking. Due to high investment costs for plastic packaging sorting technology, larger markets than the Norwegian are required if such investment should be a reality. Therefore sorting correctly at the waste generators place, rather than sorting afterwards, is a key condition in order to obtain high quantity and quality. The question is then *who* should in a market-based, collective EPR system, initiate and run such projects?

As presented in Chapter 8, there are a number of examples of waste generators that have started to source separate and consequently saved money. Obviously, if the waste generators save money on source separation, the waste management companies will reduce their income correspondingly, and although this is a business opportunity for the waste management companies to offer such solutions, it is mainly pressure from the waste generators and not initiatives from waste management companies that bring along source separation. As seen in the Tine case, it takes time to change behaviour on areas that are not at the core of the business. The producers are knowledgeable in relation to their main products, less to utilities like packaging, and even less in relation to waste, source separation and recycling. Thus, the role of Plastretur, and in general all PROs, as initiator for waste generators to demand source separation solutions is significant.

Another argument showing the necessity of correct sorting by waste generators is related to the quality input to Folldal Gjenvinning. As seen in Chapter 8, Folldal Gjenvinning has increased the quality of their product considerably after Norsk Gjenvinning established their specific sorting plant in Larvik, Norway. Contrary to other waste management companies, this plant was specialised on plastics and their skills provide high quality input to Folldal Gjenvinning. As seen from Table 8.13, the recycling efficiency factor was improved at Folldal Gjenvinning, and high quality input was a main reason for this. Another reason was the inflow of raw material from the supermarket chain Coop, which established their own sorting and compression line at their storage. This was entirely transport film, without being in contact with other polymers or other waste fractions at waste management company plants. This is, thus, an example of the advantages of correct sorting the first time at the place of the waste generator.

That said, the 'Quality-project' financed by Plastretur and carried out by Folldal Gjenvinning is considered successful as they most often observed an improved quality of supplies from the waste management companies that have been visited. This also illustrates that the networks of actors and close cooperation between various actors, is a key condition for improving the results. For instance, in Norway there are limited recycling capacities for rigid plastics, and the attention on this fraction, both from Plastretur's administration, from Plastretur's Board and from the recyclers has been partial.

A third argument showing the necessity of correct sorting by waste generators is found within household waste. The sorting efficiencies for household waste are very low and the quality of the outflows from the household sorting plants is also generally low. The evident reason for this is the variety of polymers within the household fraction, with for instance laminates, PP, PS, LDPE and EPS, that due to different melt index cannot enter the same extrusion process. This causes shot-downs, which is expensive in itself, and a higher rate of wear on the machineries. (Solem 2004, Calcott and Walls 2005)

The problem, however, is that relatively few waste generators are reached through the Plastretur projects and the effects on the recycling ratio are thus limited. However, illustrative examples will over time provide insight to those not yet converted to a source separation pattern of waste management. For instance, despite the fact that Tine has a high environmental consciousness, a strong focus on cost reduction, is the largest fee payers to Plastretur and there is a strong link between the recycling system they contribute to finance and the waste they are generating, the company did still not start systematic source separation their own waste before year 2000. This illustrates that waste has not been a key cost reduction area for such companies, and that grasping this potential is better done by external influence, for instance from organisations like Plastretur. Making them aware of the cost reduction potential, very often results in a demand for these solutions. This is something that waste management companies must take into account.

As mentioned above, some supermarket chains have seen this potential, and extended their business areas to also include management of their own waste. However, this has disturbed the market model of Plastretur as the supermarket chains do not want to commit themselves to receive plastic packaging waste from other waste generators, or others not being qualified to sign the standard agreement for waste management companies with Plastretur. Thus, on the one side, these actors provide high quality plastic packaging waste to the recyclers, but on the other side, they disturb the market model, making it potentially very expensive for Plastretur if a large number of companies should behave similarly. Thus, a key condition is that those producers paying licence fee also contribute to the EPR system downstream through careful source separation at the point of waste generation.

A final argument for paying attention to the waste generator, is related to the fact that the unit costs for Plastretur has increased the latest years due to the fact that the remaining tonnages and fractions are more demanding to collect than those already being recycled. Giving higher attention to waste generators, either directly or indirectly through the waste management companies or through examples on webpage and publicity in the media, might help to reduce the unit costs.

9.1.2 Broad scope of system cause cost-efficiency

An important key condition is that the Plastretur system has the broadest scope among all European plastic packaging systems (EPRO 2005). By including nearly all the plastic packaging in the market, Plastretur has been in the position to choose from a wide range of products and sectors in order to meet the targets. The strategy of selecting the cheapest fractions first is clearly seen in Figure 7.24 and 7.25. The unit costs for commerce and industry have been considerably lower than the unit costs for the other fractions, and for households in particular. By following this strategy, Plastretur obtained rather quickly growth in the recycling ratio. Moreover, improved knowledge and more efficient solutions cause a drop in the unit cost. The unit cost has risen considerably the latest years, due to the fact that it is now more difficult to collect the remaining tons than the first ton. As mentioned above, it is critical to approach the waste generators in order to reduce the unit costs.

9.1.3 The balancing role of PRO – internally and externally

Evidently, the role of Plastretur is critical to the recycling results that are obtained. The Plastretur system is marked-based, and relies on the cooperation with direct actors in the recycling system in order to reach its targets. There is, however, a thin line between just influencing the market through various measures and interfering the market to the extent that it disturbs market mechanisms. As shown in Chapter 8, a number of direct actors have based their activities on predictable long-term conditions, and altering these will necessarily affect the direct actors. For instance, the subsidising principle of 'net cost coverage' indicates that Plastretur does not reward high quality and good performance beyond the basic quality criteria in the contracts, but rather lift the revenues to a level that makes it interesting to deal with source separation and recycling activities. This is similar to public subsidising policy, but has generated some dissatisfaction among the direct actors, arguing that Plastretur does not reward quality, only quantity.

The logic behind 'net cost coverage' is that the competition between the market actors shall reward quality, for instance so that Folldal Gjenvinning pays more for high quality from Norsk Gjenvinning than from other waste management companies without specific sorting lines. Norsk Gjenvinning argues that they should be free to send the sorted plastic packaging wherever they want. Plastretur then counter argues that Norsk Gjenvinning can do so, but then without any financial support from Plastretur. Hence, this is about who is in command regarding the material and material flows.

Thus, a key condition is that Plastretur balances the various interests of the direct actors with Plastretur's own objectives of reaching the target. In this sense the PRO is similar to the role of central authorities, except from the important fact that Plastretur does not have any legislation supporting its actions, but just a voluntary agreement. For instance, the waste management companies have been critical to the fact that key waste generators like the supermarket chains are part of the Board of Plastretur and make important decisions concerning for instance the structure of the subsidies that necessarily affect the waste management companies as well. The fact that competitor have another influence on the market rules is critical for the legitimacy of the EPR scheme, and establishing and keeping credibility in towards these actors is imperative.

Plastretur has almost entirely focused on the actual waste management system. Combining various instruments, both financial and informational, seems to be a fruitful mix, as discussed above. However, there are tendencies that the financial support from Plastretur to direct actors are taken for granted as a regular income to the operating budget. This is critical as this does not provide any learning effect, according to Giddens, neither related to technology and organisational aspect nor to the basic values and norms. Therefore, in the long run, the efforts should to a greater extent be directed towards information, awareness rising and knowledge creation among the actors along the entire value chain, in order to stimulate the market forces to change accordingly. This role of the PRO being created through an institutional innovation is significant for educating end-of-life actors and for getting financial mechanisms for increased recycling. As for plastic packaging, the margins are incremental and key players in the market do not consider recycling to be economically beneficial for corporates without the financial support from Plastretur, at least within the broad scope of the current covenant. However, this is a discussion of whether the targets in the covenant represent a correct level, but this is beyond the scope of this thesis to debate.

Plastretur has primarily been targeting actors within the waste management system. However, within an industrial ecology perspective, improving the recycling ratio might be obtained through strategies both upstream among the producers and among secondary producers. As for the relation to upstream companies, the Board of Plastretur has decided that Plastretur shall not concentrate on stimulating these companies, unless it contributes directly to increase the recycling ratio and making the target easier achievable. Hence, the signals from downstream actors, both Plastretur and direct actors are weak and counteracts a basic intention of EPR. Interestingly, the seminar held by Plastretur for upstream companies was very welcomed, but was later on not prioritised as the tasks downstream were several and demanding.

NOC and Materialretur are those institutions that mainly interact with upstream companies. The former is primarily focused on design changes up to consumers, but omits the EoL phase and consequently have no effect on the loop closing performance. As for Materialretur, they are not in contact with product designers, but with financial managers and controllers and does, thus, not have any influence on the design process. In sum, there are few, if any, signals from Plastretur towards upstream actors in order to prepare the ground for improved recycling.

On the other side of the waste management system, we find the efforts to influence the demand for recycled material. Except from some early projects on this in 1996, this area has been entirely left out from Plastretur's priority list. During development of the long term strategy for the period 2005 – 2008, carried out in 2003, there was a tangible suggestion that Plastretur should actively contribute to projects with participants from the material recycler all along the value chain towards the consumer of the product that contained recycled plastic packaging.

Although this is something that a company should be able to do, such assistance appears to be helpful. Experiences from Germany, where DKR has a specific role in developing such markets, indicate that this is an important part of the recycling system (Quoden 2004). This includes looking for new markets, also non-packaging, where polymers might substitute materials like glass and metals, as well as virgin polymers. Working actively towards designers to encourage them to include recycled materials is successful. This also creates lots of publicity, which is excellent feedback to those initially sorting and collecting the plastic packaging waste.

This role as a coordinator for actors that previously have not been within the same network is entirely new, and important as seen from an industrial ecology perspective. The argument for doing this is to reduce the risk of having lack of receivers of the recycled material, as the European market is heavily supplied with subsidised recovered plastic packaging. This is considered as a critical part of developing a viable recycling system as it makes the system more demand driven, and not only supply driven as it so far has been. Providing stimuli for the material recyclers within the Plastretur system in order to focus on high quality and stable deliveries, seems to be important, as these issues makes potential customers somewhat hesitant to employ recycled material, particularly in extrusion processes.

The empirical material also points to some organisational issues that are critical for the outcome of the system. First, the relation to local authorities illustrates that the policy framework is not entirely clear as to who is responsible for what. When local authorities demand full cost coverage, this is dramatic for the Plastretur system as such, as it is based on the assumption to collect the tonnage where this is least expensive. The stand point of local authorities is principal, but might have practical consequences since Plastretur depends on collaborative local authorities as they are deciding how the collection system shall look like. Hence, a clear policy framework which defines responsibilities is a key condition.

As for the internal organisational issues, the empirical evidence clearly illustrates that there has been a development over time where the supermarket chains to a larger extent have taken control over the EPR schemes, reducing the roles of the packaging producers and the packers and fillers. One positive aspect of this development is that the market, through the supermarket chains, will put pressure on their suppliers to improve their packaging solutions. This, however, is not necessarily positive for the recycling ratio as optimisation efforts primarily are taken up to the consumer phase and not further down to the waste management system. Another positive aspect of this is that it might increase the supply of high quality plastic packaging waste from retailers and wholesalers. The drawback is that the decisions concerning for instance financial mechanisms to a larger extent will go in the favour of the supermarket chains. They sit on both sides of the table, first by deciding where the licence fees should be spent and then as one great waste generator having expenses when getting rid of their waste. In this sense, they get paid by others to manage their own waste. This might reduce the legitimacy of the EPR system with respect to the waste management companies. Hence, Plastretur has become a mean for corporates to improve their business positions, and not to reach the targets stated in the covenant. This might induce higher costs as decisions are not based on reaching the targets, but to optimise the business opportunities for key actors in the system. The same situation is seen abroad as well, for instance in Germany, where the introduction of external owners to DSD reduced the above-mentioned problem, but at the same time also reduced the ownership of the producers and consequently one key characteristic of EPR.

The trend, however, seems to be that the recycling activities are to a larger extent dealt with by a free market, while the main focus for the PROs is at collection and sorting. For Plastretur as PRO within a relatively small market, the problem to address is whether to sort at home or abroad and whether to recycle at home or abroad. As was evident from Chapter 8, there are particular interests within the Board of Plastretur that mix the upstream and downstream activities. Norfolier, being a member of the Board of Plastretur, owns the largest recycling plant in Scandinavia. Folldal Gjenvinning is a substantial supplier of cheap regranulated material for Norfolier's production in Norway. Thus, the Plastretur system is both a guarantee for the supply of recycled material (although this could be bought abroad) and, most importantly, that their processing plant gets subsidised for carrying out these recycling operations. It can therefore be said that the 'packers and fillers' are financing the operations of Folldal Gjenvinning and Norfolier sits on both sides of the table in this game. This is obviously not an optimal situation. As can be read from the cost estimates in Chapter 8, it would have been much cheaper if the collected plastic packaging was exported and recycled abroad.

If the waste management companies are left to themselves as of how to treat the material, experiences say that a number of companies would find traders in the market that subsequently find actual recyclers. There is then, however, no guarantee that the material is recycled in a proper way.

There are, however, some potential pitfalls related to this analysis. First, if the collected plastic packaging to a greater extent was exported, that might have had negative consequences on the households' interests in doing a good job in sorting and bringing it properly to the container. Second, in the long run this might be far more costly. Thirdly, these particular interests are not necessarily in line with what is best for Plastretur as a company. Plastretur's objectives and targets might therefore be secondary to the Board.

9.1.4 Stronger threat concerning sanctioning

The data shows that several key actors do not consider the targets in the new covenant to be absolute. Interpreting the absoluteness of the target in such a manner, face at least two explanations. First, they put emphasis on the paragraph in the covenant saying that the targets should be socio-economic optimal, and this optimum is subject to alteration depending on development in factors like technology development and general economic growth in the society. This reluctance with respect to the target might cause more modest strategies where the key point is to keep the level of the licence fee rather than to do what is needed in order to reach 30 % material recycling.

The other argument for this position is the lack of consequences if the targets are not reached. First, The Ministry of Environment is generally satisfied with the performance (NMoE 2000, SFT 2004), and the political prestige on this issue is very high. Moreover, the EPR schemes have been running for a decade and have reduced the working load for NMoE considerably (Hambro 2003) and doing changes to the type of policy for achieving certain environmental goals might not be appropriate. In addition, during these years a number of institutions have been established and companies have made investments based on a long-term basis. We might therefore expect that NMoE will be reluctant to terminate the covenant and implement a tax instead. This shows a type of 'policy lock-in' that the plastic packaging chain is able to take into their considerations when deciding strategies for the further development of Plastretur. In sum, the threat from NMoE is in fact not present, which according to experiences from other countries (Clement 1998) and policy literature reduce the effectiveness of the policy.

Another deficiency in the current covenant is the lack of third party verification. This is included in other EPR policies, for instance the WEEE directive. The lack of third party verification leaves the industrial players all by themselves to define the amount of generated waste (which constitute the denominator), as well as the actual recycling data. SFT, the receiver of the annual reports from Plastretur, admits on a general level that they do neither have the capacity nor the knowledge to quality control the numbers given by the PROs. That said, Plastretur has shown a trustworthiness and transparency on this issue so it should be relatively easy to check the numbers. We would nevertheless argue that lack of third party verification is a weakness in the system.

9.2 Key conditions for successful EPR implementation upstream – dematerialisation and design for recycling

9.2.1 Incentives for producers to focus on downstream issues

Another key condition is to create motivation for designing environmentally friendly products. The data shows however that there is a critical lack of such incentives, both from the covenant itself and from Plastretur or other organisations being part of the industrial implementation of EPR.

It is commonly accepted that EPR has the ability to provide incentives for companies to design environmentally friendly products and packages (Lindhqvist and Lifset, 1998). This study finds evidence that for the Norwegian EPR system on plastic packaging there are few, if any, incentives for producers to redesign products and enhance EoL management. We might in fact conclude the other way around. By 'outsourcing' the responsibilities to Plastretur and just pay the licence fee, the upstream companies are stating that they take responsibility without actually changing their behaviours and way of thinking for managing end-of-life issues. Plastretur takes care of that, and appear more as a sleeping pillow for the environmental consciousness. Consequently, the covenant has not created "the tools and power relationships that in turn reinforce and further embed those visions and values in the cultural underpinnings of routine actions" (Ehrenfeld 2000b, p 198)

It confirms that the "[R]esponsibility in the policy world of EPR is understood some form of legal duty, authorised by a legitimate government and enforced by the power of that authority", and "turn out to be merely an elaborate case of business-as-usual – with business doing basically what laws and regulations mandate" (Ehrenfeld 2000b, p 200). If motivation for designing more environmentally friendly products does not emerge from the values and belief (the ethical type of responsibility) external motivation is needed. Looking at the point of governmental intervention, we suggest primary three categories of EPR policies that might contribute to motivate this.

Our data shows that if the targets and commitments are downstream, the signals to upstream producers are weak and should rather be complemented with additional policy instruments that stimulate producers accordingly. This point is supported by for instance van Beukering and Hess (2002) saying that "rather than promoting one particular instrument it is concluded that none of the policy categories is sufficient to 'do the job' alone. It is recognised that an appropriate balance needs to be struck between regulatory, economic and communicative instruments" (p51). This also provides signal to the policy makers (e.g. NMoE) that specific instruments should be implemented targeting upstream actors. This is, however, another argument than Veerman who states that "EPR is not suited for prevention of waste" (Veerman 2001), since, based on our understanding of EPR (ref Figure 3.3), it is just a matter of designing (EPR) policy instruments to make this effective.

Moreover, the line of argument saying that the covenant provides incentives for the producers to innovate products which are better prepared to be recycled[1], does not take into account that the authorities will most probably not induce sanctions because they have put political prestige in this, and because it is impossible to prove that companies are not changing into a design-for-recycling behaviour, and consequently do not reach the targets. Independent of what the producers actually do related to downstream issues they run no risk of being punished, either by the market or by the authorities. Thus, the incentives to focus downstream are non-existing.

Through the case studies in Tine and Plastretur as well as the activities in NOC, we clearly see that the main focus for 'the producers' is related to the upstream phases. NOC defines packaging optimisation as the value chain onwards to the consumer. The case study of Tine obviously indicates that the when designing new products and packaging, the incentives from neither the covenant nor Plastretur is as strong as design aspects like attractiveness, costs, product durability and safety, as well as functionality.

Another argument along this line is that the financial mechanisms set up by Plastretur are not making any difference on the easiness of recycling. Contrary to individual EPR systems where the licence fee usually differentiated (see Tojo 2004, Lindhqvuist and Lifset 2003), a fee based on weight, and not on recyclability, prevents price signals to reach the producers. Cost reductions are one major reason for carrying out design changes, but these do only reduce the costs to licence fee if using less material, and as shown in Figure 8.7 from Tine the cost of licence fee is just 0.4 % of the total packaging costs. Recalling Figure 3.2, the strength of feedback from end-of-life phase back to the producers is too long and too weak, and thus neglectable. Hence, there are weak incentives for "producers to minimise the quantity of materials introduced into commerce and to design for recyclability, re-usability, durability and related objectives in order to minimise their costs." (Lifset 1999, page 2). The incentives for minimising the quantity lie primarily in the purchase of the material and not in the licence fee. Moreover, the incentives for design for EoL is absent as there are no financial risk connected to omitting doing this. A key condition is therefore to add EPR-based policy instruments to address such issues.

Materialretur has a broad interface with upstream companies while Plastretur has their main contacting surface with downstream companies. A consequence of this is that information that Plastretur ideally should have brought to upstream companies related to product optimisation, packaging optimisation and design for recycling has a long way to go. Due to this long feedback loop, the signals from downstream phase to upstream companies are rather weak. Obviously, when Plastretur explains the system for companies and fee payers they better understand it than if just Materialretur does it. In fact, it seems that companies just pay the licence fee and do nothing except from that.

The key condition in this aspect is that there are incentives neither from the covenant nor from Plastretur to the producers to design for recycling. As for the covenant, targets and consequently commitments for the producers on design for recycling could have been posed, but this would probably be difficult to carry out due to ambiguity concerning what and how to measure.

Another option is to alter the financial mechanisms so that there is linearity between licence fee and costs of recycling. In a collective system like the one organised by Plastretur, this would have caused insurmountable administrative costs and resources as the number of various plastic packaging products are in practice unlimited. For instance, in Germany with full cost coverage, the licence fee is ten times higher than in Norway. Another option might have been to differentiate between various groups of plastic packaging, for instance household waste (sales packaging) and industrial waste (transport packaging), but this would not have caused any incentive for the producers to act differently, only that the licence fee for sales packaging would have been higher.

In concluding, the present covenant contribute to an increased recycling ratio, that might be even higher if the PRO focuses more on educating waste generator and creating stronger competition among waste management companies, but it has not contributed significantly to design for recycling activities among upstream producers. This is contrary to existing assumption in the field of EPR.

9.2.2 Incentives to focus on upstream issues

The empirical evidence clearly shows an atmosphere with a mixture of factors and incentives that influence decisions made by the actors. In order to avoid free-riders, a successful action has been to stimulate the wholesalers and retailers to demand that their suppliers are members of Materialretur. This shows that pressure along the value chain is a key condition.

The retailers are also significant in defining how the packaging should be in order to reduce costs. However, as found in the Tine case and supported by Maldum (2003), the role of the covenant in this is of minor importance. That said, developing meeting places, for instance through NOC is increasing the awareness on this.

The increased awareness is, though, just the starting point for actually making changes, because it is first when the real decisions are to be made that the tangible incentives are present. As found in the survey and in the Tine-case, costs, functionality, market pressure, attractiveness and other market-related factors are the most influential ones. The relative cost of the licence fee is marginal compared to the overall packaging costs.

The power of the covenant for design for recycling and dematerialisation is considered to be relatively weak. In Chapter 6 we found a relative dematerialisation connected to consumption and material input, but no absolute dematerialisation. Several argued that the demand for waste reduction counteracts the growth objective of other non-environmental policies. This is a real challenge as the increasing demand for packaging is due to more general development trends in society that involves larger and slower mechanisms that single companies are not able to influence. For instance, the new patterns of living which to a larger extent involve one-person households and people getting older before founding families necessarily provide both higher packaging volumes and packaging intensities (conf. Figure 8.6). Thus, EPR policies are, isolated speaking, not able to reduce the absolute numbers of packaging volume, and measuring this should be based on relative numbers. In order to obtain a larger degree of relative waste reduction, there is a need for combining the core EPR policy with other policies, entering into an integrated product policy.

Our data shows that there is a weak causality between dematerialisation efforts and the covenant. This runs contrary to the existing literature. This usually shows the correlation between these two parameters, but not the causality. For instance, Lindhqvist employs Clement (1998) for arguing that "an effect of the Dutch Packaging covenant of 1991 was a drastic improvement of the overall environmental impact of packaging and a lot of innovations" (Lindhqvist 2000, p 107). However, Clement (1998) does not *show* the causality between the covenant and innovations. Based on our data, we will draw the conclusion that there are other far more influencing factors that have contributed to the observed changes in packaging design, for instance cost reduction due to increased competition. That said, it is the way the policy instrument is designed and not EPR as a policy principle that is our key message. We consequently propose an IPP approach based on the EPR policy principle.

As mentioned above, NOC's program for improved competence focuses on practical, economical and environmental improvements throughout the value chain *from producer to consumer* [author's italic]. This statement shows that the focus is not on the entire life cycle. The covenant aims at certain recycling targets and packaging optimisation. These targets are in one way or another said to be fulfilled since the recovery ratio increases and there are many examples of packaging optimisation (NOC 2002, 2003, 2004) However, the link between this optimisation and the recycling activities are missing. No actions are taken to make it easier for the recycling chain to increase recycling ratios, and no actions are taken to link the recycling activities with innovation upstream in order to increase the market pull for recycled material. We might ask who should be responsible for establishing this missing link; Plastretur, NOC or other parts of the society, for instance Ministry of Trade and Industry. It is nevertheless a need for an integrated product policy based on an EPR policy principle in order to obtain this. Waste minimisation and packaging optimisation must be commenced through outer, stronger policy instruments than covenants.

9.3 Conclusion

As we have seen there are several key conditions to be identified. The overall key condition seems however to be to strengthen the link between the upstream and downstream activities. The main problem seems to be lack of incentives for the producers to design for recycling. This is confirmed by the survey and by the Tine-case. In order to obtain this, there is a need for harmonising the policy instruments throughout the life cycle, so that the producers also get into design for recycling. As shown by Tojo (2004), the incentives for this are stronger in individual systems. As for packaging it is virtually impossible to establish individual systems as the plastic packaging entering the market is subject to diffusion throughout the country and mix up with plastic packaging from other producers, as well as with other packaging materials.

Those arguing that EPR is radical because it can stimulate and force actors to behave responsibly apparently overestimate the power of EPR policies to induce changes. It is the instruments, not the concept itself that induce changes, if considering that the understanding of responsibility has penetrated into the values and beliefs department. Our empirical evidence shows that it has not. Interestingly, however, is that within organisations it seems to be common understanding of how well they are doing in the environmental realm. But when it comes to what they actually do, they are far behind what could be expected.

(Endnotes)

[1] 'EPR challenges not only a firm's tools and authorities, but also its values and beliefs. They force designers and planners to consider issues left out if the customary focus on cost and performance. And they open the firm up to new relationships with its suppliers, distributors, customers and waste managers.' (Ehrenfeld in Fishbein, p224).

10. CONCLUSIONS

The purpose of this thesis was to identify key conditions for successful industrial implementation of collective EPR programmes in the Norwegian plastic packaging system, according to an industrial ecology perspective. Key condition was defined as those factors, both drivers and barriers, which are critical for the outcome of industrial implementation of EPR. As we have seen there are several key conditions to be identified. We have studied this by first developing a theoretical framework based on the industrial ecology perspective and combined with a modified understanding on categories for EPR policy instruments we have developed an analytical framework which combines a material flow approach and an actor approach. Based on this we have carried out a case study of the Norwegian EPR system for plastic packaging, organised by Plastretur. We have shown the complexity of this system by doing analysis on various levels, both with respect to material flows and to actors. Our conclusions are primarily valid for this system only, but we have shown how our results correspond to existing literature, both theoretically and in practice. Below we will first sum up the key conditions. Then we will clarify our scientific contributions as well as suggestions for further work on this topic.

10.1 Key conditions

The overall conclusion from this case study is that the Plastretur EPR scheme has proven to be successful with respect to recycling ratios and costs, while it has been less successful concerning dematerialisation and design for recycling. This conclusion is contrary to what is considered to be the strength of EPR policies, but it provides empirical evidence for the arguments put forth by Veerman (2004) on the Dutch system, claiming that EPR has mainly effects downstream. We argue that one of the reasons to this controversial result is that previous studies have not to a sufficient extent taken into account the need for identifying the causality between EPR policy instruments and the observed effects. We have provided this through a detailed case study on various analytical levels.

10.1.1 Successful implementation downstream – loop closing

The key condition concerning loop closing was identified to be *the need for correct sorting by waste generators*. This is valid particular in small countries like Norway where the volumes are limited which do not invite to substantial technological innovations and investments. Being preventive by sorting correctly at the point of waste generation is in line with an industrial ecology way of thinking. In order to sort correctly, the waste generators need *direct information and guidance* both from the PROs and from the waste management companies. Identifying the highest improvement potentials is preferably done by *employing a material flow approach*.

Another key condition is to have *a broad scope of the system* in order to obtain cost efficiency. If so, the cheapest fractions can be selected first and through this gaining experience on how to deal with the more expensive parts.

The role of the PRO is obviously of key importance. Our main finding is that the *PRO executes a balancing role* in order to influence the direct actors so that they contribute to the objectives of the PRO. This includes for instance that the PRO interacts with the market in a way that the interests of the various direct actors are taken into account when developing strategies and measures. Moreover, it implies that measures should be taken towards both primary and secondary upstream companies in order to create a pressure throughout the life cycle. *Lack of life cycle orientation* is identified as a barrier to establishing sufficient feedback mechanisms between downstream and upstream actors. This includes coordination of actors that are not within the same network, for instance potential users of recycled material.

As seen from the Ministry of Environment point of view, there is a need for a *clear policy framework* with defined responsibilities, for instance the relationship between local authorities and the EPR schemes. For instance, lack of technological investments in the recycling systems might be counteracted by central authorities providing additional policy instruments to stimulate this. That said, another part of the role of the central authorities is the sanctioning mechanism if targets are not met. A barrier to successful implementation is *lack of sanctions*.

10.1.2 Successful implementation upstream – dematerialisation and design for recycling

Our empirical data shows that the covenant does not seem to contribute the way it was meant. Among the main barriers is that *it does not provide significant incentives* for producers to take aspects of design for recycling or dematerialisation into account. The main explanation to this is that other factors are more significant to the companies in general and the product designers in particular. EPR for a majority of the upstream companies *remains basically a matter of licence fee payment*. In order to increase the awareness of the producer responsibility, wider group of interests and shareholders in PRO might be appropriate. In the current Plastretur EPR system, most of the 1800 licence fee payers are not involved in the system except from paying the fee.

In order to *strengthen the link between downstream actors and upstream actors*, the PROs should play a larger role through communication and guidance to upstream actors. Then the signals and requirements from actors in the recovery system might come through. As for the Plastretur, they have *become a sleeping pillow* for the upstream companies, which argue that the waste management is taken care of by the PRO and consequently that they do not have to think about it.

Overall, in order to achieve the objectives stated theoretically within EPR literature, there is a need for combining core EPR-policies with other types of policies so that it becomes an *integrated product policy with incentives and pressures throughout the life cycle*. This should be carried out both from the central authorities' point of view and from the PRO's point of view.

10.2 Scientific contributions

10.2.1 Theoretical contributions

This thesis contributes theoretically primarily in two directions. First, we have suggested a theoretical framework for industrial ecology consisting of three perspectives: i) the resource perspective, ii) the networks of actors' perspective and iii) the systems perspective. This framework contributes to develop the analytical frame work employed in this thesis. The theoretical framework is developed in order to take into account the roles and interests of actors when studying industrial economic systems. The case study in this thesis shows that this is significant for understanding the system and the mechanisms causing changes. The distinction between direct and indirect actors provides useful insight to distinguish between how various actors influence the system. However, this is just a staring point and empirical studies must be conducted in order to discover the actual influence.

The second major theoretical contribution is considered to be the categorisation of EPR policy instruments for understanding how the incentives inherent in these instruments influence the producers. It is argued that if the producers' commitments are not within their core domain, the feedback mechanisms to product design (design for environment) are weak. Thus, in order to provide incentives for design changes that will reduce the environmental impact other places in the life cycle, EPR policy instruments should be targeted within their core domain. An example of this is the RoHS directive. Phrased differently, the assumption that EPR stimulate actors to behave responsibly, apparently overestimates the power of EPR to induce changes. That said, it is the policy instruments, and not the concept itself, that induce changes, and careful attention should be given to the design of these EPR policy instruments in an integrated product policy framework.

10.2.2 Methodological contributions

This thesis contributes methodologically by providing an analytical framework for studying industrial economic systems. Combining the material flow approach and actor analysis represents two important aspect of industrial ecology: the resource perspective and the network of actors' perspective with its actors with various interests. By doing this, we are able to better understand the development of material flows and the reasons for why they have become the way they have. This thesis has shown how this analytical framework can be applied. Basic to this analytical approach is that understanding a system demands knowledge on mechanisms, not only output indicators, although this is a very good starting point for the analysis. However, if time and resources are scares, the proposed analytical framework suggest to start with an overall picture of the system and move into 'the black box' as the need for further explanations on the observed developments arise. Also, by combining material flows and monetary flows, the mechanisms within the system become more evident.

10.3 Further work

The most obvious suggestion to further studies in this area is to carry out comparative studies, preferably by using the same analytical framework, on other EPR systems. First, the Dutch covenant system could be investigated as it seems to face some of the same development trends. Second, other plastic packaging systems in the EU might be studied, preferable with as many parameters as possible similar to the Plastretur EPR system, in order to be able to control for these variables. Moreover, comparative studies can be done on more differentiating systems as well, for instance comparing individual EPR schemes with collective EPR schemes.

On the methodological side, studies are encouraged to be carried out by employing the matrix calculations, in order to more easy identify the losses from waste generators towards the recyclers.

Moreover, this thesis does only to a limited extent discuss the material qualities within the recycling systems. Hence, combining the quantitative and the qualitative aspects of the material flows within recycling systems like this would provide an even better insight to the performance of the recycling systems.

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APPENDIX A: LIST OF ABBREVIATIONS

CFC –	Chlorofluorocarbon
CfSD –	Centre for Sustainable Development
DfE –	Design for Environment
DKR –	Die Deutsche Gesellschaft für Kunststoff-Recycling mbH
DMF -	Norwegian industrial environmental association for wholesalers and retailers
DMI –	Direct material input
DNE –	Norwegian Packaging Association
DSD –	Duales System Deutschland
EE –	Electrical and electronic
EEE –	Electrical and electronic equipment
EoL –	End-of-life
EPP –	Environmental Product Policy
EPR –	Extended Producer Responsibility
EPRO –	European Association of Plastics Recycling and Recovery Organisation
EPS –	Expanded polystyrene
ERA –	Environmental risk assessment
GATT –	General Agreement on Tariffs and Trade
GDP –	Gross domestic product
HDPE –	High density poly-ethylene
HSH –	Handelens og Servicenæringens Hovedorganisasjon [Association for trade and service industry]
IOA –	Input/ output analysis
IPP –	Integrated product policy
LCA –	Life cycle assessments
LCC –	Life cycle costs

LDPE – Low density poly-ethylene

LLDPE – Linear low density poly-ethylene

MFA – Material Flow Accounting

MIPS – Material Input pr Service

MMI – Markeds- og Mediainstituttet [The Norwegian Institute for Market and Media]

NACE – Classification of Economic Activities in the European Community

NGO – Non Governmental Organisations

NHO Næringslivets Hovedorganisasjon [Confederation of Norwegian Enterprises]

NOC – The Industrial Packaging Optimization Committee

NOK – Norwegian kroner (currency)

NMoE – Norwegian Ministry of Environment

NR – Norsk Returkartong

NTNU – Norwegian University of Science and Technology

PBB – Poly-brominated biphenyls

PBDE – Poly-brominated diphenyl ethers

PET – Poly-ethylene terephthalate

PP – Poly-propylene

PP – Plastic packaging

PPP – Polluter Pays Principle

PRN – Packaging waste recovery notes

PRO – Producer Responsibility Organisations

PS – Polystyrene

PVC – Polyvinylchloride

R & D – Research and Development

RoHS – Restrictions of the Use of Certain Hazardous Substances

SFA – Substance Flow Analysis

SFT – Norwegian Pollution Control Authority

SSB – Statistics Norway

STØ – Stiftelsen Østfoldforskning

TCI – Technological change and innovation

TMR – Total Material Requirement

TM – Tine Meierier

TNM – Tine Norske Meierier

TNM FoU – Tine Norske Meierier Research and Development

UN – United Nations

WBCSD – World Business Council for Sustainable Development

WEEE – Waste electrical and electronic equipment

WMC – Waste Management Company

WTO – World Trade Organisation

APPENDIX B: LIST OF INTERVIEWEES

This list of interviewees includes those interviewed in the two main organisations that have been subject to investigation in this thesis; Tine and Plastretur. Some persons in Plastretur have been interviewed several times, particularly during the periods of participating observation in June 2002, June – August 2003 and August 2004, and this is noted accordingly.

In addition to those mentioned below, a number of interviews (>20) have been conducted with single companies along the life cycle, and those directly employed in the thesis, is referred in the reference list, under the heading 'personal communication'.

Interviewees in the Tine case

Ove Johansen	market director	Tine R&D	27 September 2001
			3 October 2001
			20 September 2002
Marit Sverdrup	Leader of Tine Market Dept.	Tine Market	2 October 2001
Edel Nagle	Packaging responsible	Tine Market	2 October 2001
Aage Kvande	sales and marketing manager	Tine Midt-Norge	23 April 2002
Stein Aasgaard	managing director	Tine Midt-Norge	26 April 2002
Per-Odd Lyngås	quality manager	Tine Midt-Norge	26 april 2002
Ola Mogstad	communication manager	Tine Midt-Norge	23 april 2002
Inger Lise Sætra	advisor	Tine R&D	19 September 2002
Merete Høraas Eide	environmental advisor	Tine R & D	1 October 2001
Janne Iren Dalberg	product developer	Tine R & D	1 October 2001
Eirik Selmer-Olsen	researcher ingredients	Tine R & D	4 October 2001
			19 September 2002
Hanne Refsholt	director R & D	Tine R & D	3 October 2001
			15 October 2002
Sonja Iversen	leader	Tine Personnel & Competence	14 October 2002
Ragnar T. Solgaard	leader of packaging dept.	Tine R & D	28 September 2001

			2 October 2001
Iver Sylte	manager	Tine Midt-Norge	22 April 2002
Bjørn Tho	purchasing manager	Tine Øst/Tine	5 October 2001
Aage Jacobsen	leader labour union	Tine	3 October 2001

Interviewees in the Plastretur organisation

Peter Sundt	managing director	Plastretur	several dates in 2002-05
Geir Schefte	technical director	Plastretur	several dates in 2002-05
Per Gjester	sales director	Plastretur	several dates in 2002-05
Edgar Skjervold	financial director	Plastretur	several dates in 2002-05
Eirik Oland	information director	Plastretur	13 June 2002
Gerd-Oddveig Braaten	region manager	Plastretur	14 June 2002
Asbjørn Bratterud	region manager	Pøastretur	13 June 2002
Dag Aursland	region manager	Plastretur	12 June 2002
Kjell Olav Maldum	board member	Plastretur	1 and 12 December 2003
Steinar Skilhagen	chairman of the board	Plastretur	5 August 2002

APPENDIX C: DATA FROM THE PLASTRETUR CASE

APPENDIX C1: DENOMINATOR FOR THE PLASTRETUR SYSTEM 1995 - 2004

DENOMINATOR	Commerce and industry									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Film	25 125	25 150	25 800	27 100	28 050	29 250	30 750	31 450	32 100	32 500
PP-bags	1 700	1 700	1 700	1 830	1 700	1 700	1 600	1 600	1 600	1 600
Rigid packaging	8 900	8 900	9 200	9 800	10 250	10 800	11 500	11 800	12 100	12 300
Feedstock recycling										
Reuse	3 900	3 900	3 800	3 745	3 700	3 200	2 700	2 200	1 700	1 200
SUM DENOMINATOR	39 625	39 650	40 500	42 475	43 700	44 950	46 550	47 050	47 500	47 600

DENOMINATOR	Agriculture									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Film	5 000	5 100	5 200	5 564	5 750	6 000	6 300	6 600	6 950	7 200
PP-bags	1 250	1 200	1 200	1 156	1 100	1 050	1 000	970	930	900
Rigid packaging	650	630	600	578	520	480	440	400	350	300
Feedstock recycling										
Reuse										
SUM DENOMINATOR	6 900	6 930	7 000	7 298	7 370	7 530	7 740	7 970	8 230	8 400

DENOMINATOR	Aquaculture									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Film	1 450	1 450	1 400	1 391	1 200	900	600	300	0	0
PP-bags	1 700	1 730	1 750	1 782	1 800	1 840	1 880	1 920	1 960	2 000
Rigid packaging										
Feedstock recycling										
Reuse										
SUM DENOMINATOR	3 150	3 180	3 150	3 173	3 000	2 740	2 480	2 220	1 960	2 000

DENOMINATOR	Households									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Film	25 100	25 200	26 400	29 000	30 800	33 150	36 150	37 500	38 750	39 550
PP-bags	-	-	-	48	-	-	-	-	0	0
Rigid packaging	15 730	15 750	16 350	17 550	18 450	19 550	20 950	20 600	21 200	21 550
Feedstock recycling			-							
Reuse									0	
SUM DENOMINATOR	40 830	40 950	42 750	46 598	49 250	52 700	57 100	58 100	59 950	61 100

DENOMINATOR	TOTAL SUM									
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Film	56 675	56 900	58 800	63 055	65 800	69 300	73 800	75 850	77 800	79 250
PP-bags	4 650	4 630	4 650	4 816	4 600	4 590	4 480	4 490	4 490	4 500
Rigid packaging	25 280	25 280	26 150	27 928	29 220	30 830	32 890	32 800	33 650	34 150
Feedstock recycling	0	0	0	0	0	0	0	0	0	0
Reuse	3 900	3 900	3 800	3 745	3 700	3 200	2 700	2 200	1 700	1 200
SUM DENOMINATOR	90 505	90 710	93 400	99 544	103 320	107 920	113 870	115 340	117 640	119 100

APPENDIX C2: COLLECTION DATA

Collection data provided by Skjervold (2003, 2005) and Skjefte (2005)

All numbers in tons	COLLECTION																	
	Commerce and industry									Agriculture								
	1996	1997	1998	1999	2000	2001	2002	2003	2004	1996	1997	1998	1999	2000	2001	2002	2003	2004
Film	2 979	2 530	6 800	6 607	7 190	6 400	8 000	9 200	9 900	2 728	923	3 450	4 440	5 910	4 300	4 700	5 700	7 000
PP-bags		71	620	1 180	390	300	600	700	900			10	20	10	200	200	200	300
Rigid packaging		205	210	408	440	300	400	300	500				-	-			100	
Feedstock recycling									100									
Reuse	2 100	2 212	3 890	5 560	5 930	4 400	3 500	2 700	2 000									
SUM COLLECTED to material recycling	**5 079**	**5 018**	**11 520**	**13 754**	**13 950**	**11 400**	**12 500**	**12 900**	**13 400**	**2 728**	**923**	**3 460**	**4 460**	**5 920**	**4 500**	**4 900**	**6 000**	**7 300**
Source separated to energy recovery		1 920	1 990	5 670	7 070	4 500	4 200	3 600	3 800			140	110	80	600	1 000	600	0
SUM source sep to energy recovery		**6 938**	**13 510**	**19 424**	**21 020**	**15 900**	**16 700**	**16 500**	**17 200**	**2 728**	**923**	**3 600**	**4 570**	**6 000**	**5 100**	**5 900**	**6 600**	**7 300**
Plastic packaging in residual waste						11 300	14 200	26 200	20 400									
SUM COLLECTED	**-**	**6 938**	**13 510**	**19 424**	**21 020**	**27 200**	**30 900**	**42 700**	**37 600**	**2 728**	**923**	**3 600**	**4 570**	**6 000**	**5 100**	**5 900**	**6 600**	**7 300**

All numbers in tons	COLLECTION																	
	Aquaculture									Households								
	1 996	1 997	1 998	1 999	2 000	2 001	2 002	2 003	2 004	1 996	1 997	1 998	1 999	2 000	2 001	2 002	2 003	2 004
Film		0	720	690	390	200	100				0	130	60	390	400	600	800	900
PP-bags		0	190	1 140	1 670	2 100	2 300	2 400	2 400		0							
Rigid packaging		0	0	0	0			0			0	200	120	140	100	200	300	300
Feedstock recycling		0									0					40	2 000	4 000
Reuse																		
SUM COLLECTED to material recycling	**0**	**0**	**910**	**1 830**	**2 060**	**2 300**	**2 400**	**2 400**	**2 400**	**0**	**0**	**330**	**180**	**530**	**500**	**820**	**3 100**	**5 200**
Source separated to energy recovery						200	200					2 030	5 820	4 700	2 400	3 000	1 500	500
SUM source sep to energy recovery	**0**	**0**	**910**	**1 830**	**2 060**	**2 500**	**2 600**	**2 400**	**2 400**	**0**	**0**	**2 360**	**6 000**	**5 230**	**2 900**	**3 820**	**4 600**	**5 700**
Plastic packaging in residual waste											34 220	30 200	37 270	43 520	43 400	39 400	33 400	43 600
SUM COLLECTED	**0**	**0**	**910**	**1 830**	**2 060**	**2 500**	**2 600**	**2 400**	**2 400**	**0**	**34 220**	**32 560**	**43 270**	**48 750**	**46 300**	**43 220**	**38 000**	**49 300**

All numbers in tons	SUM COLLECTION								
	1 996	1 997	1 998	1 999	2 000	2 001	2 002	2 003	2 004
Film	5 707	3 453	11 100	11 797	13 880	11 300	13 400	15 700	17 800
PP-bags	0	71	820	2 340	2 070	2 600	3 100	3 300	3 600
Rigid packaging	0	205	410	528	580	400	600	700	800
Feedstock recycling			0	0	0	0	40	2 000	4 100
Reuse	2 100	2 212	3 890	5 560	5 930	4 400	3 500	2 700	2 000
SUM COLLECTED to material recycling	**7 807**	**5 941**	**16 220**	**20 224**	**22 460**	**18 700**	**20 640**	**24 400**	**28 300**
Source separated to energy recovery	0	1 920	4 160	11 600	11 850	7 700	8 400	5 700	4 300
SUM source sep to energy recovery	**7 807**	**7 931**	**20 380**	**31 824**	**34 310**	**26 400**	**29 040**	**30 100**	**32 600**
Plastic packaging in residual waste	0	34 220	30 200	37 270	43 520	54 700	53 600	59 600	64 000
SUM COLLECTED	**7 807**	**42 151**	**50 580**	**69 094**	**77 830**	**81 100**	**82 640**	**89 700**	**96 600**

TABLE C2: RECYCLING DATA

Recycling data provided by Skjervold (2003, 2005) and Skjefte (2005)

All numbers in tons	RECYCLING																	
	Commerce and industry									Agriculture								
	1996	1997	1998	1999	2000	2001	2002	2003	2004	1996	1997	1998	1999	2000	2001	2002	2003	2004
Film	2 650	2 530	6 800	6 607	4 580	9 100	8 400	9 500	9 000	1 080	923	2 830	4 970	4 470	3 200	5 000	6 400	5 400
PP-bags		71	620	1 180	350	400	400	800	900			10	20	20	100	200	300	300
Rigid packaging		205	210	408	400	200	300	400	600				-	-		100	100	0
Feedstock recycling									100									
Reuse	1 910	2 212	3 890	5 560	5 930	4 400	3 500	2 700	2 000									
SUM material recycling	**4 560**	**5 018**	**11 520**	**13 754**	**11 260**	**14 100**	**12 600**	**13 400**	**12 600**	**1 080**	**923**	**2 840**	**4 990**	**4 490**	**3 300**	**5 300**	**6 800**	**5 700**
Source separated to energy recovery		1 920	3 060	7 240	7 800	4 900	3 800	4 600	3 800			550	520	420	300	1 100	200	0
Sum energy recovered source separated	**4 560**	**6 938**	**14 580**	**20 994**	**19 060**	**19 000**	**16 400**	**18 000**	**16 400**	**1 080**	**923**	**3 390**	**5 510**	**4 910**	**3 600**	**6 400**	**7 000**	**5 700**
Energy rcovered in residual waste						11 300	14 200	26 200	20 400									
SUM RECOVERED	**4 560**	**6 938**	**14 580**	**20 994**	**19 060**	**30 300**	**30 600**	**44 200**	**36 800**	**1 080**	**923**	**3 390**	**5 510**	**4 910**	**3 600**	**6 400**	**7 000**	**5 700**

All numbers in tons	RECYCLING																	
	Aquaculture									Households								
	1 996	1 997	1 998	1 999	2 000	2 001	2 002	2 003	2 004	1 996	1 997	1 998	1 999	2 000	2 001	2 002	2 003	2 004
Film		61	720	690	390	200	100	0	0	0	24	130	60	390	400	400	700	1 000
PP-bags	90	30	190	1 140	1 670	2 100	2 300	2 500	2 000		0						0	
Rigid packaging		0	0	0	0			0		120	57	200	120	140	100	100	300	300
Feedstock recycling		0								0	0	0	0	0	0	40	2 000	4 000
Reuse																	0	
SUM material recycling	**90**	**91**	**910**	**1 830**	**2 060**	**2 300**	**2 400**	**2 500**	**2 000**	**120**	**81**	**330**	**180**	**530**	**500**	**540**	**3 000**	**5 300**
Source separated to energy recovery						200	200	100	0			2 030	5 820	4 700	1 800	3 500	1 900	500
Sum energy recovered source separated	**90**	**91**	**910**	**1 830**	**2 060**	**2 500**	**2 600**	**2 600**	**2 000**	**120**	**81**	**2 360**	**6 000**	**5 230**	**2 300**	**4 040**	**4 900**	**5 800**
Energy rcovered in residual waste											34 220	30 200	37 270	43 520	43 400	39 400	33 400	43 600
SUM RECOVERED	**90**	**91**	**910**	**1 830**	**2 060**	**2 500**	**2 600**	**2 600**	**2 000**	**120**	**34 301**	**32 560**	**43 270**	**48 750**	**45 700**	**43 440**	**38 300**	**49 400**

All numbers in tons	SUM RECYCLING								
	1 996	1 997	1 998	1 999	2 000	2 001	2 002	2 003	2 004
Film	3 730	3 538	10 480	12 327	9 830	12 900	13 900	16 600	15 400
PP-bags	90	101	820	2 340	2 040	2 600	2 900	3 600	3 200
Rigid packaging	120	262	410	528	540	300	500	800	900
Feedstock recycling	0	0	0	0	0	0	40	2 000	4 100
Reuse	1 910	2 212	3 890	5 560	5 930	4 400	3 500	2 700	2 000
SUM material recycling	**5 850**	**6 113**	**15 600**	**20 754**	**18 340**	**20 200**	**20 840**	**25 700**	**25 600**
Source separated to energy recovery	0	1 920	5 640	13 580	12 920	7 200	8 600	6 800	4 300
Sum energy recovered source separated	**5 850**	**8 033**	**21 240**	**34 334**	**31 260**	**27 400**	**29 440**	**32 500**	**29 900**
Energy rcovered in residual waste	0	34 220	30 200	37 270	43 520	54 700	53 600	59 600	64 000
SUM RECOVERED	**5 850**	**42 253**	**51 440**	**71 604**	**74 780**	**82 100**	**83 040**	**92 100**	**93 900**

TABLE C2: COSTS FOR PLASTRETUR 1996 - 2004

Data provided by Skjervold (2003, 2005)

COSTS	1996	1997	1998	1999	2000	2001	2002	2003	2004
Collection and sorting [1000 NOK]	1 792	7 759	13 876	21 359	28 545	38 482	42 419	48 164	59 496
Transport and storing [1000 NOK]	0	0	0	0	0	606	11 537	19 438	15 837
Material recycling [1000 NOK]	800	12 766	19 555	27 496	15 111	11 812	13 959	23 404	25 911
Energy recovery [1000 NOK]	160	671	1 390	1 871	1 953	2 996	8 170	4 589	2 589
Other operating costs [1000 NOK]	448	755	2 810	3 795	4 669	10 465	-317	933	-904
Net total operating costs [1000 NOK]	3 200	21 951	37 631	54 521	50 278	64 361	75 768	96 528	102 929
Fixed costs [1000 NOK]	2 655	16 081	17 656	19 970	27 973	35 654	29 050	28 518	30 375
Total costs [1000 NOK]	5 855	38 032	55 287	74 491	78 251	100 015	104 818	125 046	133 304

RECYCLING RESULTS	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mechanical recycling [tons]	5 850	6 113	15 600	20 754	18 340	20 200	20 820	23 700	21 500
Feedstock recycling [tons]		0	0	0	0	0	20	2 000	4 100
Chemical recycling [tons]									
Total material recycling [tons]	5 850	6 113	15 600	20 754	18 340	20 200	20 840	25 700	25 600
Blast furnace [tons]									
Reduction medium [tons]									
Incineration with energy recovery [tons]	26 180	36 140	35 840	50 850	56 440	61 900	62 200	66 400	68 300
Total energy recovery [tons]	26 180	36 140	35 840	50 850	56 440	61 900	62 200	66 400	68 300
Total recovery [tons]	32 030	42 253	51 440	71 604	74 780	82 100	83 040	92 100	93 900

INDICATORS	1996	1997	1998	1999	2000	2001	2002	2003	2004
Total costs/ material recovered [NOK/ton], indexed 2004	183	1 158	1 390	1 276	1 118	1 288	1 354	1 424	1 420
Total costs/ material recycled [NOK/ton]	1 001	8 001	4 582	4 404	4 557	5 233	5 397	5 104	5 207
Operating costs/ material recovered [NOK/ton]	100	668	946	934	718	829	979	1 099	1 096
Operating costs/ material recycled [NOK/ton]	547	4 618	3 119	3 223	2 928	3 368	3 901	3 940	4 021
Operating mat. recycling costs/ material recycled [NOK/tc	520	3 481	2 323	2 537	2 635	3 038	3 244	3 577	3 920
Licence fee [NOK/kg]	1,00	1,00	1,00	1,48	1,70	1,70	1,50	1,40	1,40
Total amount generated waste [tons]	90 710	93 400	99 544	103 320	107 920	113 870	115 340	117 640	119 100

INCOME	1996	1997	1998	1999	2000	2001	2002	2003	2004
Licence fee [1000 NOK]	23 000	36 206	61 726	84 738	76 993	96 820	102 806	120 974	121 221
Financial interests [1000 NOK]				1 481	1 237	3 195	960	4 013	293
Sales [1000 NOK]					0	0	0	0	0
Others					22		1 052	68	186
Total income [1000 NOK]	23 000	36 206	61 726	86 219	78 252	100 015	104 818	125 055	121 700
Result [1000 NOK]	17 145	-1 826	6 439	11 728	1	0	0	9	-11 604
Potential income [1000 NOK]	90 710	93 400	99 544	152 914	183 464	193 579	173 010	164 696	166 740
Coverage [%]	25,4	38,8	62,0	55,4	42,0	50,0	59,4	73,5	72,7
GROSS DOMESTIC PRODUCT (GDP)	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
GDP [mill NOK] running values	1 026 924	1 111 349	1 132 134	1 233 039	1 469 075	1 526 233	1 519 131	1 561 915	1 685 552
Plastic packaging consumed/GDP [kg/mill NOK]	90,4	85,9	94,5	90,2	78,8	78,9	70,4	78,1	75,3
Material recovered/GDP [kg/mill NOK]	31,2	38,0	45,4	58,1	50,9	53,8	54,7	59,0	55,7
Material recycled/GDP [kg/mill NOK]	5,7	5,5	13,8	16,8	12,5	13,2	13,7	16,5	15,2
From SSB (Snesrud 2005)	5,3	5,2	2,6	2,1	2,8	2,7	1,4	0,4	3,3
Volume changes	5,3	5,2	2,6	2,1	2,8	2,7	1,1	0,4	2,9
Inflation	4,1	2,9	-0,7	6,6	15,9	1,1	-1,6	2,4	4,9
Sum	9,4	8,1	1,9	8,7	18,7	3,8	-0,5	2,8	7,8
Calculated		8,2	1,9	8,9	19,1	3,9	-0,5	2,8	7,9
GDP with volume changes for selected sectors [%]	7,1	8,9	5,9	5,1	5,6	3,6	2,8	1,9	4,1
GDP with volume changes for selected sector [mill NOK]	303 905	330 830	350 241	367 991	388 460	402 320	413 719	421 637	439 131
GDP indexed at 1996	1 026 924	1 080 324	1 107 024	1 128 589	1 157 343	1 185 070	1 196 366	1 200 474	1 230 255
Plastic packaging consumed/GDP total [kg/mill NOK]		88,4	96,7	98,6	100,0	101,6	89,4	101,6	103,1
Plastic packaging consumed/GDP selected[kg/mill NOK]		288,7	305,5	302,4	297,9	299,2	258,6	289,3	288,9
Material recovered/GDP [kg/mill NOK]		39,1	46,5	63,4	64,6	69,3	69,4	76,7	76,3
Material recycled/GDP [kg/mill NOK]		5,7	14,1	18,4	15,8	17,0	17,4	21,4	20,8
Population in Norway 31 December	4 370 000	4 405 000	4 445 000	4 478 000	4 503 000	4 524 000	4 552 000	4 577 000	4 606 000
Plastic packaging consumed/cap [kg/inh]	21,2	21,7	24,1	24,9	25,7	26,6	23,5	26,7	27,5
Material recovered/cap [kg/inh]	7,3	9,6	11,6	16,0	16,6	18,1	18,2	20,1	20,4
Material recycled/cap [kg/inh]	1,3	1,4	3,5	4,6	4,1	4,5	4,6	5,6	5,6
Plastic packaging consumed/cap*GDP [g/mill NOK]	20,7	20,1	21,7	22,0	22,2	22,5	19,6	22,2	22,4
Material recovered/cap*GDP [g/mill NOK]	7,1	8,9	10,5	14,2	14,3	15,3	15,2	16,8	16,6
Material recycled/cap*GDP [kg/mill NOK]	1,3	1,3	3,2	4,1	3,5	3,8	3,8	4,7	4,5

APPENDIX D: SURVEY ON TECHNOLOGICAL CHANGE AND INNOVATION IN PLASTIC PACKAGING SECTOR

Question 1: Your organisation is

	Frequency	Percent
A Norwegian producer og plastics or plastic packaging	15	16,1
A Norwegian user of plastic packaging (packer&filler)	26	28,0
A wholesaler or retailer in Norwegian tertiary sector	8	8,6
A industrial organisation or PRO	2	2,2
A waste management company	26	28,0
A sorting or waste treatment company	5	5,4
A recycler company	4	4,3
An importer of plastic packaging	7	7,5
Total	93	100,0

Type of organisation

	Frequency	Percent
upstream	56	60,2
downstream	35	37,6
other	2	2,2
Total	93	100,0

Question 2: What type of plastic packaging are you involved in?

			Type of plastic packaging			Total
			Sales/inner packaging	Transport or industrial packaging	Both types	
Typeorg	upstream	Count	11	9	36	56
		% within Typeorg	19,6%	16,1%	64,3%	100,0%
	downstream	Count	11	9	15	35
		% within Typeorg	31,4%	25,7%	42,9%	100,0%
	other	Count	0	0	2	2
		% within Typeorg	,0%	,0%	100,0%	100,0%
Total		Count	22	18	53	93
		% within Typeorg	23,7%	19,4%	57,0%	100,0%

Question 3: What are the most important environmental problems caused by 'your' plastic packaging/process the latest 10 years?

Typeorg * Increased amount of waste Crosstabulation

			Increased amount of waste		Total
			No	Yes	
Typeorg	upstream	Count	24	32	56
		% within Typeorg	42,9%	57,1%	100,0%
	downstream	Count	13	22	35
		% within Typeorg	37,1%	62,9%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	39	54	93
		% within Typeorg	41,9%	58,1%	100,0%

Typeorg * Emissions of GHGs from waste treatment plants Crosstabulation

			Emissions of GHGs from waste treatment plants		Total
			No	Yes	
Typeorg	upstream	Count	52	4	56
		% within Typeorg	92,9%	7,1%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	83	10	93
		% within Typeorg	89,2%	10,8%	100,0%

Typeorg * Emissions of toxic substance from waste treatment plants Crosstabulation

			Emissions of toxic substance from waste treatment plants		Total
			No	Yes	
Typeorg	upstream	Count	53	3	56
		% within Typeorg	94,6%	5,4%	100,0%
	downstream	Count	30	5	35
		% within Typeorg	85,7%	14,3%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	85	8	93
		% within Typeorg	91,4%	8,6%	100,0%

Typeorg * Consumption of limited non-renewable resources Crosstabulation

			Consumption of limited non-renewable resources		Total
			No	Yes	
Typeorg	upstream	Count	34	22	56
		% within Typeorg	60,7%	39,3%	100,0%
	downstream	Count	27	8	35
		% within Typeorg	77,1%	22,9%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	62	31	93
		% within Typeorg	66,7%	33,3%	100,0%

Typeorg * Emissions of GHGs from production and transport Crosstabulation

			Emissions of GHGs from production and transport		Total
			No	Yes	
Typeorg	upstream	Count	49	7	56
		% within Typeorg	87,5%	12,5%	100,0%
	downstream	Count	32	3	35
		% within Typeorg	91,4%	8,6%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	83	10	93
		% within Typeorg	89,2%	10,8%	100,0%

Typeorg * My plastic packaging cause neglectable environmental problems Crosstabulation

			My plastic packaging cause neglectable environmental problems		Total
			No	Yes	
Typeorg	upstream	Count	38	18	56
		% within Typeorg	67,9%	32,1%	100,0%
	downstream	Count	32	3	35
		% within Typeorg	91,4%	8,6%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	72	21	93
		% within Typeorg	77,4%	22,6%	100,0%

Typeorg * Other environmental problems Crosstabulation

			Other environmental problems		Total
			No	Yes	
Typeorg	upstream	Count	53	3	56
		% within Typeorg	94,6%	5,4%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	83	10	93
		% within Typeorg	89,2%	10,8%	100,0%

Question 5: Have environmental issues been important when doing technological changes?

	Have environmental issues been important when carrying out technological changes		
	Yes, very important	Somewhat important, not among the most important ones	No, not important
upstream	33,9%	53,6%	12,5%
downstream	51,4%	34,3%	8,6%
Total	40,9%	45,2%	10,8%

Question 6: Have you conducted changes in plastic packaging or related processes the latest 10 years?

	Have you conducted changes in plastic packaging or related processes last 10 years		
	Not answered	Yes	No
upstream	,0%	75,0%	25,0%
downstream	5,7%	48,6%	45,7%
Total	2,2%	64,5%	33,3%

Question 7: What changes have been carried out?

	Reduced consumption of materials
upstream	62,5%
downstream	2,9%
Total	38,7%

Typeorg * Reduced consumption of materials Crosstabulation

			Reduced consumption of materials		Total
			No	Yes	
Typeorg	upstream	Count	21	35	56
		% within Typeorg	37,5%	62,5%	100,0%
	downstream	Count	34	1	35
		% within Typeorg	97,1%	2,9%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	57	36	93
		% within Typeorg	61,3%	38,7%	100,0%

Typeorg * Eliminationn of potentially toxic substances Crosstabulation

			Eliminationn of potentially toxic substances		Total
			No	Yes	
Typeorg	upstream	Count	34	22	56
		% within Typeorg	60,7%	39,3%	100,0%
	downstream	Count	35	0	35
		% within Typeorg	100,0%	,0%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	71	22	93
		% within Typeorg	76,3%	23,7%	100,0%

Typeorg * Substitution of substances/materials (e.g. recycled material) Crosstabulation

			Substutution of substances/materials (e. g. recycled material)		Total
			No	Yes	
Typeorg	upstream	Count	44	12	56
		% within Typeorg	78,6%	21,4%	100,0%
	downstream	Count	32	3	35
		% within Typeorg	91,4%	8,6%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	78	15	93
		% within Typeorg	83,9%	16,1%	100,0%

Typeorg * Reduced energy consumption in production phase Crosstabulation

			Reduced energy consumption in production phase		Total
			No	Yes	
Typeorg	upstream	Count	46	10	56
		% within Typeorg	82,1%	17,9%	100,0%
	downstream	Count	34	1	35
		% within Typeorg	97,1%	2,9%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	82	11	93
		% within Typeorg	88,2%	11,8%	100,0%

Typeorg * Reduced waste generation in production phase Crosstabulation

			Reduced waste generation in production phase		Total
			No	Yes	
Typeorg	upstream	Count	34	22	56
		% within Typeorg	60,7%	39,3%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	65	28	93
		% within Typeorg	69,9%	30,1%	100,0%

Typeorg * Changed functionality in the plastic packaging Crosstabulation

			Changed functionality in the plastic packaging		Total
			No	Yes	
Typeorg	upstream	Count	46	10	56
		% within Typeorg	82,1%	17,9%	100,0%
	downstream	Count	34	1	35
		% within Typeorg	97,1%	2,9%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	82	11	93
		% within Typeorg	88,2%	11,8%	100,0%

Typeorg * Increased suitability for material recycling Crosstabulation

			Increased suitability for material recycling		
			No	Yes	Total
Typeorg	upstream	Count	41	15	56
		% within Typeorg	73,2%	26,8%	100,0%
	downstream	Count	25	10	35
		% within Typeorg	71,4%	28,6%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	68	25	93
		% within Typeorg	73,1%	26,9%	100,0%

Typeorg * Generally increased efficiency of the processes Crosstabulation

			Generally increased efficiency of the processes		
			No	Yes	Total
Typeorg	upstream	Count	40	16	56
		% within Typeorg	71,4%	28,6%	100,0%
	downstream	Count	32	3	35
		% within Typeorg	91,4%	8,6%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	73	20	93
		% within Typeorg	78,5%	21,5%	100,0%

Typeorg * Other changes Crosstabulation

			Other changes		
			No	Yes	Total
Typeorg	upstream	Count	52	4	56
		% within Typeorg	92,9%	7,1%	100,0%
	downstream	Count	31	4	35
		% within Typeorg	88,6%	11,4%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	85	8	93
		% within Typeorg	91,4%	8,6%	100,0%

Question 9: What is the frequence of the changes?

	What is the frequency of the changes			
	Once on several types of plastic packaging	Once on one type of plastic packaging	Continuous changes on several types of plastic packaging	Continuous changes on one type of plastic packaging
upstream	5,4%	8,9%	60,7%	3,6%
downstream	14,3%	,0%	20,0%	2,9%
Total	8,6%	5,4%	45,2%	3,2%

Question 10: When were these changes in general carried out?

	When were these changes in general carried out				
	1995 - 1997	1998 - 2000	2001 - 2003	All the time	Not able to specifiy
upstream	3,6%	17,9%	7,1%	46,4%	5,4%
downstream	,0%	14,3%	17,1%	11,4%	5,7%
Total	2,2%	16,1%	10,8%	33,3%	5,4%

Question 11: Which environmental problems did the changes reduce?

Typeorg * Increasing amount of waste Crosstabulation

			Increasing amount of waste		
			No	Yes	Total
Typeorg	upstream	Count	16	40	56
		% within Typeorg	28,6%	71,4%	100,0%
	downstream	Count	18	17	35
		% within Typeorg	51,4%	48,6%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	35	58	93
		% within Typeorg	37,6%	62,4%	100,0%

Typeorg * The content of toxic substances Crosstabulation

			The content of toxic substances		
			No	Yes	Total
Typeorg	upstream	Count	38	18	56
		% within Typeorg	67,9%	32,1%	100,0%
	downstream	Count	32	3	35
		% within Typeorg	91,4%	8,6%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	71	22	93
		% within Typeorg	76,3%	23,7%	100,0%

Typeorg * Consumption of natural resources Crosstabulation

			Consumption of natural resources		Total
			No	Yes	
Typeorg	upstream	Count	33	23	56
		% within Typeorg	58,9%	41,1%	100,0%
	downstream	Count	24	11	35
		% within Typeorg	68,6%	31,4%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	59	34	93
		% within Typeorg	63,4%	36,6%	100,0%

Typeorg * Emissions of GreenHouseGases Crosstabulation

			Emissions of GreenHouseGases		Total
			No	Yes	
Typeorg	upstream	Count	49	7	56
		% within Typeorg	87,5%	12,5%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	80	13	93
		% within Typeorg	86,0%	14,0%	100,0%

Typeorg * Other environmental problems reduced Crosstabulation

			Other environmental problems reduced		Total
			No	Yes	
Typeorg	upstream	Count	49	7	56
		% within Typeorg	87,5%	12,5%	100,0%
	downstream	Count	33	2	35
		% within Typeorg	94,3%	5,7%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	84	9	93
		% within Typeorg	90,3%	9,7%	100,0%

Question 13: What were the most important drivers for the changes carried out?

Typeorg * The covenant on plastic packaging Crosstabulation

			The covenant on plastic packaging		
			No	Yes	Total
Typeorg	upstream	Count	38	18	56
		% within Typeorg	67,9%	32,1%	100,0%
	downstream	Count	28	7	35
		% within Typeorg	80,0%	20,0%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	67	26	93
		% within Typeorg	72,0%	28,0%	100,0%

Typeorg * Other Norwegian environmental regualtions Crosstabulation

			Other Norwegian environmental regualtions		
			No	Yes	Total
Typeorg	upstream	Count	51	5	56
		% within Typeorg	91,1%	8,9%	100,0%
	downstream	Count	33	2	35
		% within Typeorg	94,3%	5,7%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	86	7	93
		% within Typeorg	92,5%	7,5%	100,0%

Typeorg * Environmental regulations in EU Crosstabulation

			Environmental regulations in EU		
			No	Yes	Total
Typeorg	upstream	Count	50	6	56
		% within Typeorg	89,3%	10,7%	100,0%
	downstream	Count	33	2	35
		% within Typeorg	94,3%	5,7%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	84	9	93
		% within Typeorg	90,3%	9,7%	100,0%

Typeorg * Other Norwegian 'non-environmental' regualtions Crosstabulation

			Other Norwegian 'non-environmental' regualtions		
			No	Yes	Total
Typeorg	upstream	Count	50	6	56
		% within Typeorg	89,3%	10,7%	100,0%
	downstream	Count	35	0	35
		% within Typeorg	100,0%	,0%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	87	6	93
		% within Typeorg	93,5%	6,5%	100,0%

Typeorg * Cost Reductions Crosstabulation

			Cost Reductions		Total
			No	Yes	
Typeorg	upstream	Count	22	34	56
		% within Typeorg	39,3%	60,7%	100,0%
	downstream	Count	23	12	35
		% within Typeorg	65,7%	34,3%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	47	46	93
		% within Typeorg	50,5%	49,5%	100,0%

Typeorg * Pressure from the market Crosstabulation

			Pressure from the market		Total
			No	Yes	
Typeorg	upstream	Count	35	21	56
		% within Typeorg	62,5%	37,5%	100,0%
	downstream	Count	32	3	35
		% within Typeorg	91,4%	8,6%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	69	24	93
		% within Typeorg	74,2%	25,8%	100,0%

Typeorg * Pressure from competitors and suppliers Crosstabulation

			Pressure from competitors and suppliers		Total
			No	Yes	
Typeorg	upstream	Count	43	13	56
		% within Typeorg	76,8%	23,2%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	74	19	93
		% within Typeorg	79,6%	20,4%	100,0%

Typeorg * Environmental consciouseness in the company Crosstabulation

			Environmental consciouseness in the company		Total
			No	Yes	
Typeorg	upstream	Count	31	25	56
		% within Typeorg	55,4%	44,6%	100,0%
	downstream	Count	21	14	35
		% within Typeorg	60,0%	40,0%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	54	39	93
		% within Typeorg	58,1%	41,9%	100,0%

Typeorg * Pressure from media, environmental and other NGOs Crosstabulation

			Pressure from media, environmental and other NGOs		
			No	Yes	Total
Typeorg	upstream	Count	52	4	56
		% within Typeorg	92,9%	7,1%	100,0%
	downstream	Count	32	3	35
		% within Typeorg	91,4%	8,6%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	86	7	93
		% within Typeorg	92,5%	7,5%	100,0%

Typeorg * Other contributing factors Crosstabulation

			Other contributing factors		
			No	Yes	Total
Typeorg	upstream	Count	54	2	56
		% within Typeorg	96,4%	3,6%	100,0%
	downstream	Count	34	1	35
		% within Typeorg	97,1%	2,9%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	90	3	93
		% within Typeorg	96,8%	3,2%	100,0%

Question 15: What are the main reasons why changes were NOT carried out?

Typeorg * Too high development costs Crosstabulation

			Too high development costs		
			No	Yes	Total
Typeorg	upstream	Count	48	8	56
		% within Typeorg	85,7%	14,3%	100,0%
	downstream	Count	34	1	35
		% within Typeorg	97,1%	2,9%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	84	9	93
		% within Typeorg	90,3%	9,7%	100,0%

Typeorg * Too low cost savings Crosstabulation

			Too low cost savings		
			No	Yes	Total
Typeorg	upstream	Count	44	12	56
		% within Typeorg	78,6%	21,4%	100,0%
	downstream	Count	28	7	35
		% within Typeorg	80,0%	20,0%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	74	19	93
		% within Typeorg	79,6%	20,4%	100,0%

Typeorg * Lack of incentives from the covenant between NMoE and the industry Crosstabulation

			Lack of incentives from the covenant between NMoE and the industry		
			No	Yes	Total
Typeorg	upstream	Count	54	2	56
		% within Typeorg	96,4%	3,6%	100,0%
	downstream	Count	31	4	35
		% within Typeorg	88,6%	11,4%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	87	6	93
		% within Typeorg	93,5%	6,5%	100,0%

Typeorg * Lack of incentives from other EU and Norwegian regulations Crosstabulation

			Lack of incentives from other EU and Norwegian regulations		
			No	Yes	Total
Typeorg	upstream	Count	53	3	56
		% within Typeorg	94,6%	5,4%	100,0%
	downstream	Count	33	2	35
		% within Typeorg	94,3%	5,7%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	88	5	93
		% within Typeorg	94,6%	5,4%	100,0%

Typeorg * Lack of demand on environmentally friendly plastic packaging products in the market Crosstabulation

			Lack of demand on environmentally friendly plastic packaging products in the market		
			No	Yes	Total
Typeorg	upstream	Count	40	16	56
		% within Typeorg	71,4%	28,6%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	70	23	93
		% within Typeorg	75,3%	24,7%	100,0%

Typeorg * All others in the sector produce the same and we do not need to be different Crosstabulation

			All others in the sector produce the same and we do not need to be different		
			No	Yes	Total
Typeorg	upstream	Count	49	7	56
		% within Typeorg	87,5%	12,5%	100,0%
	downstream	Count	33	2	35
		% within Typeorg	94,3%	5,7%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	83	10	93
		% within Typeorg	89,2%	10,8%	100,0%

Typeorg * Other factors preventing changes Crosstabulation

			Other factors preventing changes		
			No	Yes	Total
Typeorg	upstream	Count	44	12	56
		% within Typeorg	78,6%	21,4%	100,0%
	downstream	Count	28	7	35
		% within Typeorg	80,0%	20,0%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	74	19	93
		% within Typeorg	79,6%	20,4%	100,0%

Question 17: What will be decisive factors for your company to do environmentally friendly changes in future?

Typeorg * Changes in the covenant Crosstabulation

			Changes in the covenant		Total
			No	Yes	
Typeorg	upstream	Count	45	11	56
		% within Typeorg	80,4%	19,6%	100,0%
	downstream	Count	26	9	35
		% within Typeorg	74,3%	25,7%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	73	20	93
		% within Typeorg	78,5%	21,5%	100,0%

Typeorg * Stricter Norwegian environmental regulations Crosstabulation

			Stricter Norwegian environmental regulations		Total
			No	Yes	
Typeorg	upstream	Count	35	21	56
		% within Typeorg	62,5%	37,5%	100,0%
	downstream	Count	26	9	35
		% within Typeorg	74,3%	25,7%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	63	30	93
		% within Typeorg	67,7%	32,3%	100,0%

Typeorg * Stricter EU environmental regulations Crosstabulation

			Stricter EU environmental regulations		Total
			No	Yes	
Typeorg	upstream	Count	37	19	56
		% within Typeorg	66,1%	33,9%	100,0%
	downstream	Count	28	7	35
		% within Typeorg	80,0%	20,0%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	67	26	93
		% within Typeorg	72,0%	28,0%	100,0%

Typeorg * Stricter non-environmental regulations in EU or Norway Crosstabulation

			Stricter non-environmental regulations in EU or Norway		
			No	Yes	Total
Typeorg	upstream	Count	54	2	56
		% within Typeorg	96,4%	3,6%	100,0%
	downstream	Count	33	2	35
		% within Typeorg	94,3%	5,7%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	89	4	93
		% within Typeorg	95,7%	4,3%	100,0%

Typeorg * Increased pressure from costumers Crosstabulation

			Increased pressure from costumers		
			No	Yes	Total
Typeorg	upstream	Count	11	45	56
		% within Typeorg	19,6%	80,4%	100,0%
	downstream	Count	24	11	35
		% within Typeorg	68,6%	31,4%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	37	56	93
		% within Typeorg	39,8%	60,2%	100,0%

Typeorg * Increased demand on cost reductions Crosstabulation

			Increased demand on cost reductions		
			No	Yes	Total
Typeorg	upstream	Count	36	20	56
		% within Typeorg	64,3%	35,7%	100,0%
	downstream	Count	18	17	35
		% within Typeorg	51,4%	48,6%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	56	37	93
		% within Typeorg	60,2%	39,8%	100,0%

Typeorg * Increased pressure from competitor and/or suppliers Crosstabulation

			Increased pressure from competitor and/or suppliers		
			No	Yes	Total
Typeorg	upstream	Count	41	15	56
		% within Typeorg	73,2%	26,8%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	72	21	93
		% within Typeorg	77,4%	22,6%	100,0%

Typeorg * Increased environmental consciuousness within the company Crosstabulation

			Increased environmental consciuousness within the company		
			No	Yes	Total
Typeorg	upstream	Count	36	20	56
		% within Typeorg	64,3%	35,7%	100,0%
	downstream	Count	28	7	35
		% within Typeorg	80,0%	20,0%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	66	27	93
		% within Typeorg	71,0%	29,0%	100,0%

Typeorg * Increased pressure from NGOs and media Crosstabulation

			Increased pressure from NGOs and media		
			No	Yes	Total
Typeorg	upstream	Count	47	9	56
		% within Typeorg	83,9%	16,1%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	78	15	93
		% within Typeorg	83,9%	16,1%	100,0%

Typeorg * Increased knowledge on environmental impacts and on how to improve environmental performance Crosstabulation

			Increased knowledge on environmental impacts and on how to improve environmental performance		
			No	Yes	Total
Typeorg	upstream	Count	36	20	56
		% within Typeorg	64,3%	35,7%	100,0%
	downstream	Count	29	6	35
		% within Typeorg	82,9%	17,1%	100,0%
	other	Count	2	0	2
		% within Typeorg	100,0%	,0%	100,0%
Total		Count	67	26	93
		% within Typeorg	72,0%	28,0%	100,0%

Typeorg * Other factors Crosstabulation

			Other factors		
			No	Yes	Total
Typeorg	upstream	Count	50	6	56
		% within Typeorg	89,3%	10,7%	100,0%
	downstream	Count	31	4	35
		% within Typeorg	88,6%	11,4%	100,0%
	other	Count	1	1	2
		% within Typeorg	50,0%	50,0%	100,0%
Total		Count	82	11	93
		% within Typeorg	88,2%	11,8%	100,0%

Question 19: Has EPR contributed to increased cooperation between actors for developing environmentally friendlier packaging solutions?

Typeorg * Has EPR contributed to increased cooperation between actors for developing environmentally friendlier packaging solutions Crosstabulation

			Has EPR contributed to increased cooperation between actors for developing environmentally friendlier packaging solutions				
			Not answered	Yes	More cooperation, but not due to the covenant	No, covenant without significance	Total
Typeorg	upstream	Count	1	14	23	18	56
		% within Typeorg	1,8%	25,0%	41,1%	32,1%	100,0%
	downstream	Count	7	11	6	11	35
		% within Typeorg	20,0%	31,4%	17,1%	31,4%	100,0%
	other	Count	0	0	1	1	2
		% within Typeorg	,0%	,0%	50,0%	50,0%	100,0%
Total		Count	8	25	30	30	93
		% within Typeorg	8,6%	26,9%	32,3%	32,3%	100,0%

APPENDIX E: DATA FROM THE TINE CASE

Table E: Background data Tine

Data provided by Solgaard (2001, 2002 and 2005), Eide (2001, 2005), Snesrud (2005) and Skogesal (2005a)

ECONOMIC INDICATORS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Turnover [1000 NOK]	9 461 671	9 692 402	10 250 254	10 467 384	10 250 307	10 391 621	10 562 537	10 001 462	10 130 350	11 400 000
Turnover [1000 NOK] indexed	12 830 026	12 745 509	13 181 827	13 534 328	12 577 127	11 098 251	11 164 602	10 731 569	10 626 737	11 400 000
Number of employes		5 100	5100	5 000	4 730	4 378	4 292	4 710	4 774	4 844
Number of dairies	101	87	87	81	81	76	71	65	60	53
Raw cow milk input [mill liter]	1 734	1 700	1 682	1 664	1 634	1 544	1 500	1 483	1 482	1 471
Raw goat milk input [mill liter]	24,2	24,0	22,9	22,2	21,2	20,6	19,7	20,1	19,7	20,0
Liquid output (milk, sour cream, yoghurt etc) [mill liter]	687	666	617	636	597	582	562	552	538	538
Solid output (cheese, butter etc) [ktons]	80	78	78	76	82	82	72	74	74	75
Market shares										
Milk [%]	n.a	n.a	n.a	99,0	99,0	98,0	98,0	95,7	95,1	93,8
Cheese [%]	n.a	n.a	n.a	87,0	83,0	81,0	79,0	78,1	77,8	74,8
Goat cheese [%]	n.a	n.a	n.a	89,0	88,0	89,0	90,0	91,9	93,3	93,5
Cream [%]	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Yoghurt [%]	n.a	n.a	n.a	91,0	92,0	88,0	87,0	86,8	83,9	83,4
Butter [%]	n.a	n.a	n.a	100,0	97,0	98,0	99,0	99,8	99,6	99,5
Production of myse [klitre]			881,6	907,6	841,0	819,0	776,4	773,2	791,8	805,5
Byproducts in total [ktons]	879	885	862	906	839	822	781	770	832	840
Byproducts as ingredients in new products [ktons]	178,6	173,4	165,5	172,1	164,6	155,4	133,5	132,2	135,3	142,8
Byproducts as animal feed [ktons]	683,1	695,4	680,1	706,3	647,1	628,2	618,0	601,9	654,9	660,5
Byproducts to disposal [ktons]	17,4	16,0	16,4	27,4	26,9	38,5	29,4	36,1	41,6	36,3
		2 655								
Total costs [1000 NOK]	4 802 413	4 680 854	5 054 200	5 214 973	5 307 653	5 446 823	5 934 336	5 086 574	5 797 687	5 532 231
Total costs [1000 NOK] indexed, 2004	6 512 072	6 155 323	6 499 701	6 742 960	6 512 490	5 817 207	6 272 593	5 457 894	6 081 774	5 532 231
Packaging costs [%]	25,7	22,6	24,3	21,2	23,5	24,2	27,2	25,0	25,5	25,2
Packaging costs [1000 NOK]	1 231 887	1 056 971	1 229 975	1 105 574	1 247 298	1 318 131	1 614 139	1 700 000	1 750 000	1 800 000
Packaging licence fee costs [1000 NOK]		22 638	22 216	21 996	20 474	24 220	25 040	24 795	25 989	26 504
Packaging licence fee costs [1000 NOK], indexed		29 769	28 570	28 441	25 122	25 867	26 467	26 605	27 262	26 504
Plastic packaging licence fee costs [1000 NOK]		3 168	3 242	3 383	4 397	6 220	6 161	5 653	6 718	6 906
Plastic packaging licence fee costs [1000 NOK], indexed		3 168	4 169	4 374	5 395	6 643	6 512	6 066	7 047	6 906
Packaging licence fee costs of total costs [%]	0,00	0,48	0,44	0,42	0,39	0,44	0,42	0,49	0,45	0,48
Packaging licence fee costs of total pack. costs [%]	0,00	2,14	1,81	1,99	1,64	1,84	1,55	1,46	1,49	1,47
Plastic pack. licence fee costs of total pack. costs [%]	0,00	0,30	0,26	0,31	0,35	0,47	0,38	0,33	0,38	0,38

ENVIRONMENTAL INDICATORS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Energy consumption [kJ]		5 850	6 113	15 600	20 754	18 340	20 200	20 820	23 700	21 500
Packaging consumption [tons]	29901	25 829	26 344	25 280	24 300	24 421	24 522	24 874	25 071	26 044
Plastics [tons]	2809	2 755	2 819	2 942	3 140	3 659	3 624	3 769	3 814	3 990
Metals [tons]		197	204	204	204	220	229	247	209	295
Carton [tons]		664	677	364	236	215	312	370	401	404
Cardboard [tons]	6345	5 071	5 170	5 134	4 957	4 971	5 160	5 459	5 260	5 635
Liquid carton [tons]	19975	17 142	17 474	16 636	15 763	15 356	15 197	15 029	15 387	15 740
Emissions to water [% above consession]		10,5	25,0	46,8	26,6	13,2	23,6	29,9	10,0	10,9
Transportation [km]	35 300	36 300		34 041	39 540	39 655	42 079	52 415	52 878	53 266
Transportation [km]	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Solid waste generation [tons]	n.a	n.a	n.a	n.a	n.a	5 588	6 322	6 198	7 241	8 656
Source separated plastics [% of total]	n.a	n.a	n.a	n.a	n.a	n.a	3,94	5,91	3,87	8,09
Source separated plastics [tons]	n.a	n.a	n.a	n.a	n.a	n.a	249	366	280	700
Source separated waste for recovery [% of total]	n.a	n.a	n.a	n.a	n.a	51,0	60,9	62,6	60,7	63,0
Source separated waste for recovery [tons]	n.a	n.a	n.a	n.a	n.a	2 850	3 850	3 880	4 395	5 453
Source separated waste for energy recovery [% of total]	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Plastics [% of total plastics potential]	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Solid waste to disposal [% of total]	n.a	n.a	n.a	n.a	n.a	n.a	2 104	2 319	2 039	1 927

COMBINED INDICATORS	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Packaging intensity [kg/1000 NOKturnover]	3,16	2,66	2,57	2,42	2,37	2,35	2,32	2,49	2,47	2,28
Packaging intensity [kg/1000 NOKturnover] justert konsumpri	2,33	2,03	2,00	1,87	1,93	2,20	2,20	2,32	2,36	2,28
Plastics	0,22	0,22	0,21	0,22	0,25	0,33	0,32	0,35	0,36	0,35
Metals	0,00	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03
Carton	0,00	0,05	0,05	0,03	0,02	0,02	0,03	0,03	0,04	0,04
Cardboard	0,49	0,40	0,39	0,38	0,39	0,45	0,46	0,51	0,49	0,49
Beverage carton	1,56	1,34	1,33	1,23	1,25	1,38	1,36	1,40	1,45	1,38
Packaging intensity [kg/1000 liter of raw milk input]	17,01	14,98	15,45	14,99	14,68	15,61	16,14	16,55	16,70	17,47
Plastics [tons]	1,60	1,60	1,65	1,74	1,90	2,34	2,38	2,51	2,54	2,68
Metals [tons]	0,00	0,11	0,12	0,12	0,12	0,14	0,15	0,16	0,14	0,20
Carton [tons]	0,00	0,39	0,40	0,22	0,14	0,14	0,21	0,25	0,27	0,27
Cardboard [tons]	3,61	2,94	3,03	3,04	2,99	3,18	3,40	3,63	3,50	3,78
Liquid carton [tons]	11,36	9,94	10,25	9,87	9,52	9,81	10,00	10,00	10,25	10,56

Packaging intensity [kg/ton solid output]	38,98	34,72	37,91	35,51	35,79	36,78	38,68	39,73	40,97	42,49
Plastics [tons]	3,66	3,70	4,06	4,13	4,62	5,51	5,72	6,02	6,23	6,51
Metals [tons]	0,00	0,26	0,29	0,29	0,30	0,33	0,36	0,39	0,34	0,48
Carton [tons]	0,00	0,89	0,97	0,51	0,35	0,32	0,49	0,59	0,66	0,66
Cardboard [tons]	8,27	6,82	7,44	7,21	7,30	7,49	8,14	8,72	8,59	9,19
Liquid carton [tons]	26,04	23,04	25,14	23,37	23,22	23,13	23,97	24,01	25,14	25,68

Packaging intensity [kg/ton liquid output]	43,52	38,78	42,70	39,75	40,70	41,96	43,63	45,06	46,60	48,41
Plastics [tons]	4,09	4,14	4,57	4,63	5,26	6,29	6,45	6,83	7,09	7,42
Metals [tons]	0,00	0,30	0,33	0,32	0,34	0,38	0,41	0,45	0,39	0,55
Carton [tons]	0,00	1,00	1,10	0,57	0,40	0,37	0,56	0,67	0,75	0,75
Cardboard [tons]	9,24	7,61	8,38	8,07	8,30	8,54	9,18	9,89	9,78	10,47
Liquid carton [tons]	29,08	25,74	28,32	26,16	26,40	26,38	27,04	27,23	28,60	29,26

GROSS DOMESTIC PRODUCT (GDP)	1996	1997	1998	1999	2000	2001	2002	2003	2004
GDP [mill NOK] running values	1 026 924	1 111 349	1 132 134	1 233 039	1 469 075	1 526 233	1 519 131	1 561 915	1 685 552
From Olav Skogesal SSB (2005a)	5,3	5,2	2,6	2,1	2,8	2,7	1,4	0,4	3,3
Volume changes (Snesrud 2005)	5,3	5,2	2,6	2,1	2,8	2,7	1,1	0,4	2,9
Inflation (Snesrud 2005)	4,1	2,9	-0,7	6,6	15,9	1,1	-1,6	2,4	4,9
SUM	9,4	8,1	1,9	8,7	18,7	3,8	-0,5	2,8	7,8
Calculated		8,2	1,9	8,9	19,1	3,9	-0,5	2,8	7,9
GDP with volume changes for selected sectors [%]	7,1	8,9	5,9	5,1	5,6	3,6	2,8	1,9	4,1
GDP with volume changes for selected sectors [mill NOK]	303 905	330 830	350 241	367 991	388 460	402 320	413 719	421 637	439 131
GDP 1996-indexed	1 026 924	1 080 324	1 107 024	1 128 589	1 157 343	1 185 070	1 196 366	1 200 474	1 230 255