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Extended Producer Responsibility and the Market Development for Recycled Plastics

Two Norwegian cases of using recycled polypropylene in chairs

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Two Norwegian Cases of Using Recycled Polypropylene in Chairs

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Abstract

To deal with the problems resulting from the current unsustainable pattern of resource utilization, the material life cycle of plastics should be extended. Extended producer responsibility (EPR) has been increasingly adopted as a strategy to redirect the material flow, but its contributions to the market development of recycled plastics have not been well researched.

Norway is one of the countries where various EPR programmes have been implemented for a number of years. This thesis presents two Norwegian cases in which recycled polypropylene is used to replace virgin plastics in the product application of chairs. Material chain, including actors of the plastic recycler, the plastic converter, the product manufacturer and the end-user of product, is chosen to be the unit of analysis. The change process of using recycled plastics in the material chain is observed and analyzed, in order to understand the contributions of the related EPR programmes. The study shows that the implementation of EPR programmes increases recycling activities, and thus strengthens the supply side of the market, but its influence on the demand side is far less significant.

Executive Summary

Along with the rapid growth of economy, environmental problems of waste generation and resource depletion have gradually caught people's attention. To deal with these problems resulted from the existing pattern of resource utilization, the concept of industrial ecology has evolved. Understanding the cyclic mode of material flows in the natural ecosystem is only the first step. The most important task that follows is to introduce solutions.

Extended producer responsibility (EPR) has been considered as the realization of industrial ecology in the governmental arena. The EPR policy is intended to have influences on the entire life cycle of the focal product systems. Producers, users and waste managers are considered as three groups of key actors in the EPR product system. So far, EPR programmes cover different products or product groups such as packaging, batteries, end-of-life vehicles (ELVs), electrical and electronic equipments (EEE). EPR programmes typically require producers to reuse or recycle various material contained in these products. Plastics is one of these materials. Thus, we may say EPR programmes redirect the material flows.

Plastics is a versatile material in application. However, its versatility creates problems for its end-of-life treatment and the application of recycled plastics. Plastics recycling has grown significantly in the last decade, but the market of recycled plastics is still at an immature stage. Various barriers in the market development can be identified, such as high costs of recovery, inconsistent quality and quantity, and difficulty to find proper applications. Nevertheless, there are observable drivers for using recycled plastics as well.

The material life cycle of plastics is extended as a result of the recycling activities induced under different EPR product systems. However, there is a lack of study on how EPR programmes further influence the market of recycled material. In order to *understand the contributions of EPR policy instruments to the market development of recycled plastics*, which is the purpose of this study, the author chooses the material chain as the unit of analysis, which includes the following actors: the plastic recycler, the plastic converter, the product manufacturer and the end-user of product. To study the use of recycled plastics as a change in the material chain, the author establishes an analytical framework with three steps: (1) observing the change process, (2) identifying the drivers and barriers to the change, and (3) discussing the contributions of a certain environmental policy to the drivers and barriers. Two Norwegian cases of using recycled polypropylene (PP) in chairs have been studied.

Some contextual background is laid out about the situation in the country of Norway. First, the author introduces briefly the material flow of plastics in Norway: from production and consumption to the waste generation and waste management including collection, sorting and recovery. Second, the author reviews the current status of EPR implementation in Norway, particularly focusing on the existing Norwegian EPR programmes with influences in the post-consumer plastics. The EPR programmes relating to plastics include the deposit-refund systems for PET bottles, the voluntary agreement on plastic packaging, and non-packaging programmes on EEE and ELV, among which the voluntary agreement (or also referred to as the covenant), in which the producer responsibility organization (PRO), Plastretur AS, is set to run the recovery system of plastic packaging, is the most influential.

The two cases selected have something in common: they are open-loop recycling, following the EPR product systems; and the recycled PP was used to replace virgin plastics in the product applications of chairs. In the TIK case, about 1,300 chairs made of recycled PP were installed in the Trondheim Ice Hockey Stadium. Trondheim Ice Hockey Club (TIK) was the initiator of the case, and also the users of chairs. IFAS Sport AS was the producer designer, Polimoon AS Moss the plastic converter and Strandplast AS the plastic recycler. In the HÅG case, recycled PP has been used in the office chairs produced by HÅG, the initiator as well as the product manufacturer. In 2001, recycled PP accounted for 24% of all the plastics used in HÅG. There were two stages in this case, in Stage I, Dynoplast (the previous Polimoon AS Stjørdal) was the plastic converter, and Strandplast AS the plastic recycler. In

Stage II, which extended to the present time, Lycro AS is the plastic converter, and the Swedish company, Plaståtervinning AB, the plastic recycler.

The initiators in both cases, TIK and HÅG, were mainly triggered by *the wish to use ecological arguments in the marketing*. They have established active environmental strategy to differentiate themselves from other similar actors. The implementation of EPR programmes does not seem to have contributed in the initiation.

The following part of the change process in the cases was influenced by a complex set of factors. The author analyzed them into the categories of technological, economic, social and political factors, and discussed the influence of EPR in each category.

The author looks at the technological factors in processing steps of sorting, recycling, plastic conversion and plastic products. The technology involved in the cases was not very sophisticated. The collection and separation in EPR mechanism reduce the need of sorting technology.

The economic factors were examined with the possible cost and benefits of using recycled plastics for the actors. The economic outcomes in the cases seemed to be acceptable, if not satisfactory, for all the actors. The major contribution of EPR here is to reduce the cost from collection, sorting and processing for the actors in the material chains following the EPR product systems, and to ensure the source availability. In the TIK case, Plastretur sponsored TIK to make the change happen, but this should be regarded as conventional.

Among the social and political factors, the author looks at organizational status, perception, information flow and inter-organizational coordination, and the influence of external actors. Using recycled plastics seems to require higher coordination of actors in the material chain. PROs in EPR programmes played the role to provide crucial information to the initiator in the TIK case, and even got involved in material arrangements in the stage II of the HÅG case.

If an environmentally positive change is successful, the experiences should be extended or disseminated to drive other similar changes. The studied cases have been used by Plastretur for their own marketing campaign to demonstrate the usability of recycled plastics to the citizens.

Finally, summarizing the influences and contributions of EPR programmes to the market development of recycled plastics, the author propose to look at the supply side and demand side. On the supply side, EPR may help to release the cost burden of collection, sorting and processing; provide mechanism to stabilize price fluctuation of recycled plastics; ensure the supply of material, both on quantity and quality; and provide information to improve the visibility of recyclers. On the demand side, some PROs demonstrate the successful product applications with the attempt to lower the resistance of using recycled plastics.

While the supply side of the market has been strengthened by various EPR programmes, their influences on the demand side seem far less significant. However, to extend the material life cycle of plastics more smoothly, the author thinks that in the countries where EPR programmes are implemented to promote recycling, capacity should also be built with the aim to drive the demand of the recycled plastics.

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1. Introduction

1.1 Background

Along with the rapid industrial and economic development, the dramatic increase of production and consumption has made our life more comfortable. The material flows between technosphere and biosphere have consequently become intensive, from material extraction and the disposal of waste. What follows is environmental degradation of different kinds. Waste generation is regarded as one of the most serious on the list. Final treatment of waste- landfilling or incineration, may possibly cause negative environmental effects resulted from emissions into air, soil and water, and incontrollable overtaking of space for landfill sites. Improper waste disposal might bring nuisances like negative aesthetics and unpleasant smell. In addition, depletion of various natural resources has also gained people's growing concern.

Governments and authorities in different countries have tried, individually or cooperatively, to work on different policy instruments to reduce the waste generation and improve the efficiency of waste management. In the various levels of the hierarchy of waste management- reuse, recycling, incineration and landfill, recycling has been increasingly emphasized as a way out to solve the waste problems. It helps to 'close the loop' of the material life cycle and reduce the actual amount of waste for disposal. However, successful recycling, which is economically and ecologically acceptable, involves a lot of efforts and coordination of different actors.

The concept of industrial ecology, which has been formed from the analogy of natural ecosystem, provides a theoretical framework for closing the loop of material flows. "In nature, nothing is eternally discarded; in various ways, all materials are reused, generally with great efficiency" (Graedel & Allenby, 1995, p.10). However, while such cyclic pattern of resource utilization in nature has evolved spontaneously, the mimicking process in the industrial system takes intentional actions of the actors. The actors in the industrial system are highly interconnected and interdependent. The re-structuration will not be an easy task.

Since the beginning of the 1990's, extended producer responsibility (EPR) has been a strategy increasingly adopted. Some people consider EPR implementation as the realization of industrial ecology in the governmental arena (Ehrenfeld, 2001 and Solem & Brattebo, 1999). With the implementation of EPR, the responsibility of waste management is defined to fall on the 'producers' of the products, as compared to the consumers and the governmental authorities in the traditional cases. The influences of EPR programmes occur both before and after the product is being used. It drives eco-design or material reduction among the 'producers' of the products, and at the same time, it also drives the recycling system of the end-of-life products.

In some of cases, an EPR policy instrument helps to prolong the life of materials by setting a recycling[1] target. Once those materials are recycled, they may either be used as raw material in the original product group, or enter the product chain of other types of products. An EPR programme may contribute to set up and drive the recycling system, but the market of the recycled materials also play a key role for the efficiency of the recycling system. Once the market development of the recycled material is prosperous, the recycling system may function better and the EPR targets are more likely to be met.

Recycling that is profitable has taken place without much governmental intervention. Recycling of materials like metal and glass offers good example. Meanwhile, there exist a variety of other materials

[1] Recycling here is defined as material recovery, utilizing waste in such a way that the material is wholly or partly retained, either for its original purpose or for other purposes. (Norwegian Ministry of Environment, 1995)

whose conventional use in the current industrial system make their recycling economically unattractive. Among the list of such materials is plastics. Plastics is a versatile material in application. This versatility, however, highly increases the complexity in its end-of-life treatment and influences the application of the recycled material. Obviously, the implementation of some EPR programmes increases the supply of recycled plastics. This contributes to the market development of recycled plastics. While studies and reports can be found for the understanding and evaluation of EPR mechanisms and outcomes, very few researchers have looked into the influences or impacts of EPR to the market of recycled materials. Considering the broader perspective of industrial ecology, the author thinks there is a need to understand if implementation of various EPR programmes plays an important role to somehow strengthen the market position of recycled plastics.

1.2 Purpose

The purpose of this research is:

To contribute to the understanding of influences of EPR policy instruments in the market development of recycled plastics in Norway.

In order to achieve the above-mentioned purpose, this research is intended to answer the following research questions:

1. How is the demand to use recycled plastics triggered in the material chain?

2. Once the change is initiated, how do actors in the material chain accomplish the change process of using recycled plastics?

3. How have various EPR programmes contributed to the above?

Moreover, in order to set the contextual background for the analysis, the current status of EPR programmes in Norway will be examined, particularly those relating to plastics.

1.3 Scope and Limitation

The following Figure 1-1 which depicts the material flow may facilitate the understanding of the scope of this research. The virgin material flows into the product chain of product I. A portion of the post-consumer products enters the end-of-life (EOL) management. Among the stream of recycled material, some returns to the original application of product I, and some enters another product chain, say, of product II, one of the reasons for which may be the quality of recycled material does not meet the requirement of the application of product I. We may call this the cascading of material.

In this research, the author follows the material flows of plastics. Among all the product groups that EPR programme may cover, the author focus more on those related with the material of plastics. Due to the wide applications of plastic materials, a number of different programmes have to be included. However, according to an analysis conducted by the Association of Plastics Manufacturers in Europe (APME), the packaging sector takes the largest part of plastic consumptions (37.3% in year 2000 in Western Europe), and the EPR programmes of plastic packaging are more directly related to the recovery of plastic itself. Thus, more emphasis will be put in the packaging sector while the non-packaging programmes will be briefly reviewed, due to the percentage of plastics in those product groups and the growing attention from the government and the industry to the sectors like cars and electronic products.

The purpose of this research is not to discuss the EPR programmes as such, but to understand the influence of EPR programmes on various actors in the chain of product II. Therefore, background and content of relevant EPR programmes will be introduced, but only to the extent that is necessary for the successive discussion about their influences to the chain of product II.

Two cases among the product chains of product II are studied. The material flow continues after the consumer in product chain of product II. However, that is outside of the scope of this research.

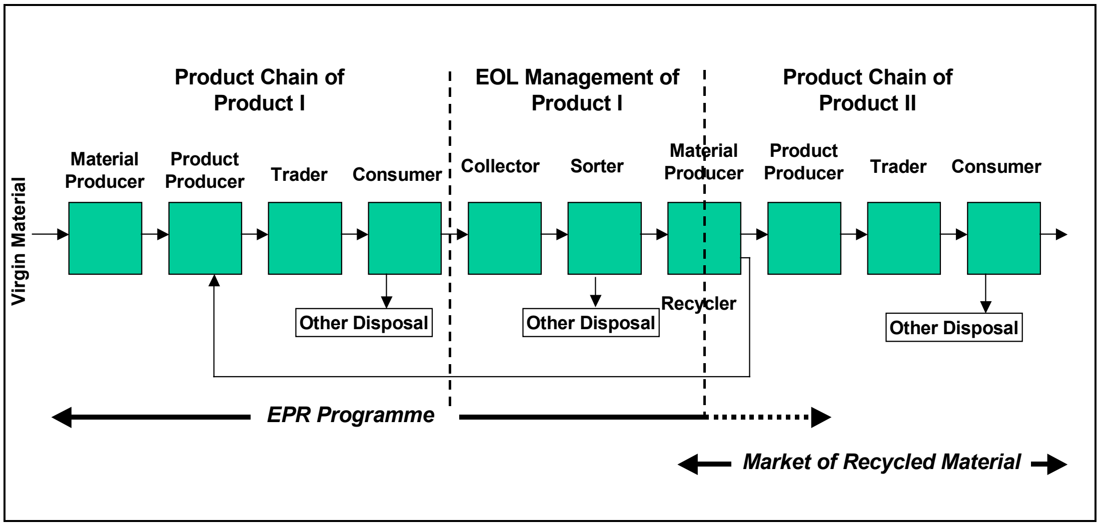

Figure 1-1 Material Flow from One Product to Another

Norway has been selected to be the focal country of this research because of the following reasons: (1) Various EPR programmes can be found implemented in Norway, and some of them have been implemented for a number of years. (2) There are cases available for the purpose of this study. The selected cases in the market using recycled plastics were used by Plastretur AS, the Norwegian PRO (producer responsibility organization) of plastic packaging, as illustrative cases. (3) Researches with similar focus have already been initiated at the Industrial Ecology (IndEcol) programme in the Norwegian University of Technology and Science (NTNU) in Trondheim[2], and there is existing cooperation between the IndEcol programme and the International Institute for Industrial Environmental Economics (IIIEE).

In terms of geographical boundary, the policy-related issues in this research are mainly discussed within the Norwegian context. As to the market-related issues of recycled materials, the geographical scope extends further to a more international level, due to the reality of global economy or trans-national trade. In one of the two case studies, the product chain of using recycled plastics extends to Sweden, the neighboring country.

In both of the cases in the case study, it is recycled polypropylene that is applied, which is in the category of commodity plastics. The recycling of technical plastics may involve different considerations. The magnitude of the chosen cases is far from large enough for the author to be able to generalize the conclusion to other cases. However, this research may bring some insight to the complexity of the whole mechanism between policy issues and market issues.

A list of definition terms can be found in Appendix I.

[2] The topic in this thesis is initiated by my research fellow, as well as one of my supervisors, Kjetil Røine. He is PhD candidate at the IndEcol programme in NTNU.

1.4 Methodology

1.4.1 Case study method

Case study method has been chosen as the research strategy of this research. According to Yin (1994), the research design of case studies consists of five components: (1) a study's question; (2) its propositions, if any; (3) its unit(s) of analysis; (4) the logic linking the data to the propositions, and (5) the criteria for interpreting the findings. Another very important element is the development of theory. Based on this, the author determines the flow of this research as the following:

1. **Identifying the problem issue and establishing the research questions:** The author conducts literature review regarding policy-related and market-related issues covered by this research and establishes the research purpose (Chapter 1 & 2).

2. **Theoretical propositions and designing analytical framework:** The author discusses several theoretical perspectives in order to establish the analytical framework for this research (Chapter 3).

3. **Research on the contextual background:** The author lays out the background of the material flow of plastics and the EPR programmes in Norway (Chapter 4 & 5).

4. **Selecting units of analysis and gathering data for the case studies:** Here the author selected two cases to study, not necessarily for making comparison, but to add depth of discussion (Chapter 6).

5. **Analyzing the collected data:** The author makes analysis by linking the data with the theoretical propositions and the theoretical framework (Chapter 7).

6. **Conclusion and recommendation:** Based on the case findings and analysis, the author answers the research questions and makes recommendations (Chapter 8).

1.4.2 Data Collection

The collection of data is multiple-sourced, both for the two case studies and the information of the contextual background. For the two case studies, secondary data such as company websites, annual reports, advertising materials and media reports are collected and referred to. As to the primary data, for each actor in the two product chains, one on-site in-depth interview is conducted with the key informant. Other than the interviews, visits to the production site enhance the understanding of the process and possible concerns. Communications via emails and phone calls are made after the interview for validating the information and clarification. The author would like to acknowledge that the collection of empirical data is conducted in close collaboration with Kjetil Røine, my research fellow at the IndEcol programme as well as one of my supervisors.

The information of the contextual background is mainly based on secondary data, including books, journals, academic reports, websites, governmental publications such as regulations and policy statements, newsletters and so on. When the published information is insufficient or when some issues need to be clarified, primary data from emails and phone calls are sought.

1.5 Structure of Thesis

In this section, the author presents briefly the structure of this thesis.

Chapter 1 is the introduction of this research. It provides the function as the reader's guide, leading the readers through the fundamentals of the research: background, the research purpose, the scope and limitations of the study, the methodology applied and the structure of the thesis.

Chapter 2 has the objective to provide the background discussion about material life cycle of plastics and the EPR mechanism. The concept of industrial ecology is briefly introduced as a good umbrella concept for improving the resource utilization in the material flow of plastics. To understand the extension of the material life cycle, the author discusses issues in plastic waste management and development of market for recyclates. The chapter also introduces the concept of EPR and its implication to the use of recycled plastics.

Chapter 3 lays out the theoretical perspectives of this research. In the end of this chapter, an analytical framework is established, which would be applied later on for the analysis of the findings of cases.

Chapter 4 presents the situation of plastic material flow in Norway: production, consumption, waste generation and waste management including collection, sorting and recovery.

Chapter 5 introduces the EPR programmes for plastics in Norway. First, we take a look at the Norwegian waste policy and try to find out the relevance of EPR strategy in it. A brief introduction about currently implemented EPR programmes then gives the readers an idea about the Norwegian EPR status. More details are to be introduced for the programmes relating with the material of plastics, among which the packaging programmes are of higher importance.

Chapter 6 presents the data collected from the two Norwegian cases of using recycled polypropylene in chairs: the chairs in Trondheim ice hockey stadium and the office chairs produced by HÅG. Actors in the selected material chain are introduced, followed by the observation of the change process of using recycled plastics.

In **Chapter 7,** the author first analyzes the case findings, and then discusses the influences of EPR on the supply side and demand side of the market for recycled plastics.

Chapter 8 concludes the thesis with the purpose of research about understanding EPR's contributions in the market development. Some recommendations are made in order to aim for better resource utilization.

2. Improving the Resource Utilization of Plastics

The objective of this chapter is to provide background discussion for material life cycle of plastics and the concept of extended producer responsibility (EPR). In the first part of this chapter, the author introduces the concept of industrial ecology (IE), one of the main objectives of which is to improve the overall resource productivity in the industrial system, in order to provide the umbrella concept for this research and to explain the optimal pattern of material flow of plastics. Compared to the traditional waste policies and regulations, EPR provides a life cycle perspective. Some industrial ecologists consider EPR implementation as the institutionalization of IE in the political arena (Ehrenfeld, 2001). Different EPR programmes assists to prolong the material life cycle of plastics. However, when the recycled plastics flows into the market, the change process for the existing material chain to use recycled plastics is rather complex.

2.1 Industrial Ecology and Material Flows

2.1.1 Industrial Ecology

In a natural ecosystem, living organisms tend to make use of any available source of useful material and energy. There is a high degree of interaction and interconnectedness among different species. In the industrial system, the components are integrated and connected by flows of energy, materials, information, money and so on. The actors in the industrial systems contribute considerably to the environmental impacts and at the same time, they are the ones that are capable and knowledgeable to come up with solutions. However, none of these actors is an isolated body. They depend on other actors and the system conditions.

Facing the growing environmental threats, people began to apply the analogy of natural ecosystem to the industrial system. The interconnectedness and interdependency of actors in the industrial systems add high complexity to the change process to introduce solutions. The metaphor of industrial ecology (IE) has consequently been formulated, evolved and been accepted after the early 1990s. Graedel & Allenby (1995, p.9) give the following definition:

> *Industrial ecology is 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.*

People have to keep in mind that the earth is a closed system for materials, and therefore, there are only limited resources available. Understanding the stocks and flows of material and energy is the core element of IE. "In nature, nothing is eternally discarded; in various ways, all materials are reused, generally with great efficiency" (Graedel & Allenby, 1995, p.10). IE gives a hypothesis about a sustainable industrial structure: "if human society adopts principles found in natural systems, our society will become more sustainable" (Røine, 2002a).

However, Boons and Baas (1997) pointed out the difference between the biological and industrial ecosystem. Evolution towards greater efficiency is spontaneous in the former, while *intentional action* is needed in the latter. Therefore, understanding the industrial system on the basis of the ecosystem is only the first step. What comes more importantly is to determine *how it could be restructured*, i.e. how to introduce and implement solutions (Erkman, 1997). From nature, we should learn that obsolete materials and products are residues rather than wastes, which the human economy has not yet learned to use efficiently (Graedel & Allenby, 1995). In the natural ecosystem, decomposers in the ecosystems play the crucial role to maintain the loop and make the elements move in a cyclic manner. These decomposers are not often found in the linear industrial economy (Røine, 2002a). Along with growing awareness of the environmental problems, recycling options including product reuse, material recycling and energy recovery, have begun to play an important role in the industrial metabolism.

In the industrial ecosystem, numerous subsystems, co-existing or one embedded in another, consist of different actors carrying out activities with the available resources. Systems, however, may be defined for analytical or operational purposes. It is up to the person in the task to decide how to draw the *system boundary*. Boons and Baas (1997) mention the following types of industrial ecology by setting the boundaries: product life cycle, material life cycle, geographical area, sector and miscellaneous. "Sub-optimization, optimization of a particular process or subsystem, may be less efficient than optimization of the large-scale system" (Frosch, 1994). Thus, the loop closure of material flows should be aimed for the entire industrial system, rather than a single process, a single plant or even a single product system.

Røine (2002d) argues that industrial ecology can be characterized through three perspectives: *the resource perspective, the systems perspective* and *the network of actors perspective*. The author thinks it is proper to use such a characterization to summarize the IE concept. The resource perspective identifies the problem, i.e. the resources are limited, and points out the direction to solve the problem, i.e. increase resource efficiency mimicking the cyclic pattern of material flow in natural ecosystems. The system perspective provides a scope to interpret the complexity of the industrial phenomena for optimization. "A system perspective means to investigate the interactions within the defined system, and the interactions between the system and its surroundings" (Røine, 2002a). And lastly, through the network of actors perspective, the interconnectedness of actors is understood in order to implement effective solutions.

2.1.2 Material Flows in Industrial System

Industrial metabolism is used to describe "the whole of materials and energy flows going through the industrial system" (Erkman, 1997). Understanding industrial metabolism facilitates the decision making of resource management. In thermodynamics, the *cascading principle* provides the basic idea that energy may be utilized in the flows as many times as possible on their way to *zero exergy*. This applies for material flow as well. When the energy or material leaves from one system, it may enter another system and be used if it is still useful (Røine, 2002b). Inspired by the ecological concept, the principle of "waste or by-products of one company are used as resources by another company" is implemented for the establishment of eco-industrial parks (Erkman, 1997). Similarly, waste or by-products of one product system may be usable resources when entering another product system (see Figure 2-1). To maximize the resource efficiency within the overall industrial system, both closed-loop recycling[3] and open-loop recycling[4] should be promoted. In the industrial systems, the material flow is driven by economy. To promote the recycling activities, it demands the *coordination* of activities of economic actors as well as governmental agencies (Boons & Baas, 1997).

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[3] Closed-loop recycling is defined as "A recycling system in which a particular mass of material is remanufactured into the same product. Also known as Horizontal recycling" (Graedel & Allenby, 1995, p398).

[4] Open-loop recycling is defined as "A recycling system in which a product from one type of material is recycled into a different type of product. The product receiving the recycled material itself may or may not be recycled. Also known as Cascade recycling" (Graedel & Allenby, 1995, p400)

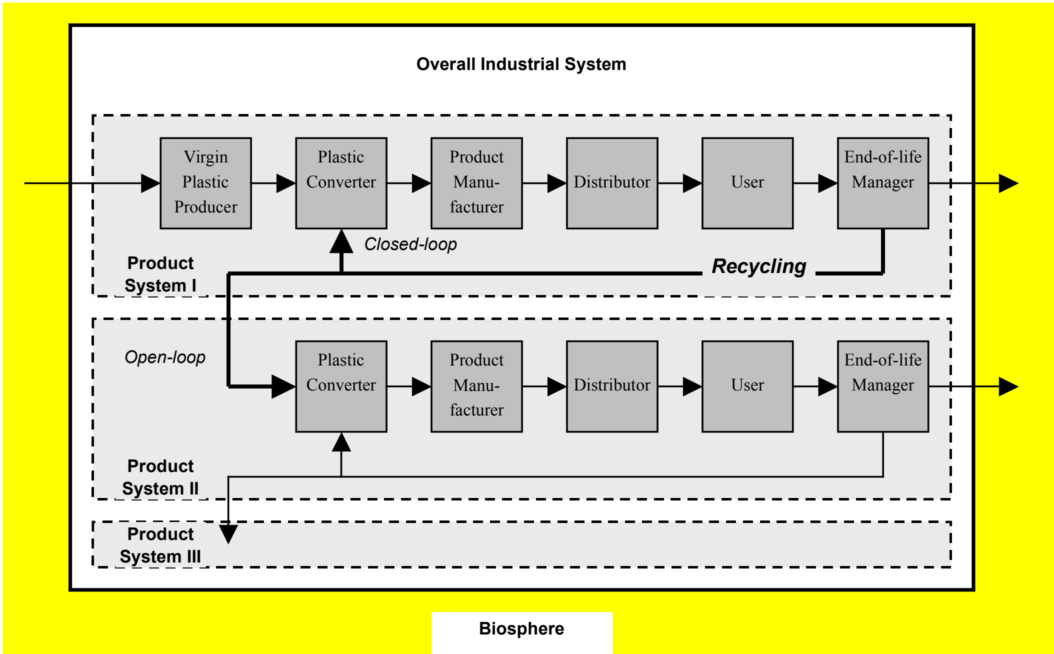

Figure 2-1 Material Flow of Plastics through Different Product Systems

Let us take the material flow of plastics in the industrial system as an example. The production of virgin material (the primary production) requires natural resources. Most of virgin plastics is produced from crude oil. In addition, the volume of post-consumer plastics in the waste streams has been considered problematic. To improve the pattern of resource utilization, different recycling options should be aimed to increase the resource productivity of plastics in the overall industrial system. In the case of plastics recycling, closing the material loop in one product system, or closed-loop recycling, is not always possible. In some cases of mechanical recycling (see 2.3.1 for more descriptions), the quality of plastics decreases after being recycled. Therefore, the recycled plastics may be able to not return to the original product chain for the same application due to the high quality demand, e.g. material strength or hygienic reasons. In these cases, the recycled material should be utilized in a second product chain, or open-loop recycling, where lower quality of plastics is acceptable (see Figure 2-1).

2.2 EPR as Strategy to Re-direct the Material Flow

Industrial ecology provides the theoretical picture of a sustainable industrial system. According to Solum and Brattebo (1999), "Industrial ecology may be considered as a new paradigm for how to deal with the production and product oriented environmental challenges of our industrial society." However, to bring the goals of industrial ecology into reality, efforts have to be put into practice. "The idea of industrial ecology must become institutionalized if they are to have much effect on the reality of everyday activities" (Ehrenfeld, 2001, p.870). After the idea has been introduced for around a decade's time, Ehrenfeld (2001) discussed about the institutionalization[5] progress of industrial ecology in the field of academia, industrial strategy and governmental policy. He considered that extended producer responsibility (EPR) has "become a part of EU policy and a key factor in moving towards a closed-loop society" (p.873).

[5] Institutionalization is defined by Ehrenfeld (2001) as the process by which the structures of beliefs and norms, cultural bases, paradigms, etc., become embedded through everyday societal activities and dualistically create the same activities. (p872)

OECD (2001) defines EPR as "*an environmental policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle*" and identifies two related feature of EPR policy: 1) the shifting of responsibility from municipalities upstream wise to the producers, and 2) to provide incentives to producers to incorporate environmental considerations in the design of their products. Traditionally, producers have not been particularly interested in considering the environmental qualities of their products beyond the point of sales or certain point in the use phase. The responsibility for waste management, in which recycling options are included, falls on the society, particularly the governmental authorities. This is not the most resource efficient way.

Since the early 1990s, a number of countries, mainly in Western Europe, have begun to adopt the concept of EPR into their environmental policy for managing products in the waste stream (Tojo, et al., 2001). EPR policy sends signals to producers to consider the life cycle environmental impacts of their products, in order to achieve the four principal goals (OECD, 2001):

- Source reduction (conservation of natural resources/materials),
- Waste prevention,
- Design of more environmentally compatible products,
- Closure of material use loops to promote sustainable development.

We may say that EPR policy aims to extend the *boundary* of the policy effect to the entire life cycle of the product system, including stages of material extraction, component manufacturing, product manufacturing, distribution, use and end-of-life management. Though EPR includes the intention to create upstream effect for the reduction and prevention of resource consumption, in this research, the author mainly discusses about its goal of 'closing the loop' of material use at the end-of-life stage.

EPR programmes have been implemented for various *products* or *product groups* such as packaging, batteries, automobiles, solvents, paper, plastics, tires, carpets, and electrical and electronic equipment (EEE), which are of very different sizes, complexities, durability and prices. But the focus has been put on products that impose pressure on the environment (containing hazardous substances), add volume of waste (high volume) and have low potential for recovery and recycling (difficult to manage) (Tojo, et al., 2001 and OECD, 2001).

The mechanism of EPR programmes has may fall on a continuum from mandatory to fully voluntary: mandatory legislation or regulations, negotiated agreements between the government and producers, and voluntary initiatives by producers (Tojo, et al., 2001). In this research, the author particularly looks into the programmes with a certain degree of governmental involvement, which are more on the policy basis.

Among various policy instruments for implementing EPR policy, there are three basic categories (OECD, 2001):

1) *Take-back requirements:*

Product take-back is regarded as the purest form of EPR and is frequently in use. It assigns the responsibility to the producers for the end-of-life management of their products. This type of programme is often associated with targets for collection and recycling and/or reuse. Pioneered in a large scale in the 1991 German Packaging Ordinance, the take-back concept is now applied to a wide range of products/product groups such as ELV, EEE, batteries, tyres, packaging and so on, with both voluntary and mandatory approaches.

2) *Economic instruments:*

The economic instruments provide direct financial incentives for producers to implement EPR and meet the objectives. Examples of these instruments include deposit-refund schemes[6], advance disposal fees, material taxes. It is important to ensure that a significant degree of the physical and/or financial responsibility is allocated to the producers when using economic instruments for EPR implementation. For example, if the material taxes are earmarked, the money paid by producers should be used for treatment of the end-of-life products subject to the programme, and the tax should be set to differentiate materials that have more ecological advantages.

3) Performance standards:

An example here is a target of a minimum amount of recycled content or secondary materials per product, which encourages take-back of materials for recycling and reuse. Minimum recycled content requirement may be found in use with paper products, glass containers and plastic beverage containers.

Lindhqvist (2000, p.118-119) identifies four groups of key actors in the implementation of EPR systems: *producers, users, waste mangers* and *authorities*. Producers[7], users[8] and waste managers[9] together cover all aspects of actors in the product systems. Authorities[10] are the external actors exerting influences on the actors in the focal product system. Figure 2-2 shows the actors and their relations.

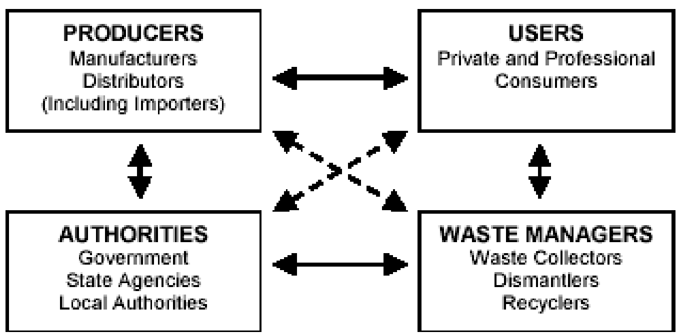

Figure 2-2 Four Group of Key Actors in an EPR System (Lindhqvist, 2000)

"EPR programmes generally *increase collection and recycling rates significantly* by making resources available that governments, by themselves, through taxpayer funding, are typically unable to commit" (Tojo, et al., 2001, p.36). Therefore, we may say that EPR policy has been designed to re-direct the material flow and do so in a more resource-efficient way.

2.3 Extending Material Life Cycle of Plastics

To realize the idea of industrial ecology and maximize the resource productivity, the material life cycle of plastics has to be extended after the post-consumer stage in the previous product system. In this part of the chapter, after a brief introduction of plastic types, the author discusses the plastic waste management, from which part of the materials are processed into secondary materials or recycled materials. Following the material flow, some of the recycled plastics enters the market. In the last

6 In a deposit-refund system, a payment (the deposit) is made at the purchase of the product and is fully or partially refunded at the return of the product to a dealer or specialized treatment facility (OECD, 2001).

7 *Producers* include all the actors from raw material extraction, component manufacturing, final product assembly and distribution. The distribution stage includes actors like wholesalers, importers, dealers and retailers.

8 *Users* include private and professional consumers.

9 *Waste managers* include the actors collecting the discarded products, the sorters, dismantlers, and recyclers.

10 *Authorities* include various governmental levels involved in the supervision and management of the EPR systems.

section, the author aims to identify the possible barriers and drivers in the market development of recycled materials, particularly plastics.

2.3.1 Brief Introduction of Plastic Types

Plastics are polymers. The size and structure of the polymer molecules determine the properties of the plastic material and thus allow great variety and versatility of materials of this category. There are two main groups of plastics: *thermoplastics*, which soften with heat and harden with cooling, and *thermosets*, which are cured or hardened by heat. Some major types of plastics in each group and some of their applications have been compiled in Appendix II. According to Association of Plastics Manufacturers in Europe (APME, 2002), in 2000 the large-volume, thermoplastic families of polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS & EPS) and polyethylene terephthalate (PET) represented 75% of total plastics consumption in typical plastics applications in Western Europe.

Plastics can also be categorized for scientific purposes into five groups: (1) commodity plastics, (2) engineering thermoplastics (or technical plastics, technoplastics), (3) high-performance thermoplastics, (4) functional thermoplastics (specialty plastics), and (5) thermosets (Bellmann & Khare, 1999).

2.3.2 Plastic Waste Management

The plastic waste management involves activities of three phases: *collection, sorting,* and *recovery/disposal.* Sorting is a crucial step for the recycling of plastics, and probably the most challenging one as well, due to the wide range of different plastics in the waste stream. According to Mader (1997), "difficulties in segregation of incompatible plastics can be a significant obstacle to the ready recycling of plastic waste." In order to produce high quality recycled material, contamination is not desirable or even not allowed. Different technologies for separation continue to evolve, to enhance its cost efficiency. However, upstream improvements in design, e.g. easy to dismantle, are also important.

Identification of various plastic types is an important issue for sorting and separation. In 1988, the Society of Plastic Industry, Inc. (SPI) in USA developed a resin identification code for rigid packaging, urged by the recyclers around the country to facilitate the recycling system. Nowadays, its use has extended beyond rigid plastic packaging and got growing international recognition. The identification system divides plastic into seven distinct types and uses a number code for each (see Figure 2-3). The symbol can generally be found on the bottom of containers or some part of other plastic packaging (American Plastics Council, 2000).

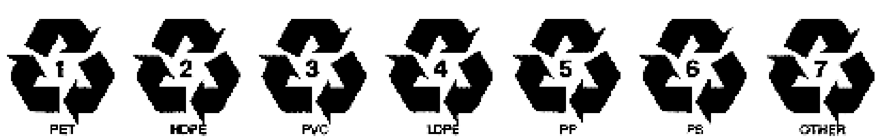

Figure 2-3 Identification Codes for Plastic Packaging

Figure 2-4 shows the possibilities in the last phase of plastic waste management: recovery/disposal. The resources in the plastic waste may be recovered to make use of its material content or its energy content. In the task group report "Collection and Recovery of Plastic Waste" made in 1995 from Norwegian Ministry of Environment, *mechanical recycling* is defined as recycling to do with "waste, sorted preferably by type and by similarity, that is smelted and re-used for the same purpose or for related products", and *feedstock recycling* as "the breakdown and conversion of polymer chains to constituent components. Both of them come under material recovery" (Plastretur, 2002b).

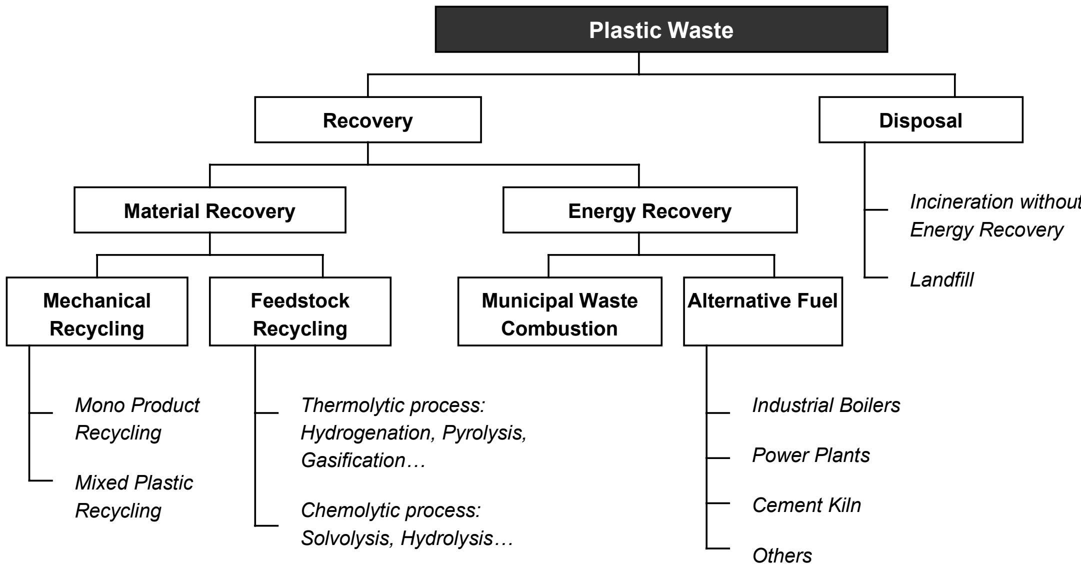

Figure 2-4 Last Phase of Plastic Waste Management[11]

"Mechanical recycling is the European plastics industry's preferred recovery route, provided recyclate can replace virgin plastics in an eco-efficient way" (APME, 2002, p.7). Mechanical recycling is the most environmentally favored method, since it reduces the material and energy required to produce new plastic material. However, mechanical recycling requires a high degree of homogeneity of the plastic waste, i.e. if the different types of plastics are not mixed, and to achieve this, it depends on the capacity of collection and sorting, which has to be environmentally and economically feasible. In cases where this is not viable, the recovery of the chemical value or of the high energy content of mixed plastics waste might become the preferable option (Mader, 1997).

The recycling of plastics is a complex issue with influencing factors of technological demands, economic considerations, energy consumption and environmental concerns (Bellman & Khare, 1999). With tools like life cycle assessment (LCA), different waste management options may be compared for their environmental benefits. A number of LCA studies show that there is no single optimal solution existing and the environmental and economical viability varies case by case. Therefore, an integrated system including various recovery options is necessary (Markovic, 1997).

According to Merkx (2000), chairman of the association of European Plastics Recyclers (EuPR), there are three main sources of plastic waste, the nature of which would influence their management:

- **Waste from industrial sector:** It is high quality and generally easier to exploit
- **Waste from households:** It is generally of low grade unless it is properly sorted at source. Municipal collection and sorting schemes may improve the quality of the recyclables.
- **Waste from end-of-life goods like EEE and ELV:** It is multi-material wastes, which require complex separation techniques. Design for dismantling and recycling and a product-specific take back system may enhance its end-of-life management.

[11] The 'Recovery' part of this figure is from Bellmann, K. & Khare, A. (1999). European Response to Issues in Recycling Car Plastics. *Technovation*. 19. p724.

In 2000, among the 19,540,000 tonnes of plastic waste in the Western European countries, 13% was material recovered (11% mechanical recycling[12] and 2% feedstock recycling), and 23% was energy recovered. The capacities of feedstock recycling came from mainly Germany and Austria. In various sectors, different percentages of mechanical recycling are achieved: 11% from municipal solid waste, 30% from distribution and industry, 4% from electrical and electronic sector, 10% from automotive sector (mainly PP from batteries and bumpers), 10% from building and construction and 53 % from agriculture (APME, 2002). These figures reflect the relative difficulties to mechanically recycle plastic waste from different sectors.

Clean fractions and an increasingly amount of mixed fractions of plastic waste after sorting can be mechanically recycled. As the quality of the recycled plastics gets improved, they can be used in an increasing number of products. There are a wide variety of plastics processing capabilities existing today. The most typical and longest standing approaches usually involve granulation of parts, followed by extrusion to create pellets that meet the specification regarding the physical, mechanical and appearance requirements of a certain application (Arola & Biddle, 2000).

In the last decade, plastic recycling gradually became a significant activity. For example, the recycling of plastic waste from packaging in Germany increased from close to zero in 1989 to more than half a million tons in 1997. A dramatic increase happened between 1992 (less than 50,000 tons) and 1994 (450,000 tons) (Lindhqvist, 2000).

2.3.3 Barriers and Drivers in Market Development of Recycled Plastics

After recycling activities, the supply of recycled materials is generated, and the market emerges, particularly when closing the loop for the material in the original application is not possible. Sometimes the recycled plastics enter a lower-end application, or the plastic may be upgraded via additional purification and/or compounding steps to meet high-end material specifications (Arola & Biddle, 2000). For example, there is limited demand of recycled plastics in the applications of food packaging, due to food safety regulations and concerns (APME, 2002).

It is recognized that the market of recycled materials is still at an immature stage (Watts, et al., 2001). European Commission has recognized that recycling is an important component of waste management strategy and launched initiative to improve *competitiveness of recycling industry* in 1998. A Communication was adopted, to identify the key problems and propose some solutions. On the supply side, "structural and technical weakness, in particular at the level of collection and sorting, constitutes a significant brake on the economic performance of the whole recycling chain." On the demand side, the problems include a lack of preference for recyclable and secondary materials due to their technical properties, limited applicability and/or negative image; a lack of industrial standard or even discrimination of standards. Additionally, the recycling markets are in lack of transparency (OneWorld Europe, 1998).

For example, Forsch (1994) classified the barriers to the industrial recycling of metals into six areas: *technical, economic, informational, organizational, regulatory* and *legal*. "Even when recycling is technically feasible, it may be economically unsound. Even when it is technically and economically satisfactory, a lack of information in the right places may block its adoption. And even when the requisite information is at hand, organizational problems can still stymie implementation. Finally, when all else is satisfactory, a recycling scheme can founder on the rocks of regulatory or other legal barriers".

The author tries to look further into the possible barriers and drivers existing in the market of recycled materials, and particularly for plastics. In a report written by the Market Development Group set up by the Department of the Environment, Transport and the Regions (DETR) in UK (1999), three long-term *barriers to increased demand for recycled plastic*s were identified:

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[12] This figure includes both mechanical recycling within Europe and exported out of Europe.

- Lack of sustained competitive pricing
- Resistance to use of recyclate in new products
- Sub-optimal technology and skills.

"Plastics recycling companies are often small and medium sized companies (SMEs), typically with a capacity of 5,000 to 20,000 tonnes per annum" (DETR, 1999, chap.4.4). Compared to the recycling of other materials, the plastics recyclers are more diverse and fragmented, partly due to the diversity of polymers and products and partly due to the comparatively low investment required for setting up a plastics recycling plant (DETR, 1999).

When energy and the raw material are cheap to produce virgin materials, it is not easy to develop solution for recycled plastics. The existing regulations or specifications unnecessarily limit the use of recycled plastics (Plastretur, 2002b ;OneWorld Europe, 1998). Moreover, the price of recycled plastics has its dependency on price of virgin material. The year 2001 was a year with sinking prices of plastic raw material. "These price falls were also felt by the recycling market. In such turbulent times, Europe sees some recycling companies go out of business… The recycling industry receives more stable support when prices are low" (Plastretur, 2002a, p.16).

Another report entitled 'Developing markets for recycled materials' (AEA Technology, 1999) produced for the Department of Trade and Industry in UK discussed about a number of *factors influencing the demand for recycled materials* in general:

- Technical barriers
- Standards
- Health & Safety aspects
- Cost/price
- Perception of performance
- Ensuring supply
- Over capacity of primary production
- Size of market
- Information requirements

Particularly for *recycling of plastics*, the report mentioned the following barriers:

- Quantity, quality and consistency of supply
- Price of recovered polymer
- Use in packaging destined for food contact applications

According to the California Integrated Waste Management Board (2001), analyses show that *barriers to developing markets for recycled materials* include:

- Lack of reliable market information
- Lack of consistent supplies of sufficient quality
- High costs in using secondary materials, covering collection, transportation and processing
- Manufacturer and consumer wariness of products made from secondary materials
- Financial barriers

However, other than various types of barriers identified, there are also drivers or stimuli that offer 'incentives' to the actors in the industry to change their behavior towards using recycled materials. One Dutch study was conducted to learn about factors that stimulate and hamper small and medium sized companies (SMEs) towards greening their products via various eco-design solutions (Van Hemel & Cramer, 2002). Under the eco-design principle of 'recycled materials', as the most frequently mentioned in the survey, the *external stimuli* included governmental regulation and customer demands; the *internal stimuli* include environmental benefit, cost reduction, image improvement and new market opportunities.

In order to enhance the market development of recycled plastics, it should be aimed to remove the above-mentioned barriers and to amplify the drivers.

2.4 EPR and the Market Life Cycle of Plastics

EPR policy is applied in some Western European countries to deal with different products or product groups with various material contents. For simple products like packaging, it is easier to reprocess the collected materials for further use. For complex products like end-of-life vehicles (ELV) and electrical and electronic equipment (EEE), a lot of efforts has to be devoted into dismantling and sorting before the materials may be recycled. Considering the material flow of plastics, various types of plastics may come out as a result of EPR programmes covering different product groups with plastics content. The outcome of these EPR programmes, therefore, is expected to influence the material flow of plastics into the next product system. For example, the German Packaging Ordinance was implemented in 1991 and set the recycling targets of plastic packaging waste. Plastics recycling increased dramatically between 1992 and 1994.

In some EPR programmes, targets for recycling or recovery are set to assure the treatment of end-of-life products. Even in the EPR programmes without specific recovery targets, the mechanism for collecting the end-of-life products increases the possibility to make use of the material contents. Thus, these EPR programmes help to prolong the material life cycle.

About EPR's impacts on the market, Tojo et al. (2001) mentioned: "Some argue that in order for the recycling system to work properly, it is important to develop the market for the secondary materials first. Others argue, however, that after a certain time passes since the market for recycled materials become saturated, a new market will occur." "EPR programmes can have a significant impact on markets for recyclable materials as they create additional supply, especially if they are subsidized" (OECD, 2001, p.70). For example, the excessive supply of recyclable plastics and paper generated in EPR programmes for packaging can be problematic. The national surpluses were 'dumped' on international markets at very low price (OECD, 2001). Nevertheless, markets for recyclable materials have been deepened over the last decade, and the range of uses for the recycled material has also been expanding.

Among the stated goals for Plastretur AS, the Norwegian producer responsibility organization[13] (PRO) for plastic packaging, we may find "*to decrease gradually the different support arrangement and to build up a sustainable market for recycled plastic packaging*", which explicitly relates the market aspect within the EPR realm.

"Policy makers should consider the impact of new EPR schemes on the secondary markets for the collected materials" (OECD, 2001, p.70). However, while studies and reports can be found being made for the understanding of EPR mechanisms and outcomes, not many researchers have looked specifically into the influences or impacts of EPR programmes to the market of recycled materials. Røine (2002d) carried out a case study about using recycled polyethylene (PE) in carrier bags. The result shows that the triggering factor is the customer demand. Factors like EPR implementation and existence of recyclers are only premises whose presence supports the case occurrence. Considering the broader resource perspective in industrial ecology, the author thinks there is a need to strengthen the

[13] In some EPR programmes, the producers create a collective system to fulfil their responsiblity for collection and recycling, which is referred to as producer responsiblity organization (PRO) (Tojo, et al, 2001).

understanding about whether the implementation of EPR programmes plays an important role to somehow strengthen the market position of the recycled materials.

To achieve this purpose, the author selects *material chain*[14] as the unit of analysis and regards the use of recycled plastics to replace virgin plastics as a *change process* in the existing material chain using virgin plastics. After the EPR product systems, the recycled plastics flows into the market to be used in the successive product system. In this research, the *key actors* in the material chain to be studied for using recycled plastics include: the plastic recyclers, the plastic converters, the product manufacturers and the end-users of the product (see Figure 2-5).

In the following chapter, the author aims to understand some theoretical perspectives about the relationships and rationales of the focal actors and the change process in industrial systems, based on which an analytical framework for this research is to be established.

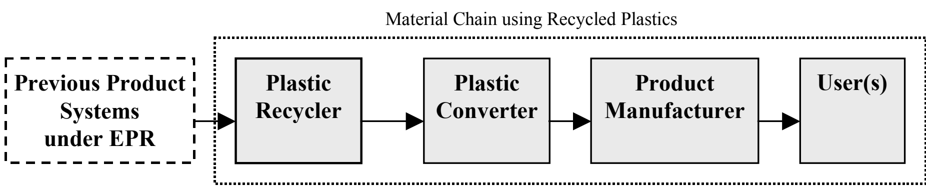

Figure 2-5 Key Actors in the Material Chain of Recycled Plastics

[14] Boons (1998) mentions several ways to draw the system boundary and differentiates 'material life cycle' from 'product life cycle'. "Material life cycle is similar to the product-approach. The boundary can also be drawn around actors dealing with a specific material such as steel, plastics and platinum." (p.153).

3. Theoretical Perspectives and Analytical Framework

In this chapter, the author aims to provide the theoretical perspectives that lay out the background of this research and to establish the analytical framework.

3.1 Structures and Actors in Industrial System

Change is fundamental in every dynamic system. Society and natural ecosystems are continuously changing, driven forth by internal and external forces. In industrial ecology, changes such as loop closing and improved metabolism, are to be introduced towards reducing the environmental impacts. To understand about changing the industrial metabolism into a more sustainable manner, Røine (2002c) applies the structuration theory of Giddens proposed in 1984 and recognizes that "human actions are enabled and constrained by structures and that these structures are the result of previous actions". Therefore, the author agrees that before the discussion about change process, there is a need for some knowledge on the *structures* and *actors*.

3.1.1 Social Structures

According to Graedel & Allenby (1995, p.63), "Industrial systems operate within societies and their economic structures, rather than distinct from them. The relationship produces benefits, such as the creation and expansion of markets; it also produces liabilities, such as environmental impacts. As a consequence, industrial systems are constrained by governmental policies and regulations, and more broadly, by social morays and economic and technological conditions."

Other than the natural structures in the biosphere, the industrial system is supported or constrained by *social structures* such as physical infrastructures, political systems, societal values and so on. However, according to Gidden's structuration theory, these structures are not "given, external, over-individual and physical facts", but instead, they are the result of previous actions (Røine, 2002c).

Through these "physical, political, economic and cultural structures", changes in the industrial system may be either stimulated or restrained (Røine, 2002c). If we take recycling as an example, it is influenced by the infrastructures of waste management, governmental measures such as laws, regulations and taxes, market pulls and the social trend. All of these influencing factors have been formed as solutions to today's problems resulted from yesterday's actions. The decisions and actions of the actors are influenced by these structures, but at the same time, they are also the ones that contribute to the formation of these structures.

3.1.2 Product Chain as a Network of Actors

In this section, the author first aims to understand the rationales of actors in the industrial system, adopting the model of industrial network. In the model of industrial network proposed by Håkansson and Johanson (1992), there are three basic classes of variables: *actors, activities* and *resources*. Actors, which can be individuals, groups of individuals, parts of firms, firms, or groups of firms, control activities and/or resources. An activity occurs when one or several actors combine, develop, exchange or create resources by utilising other resources. There are two main kinds of activities: transformation activities, through which resources are changed by one actor, and transfer activities, through which control over a resource is transferred from one actor to another. Resources are heterogeneous. One definition of industrial network describes it as "sets of connected exchange relations among actors performing industrial activities" (Håkansson and Johanson, 1993, p.40). The network of actors are embedded in a larger context of social, economic and technological system" (Andersson & Sweet, 2002).

Actors like companies or organizations interact with each other and develop relationships in order to "exploit and develop their resources". Turnbull et al. (1996) categorize these resources into three categories: (1) financial resources, (2) a company's network position[15] and (3) skills the company possess – a set of technologies. Organizations may be viewed as "open systems dependent upon their environment for needed resources and legitimacy" (Sweet, 2000, p.45). This interdependence takes many forms. Most obvious is "the need to generate revenue from other companies for existence and development" (Turnbull, et al., 1996). In reality, organizations are rarely completely autonomous. "To a large extent they are dependent on other organizations for attaining their goals, in terms of physical resources and social resources." This *resource dependency theory* also holds for environmental issues (Garcia, 1999, p.12).

"The main focus in industrial network studies is on connected relationships where there is an element of economic exchange, usually involving *buyer-seller relationships*" (Sweet, 2000, p.39). However, there is a need to integrate the non-economic exchanges into network analysis as well. Andersson & Sweet (2002) mentioned that five types of interdependent bonds have been identified: *technical, temporal, knowledge, social and economic/administrative* bonds. "The characteristics of these bonds have implications for a single firm's possibility to act, in that it is dependent on other actors to pursue a specific change" (Andersson & Sweet, 2002, p.467).

Among different types of industrial networks, the *product chain* is "the set of actors, and their relations, that are directly responsible for the material streams in the life cycle of a product" (Boons, 2002, p.496). The life cycle of the product chain include different phases: extraction of raw materials, production of intermediate products, production of end products, distribution, consumption, recycling, and disposal. Product chains include *flows of materials, money and information* between the actors involved. "All the parties in a product chain depend on each other in the search for, and implementation of, environmental improvements within the chain" (Garcia, 1999, p.12). Between the actors in a product chain, there is symbiotic dependency[16].

Product chain management has got growing attention in recent years, but its practical experience is still in infancy (Garcia, 1999). Boons (2002) proposes a framework for product chain management, which consists of three building blocks:

(1) *The product chain as a network of actors*: The actions of the actors in the product chain are coordinated by mechanisms such as markets, joint ventures, cooperative network, collective agreements and so on. Actions happen both *within* a phase (i.e. production) and *between* phases (i.e. between production and distribution). The relations between actors can be scaled on the continuum between *strong* and *weak* (Boons, 2002).

(2) *The options available to reduce the ecological impact of a product*: These options include *material reduction, material substitution, material recycling, product substitution, product substitution, product recycling* and *eliminate function*. Among them, material recycling is "recycling a material which constitutes the product", which is closed-loop recycling; and material substitution is "replacing one or more materials for ones that have less negative ecological effects", which open-loop recycling of plastics may fall within.

(3) *Assumptions about the behavior of actors in the product chain*: Here Boons makes two assumptions. The first one is related to the resource dependency theory. Actors tend to act towards *dependency reduction* from other actors, in order to gain control and reduce costs. The second assumption is based on the economic approaches for firms to make rational choices, *utility maximization*. Each

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[15] According to Turnbull et al., network position is both an outcome of past relationship strategy and a resource for future strategy. It consists of the company's relationships and the rights and obligations which go with them.

[16] Boons and Baas (1997) mentioned two types of resource dependency: *competitive dependency* exists between organizations that have similar goals; and *symbiotic dependency* exists when the output of organization A is the input of organization B.

individual actor weighs the costs and the benefits in choosing an action. Boons considers the increased dependency as a cost for the actors.

As mentioned in chapter 2.4, the author uses 'material chain' as the unit of analysis to understand the extension of material life cycle of plastics. According to Boons (1998), material life cycle is similar to the product approach, but with a different system boundary. Therefore, the above-mentioned discussion about actors in the product chain should be valid for the actors in the material chain.

3.2 Change Process

In this section, the author discusses stages in the change process and the influences to the change process. In the industrial networks, the development of exchange relationships, activities and routines tends to create *stability* overtime. Stability is both a restriction to and a prerequisite of change. *Changes* occur through adaptation and problem-solving processes in the established network settings. The property or tendency of a system to remain stable and to resist change is called *inertia*. "Social inertia is a physical metaphor in which social entities are characterized as bodies in motion" (Sweet, 2000, p.72). Such inertia may also be observed in the industrial network of actors, for example, in the **existing material chain** using virgin plastics.

Change towards sustainable industrial system is a problematic process (Andersson & Sweet, 2002). To understand the change process, we need to keep in mind that "resistance to change is inherent in the organizational structure" (Sweet, 2000, p.77). Various factors contribute to inertia, for example: existing investment, interdependency and structural complexity in the network, and standardization of activities. While internal factors tend to inhibit rather than stimulate changes, change-promoting forces are usually resulted from external pressures such as evolving technologies and governmental regulations. The development of environmental policies may be considered as an initiator of change processes towards more environmentally suited behavior (Sweet, 2000). Boons (2002) considers as the triggers to the actions for the individual actors either *external pressure* (from government and/or environmental groups) or *the wish to use ecological arguments in their marketing*. When one actor or a group of joint actors in the material chain decide that some change has to be introduced, the author calls it **the initiation stage**.

However, the change processes may be "shaped and altered by processes pertaining to exchange relationships and resource dependencies in the industrial network" (Sweet, 2000, p.35). The exchange relationships between actors might "restrain, facilitate and/or influence the change at the industrial network level" (p.39). "New insights into the handling of resources can break existing activity cycles and transfer chains and contain the seeds for development and change in industrial networks." (Håkansson and Johanson, 1993) In the change process, new relationships may need to be formed while some existing relationships are to be broken in the network. For example, "for eco-design and integrated chain management to be successful, actors must be able to make as well as break networks of stakeholders" (Boons, 1998b, p.31). This may be considered **the formation stage** of a new material chain. After the new chain is formed, it enters **the operation stage** when material flow, economic flow and information flow along the chain occur.

Trudgill (1990) identified barriers to finding and implementing solutions to environmental problems and classified them into six major categories: agreement, knowledge, technological, economic, social and political. According to Trudgill, the barriers will often, but not necessarily, operate in this sequence. From the recognition of the environmental problem to implementing solutions, people need to agree that something has to be done about a problem, build the knowledge about the cause of the problem, establish the technology to tackle the problem and then deal with the economic, social and political factors influencing the implementation. In this research, the author aims to understand the process of an observable change (using the recycled plastics). Therefore, the author discusses the *technological, economic, social and political factors* that may influence the change process. "How change processes influence the resulting patterns of behavior in network structures is related to the actors' abilities to adapt and adjust resource and activities relative to each other, and to interdependencies in the economic and technological systems of which they are a part" (Sweet, 2000, p.41).

♦ **Technology factors**

Turnbull et al. (1996) separate technologies into three areas: product technology, process technologies and market technologies. They argue that "technologies are the basis of all companies' existence, but, in themselves, the technologies have no value" (p.48).

Technologies evolve to satisfy human needs, and thus, play an important role in solving environmental threats. However, "concluding that one product is more eco-efficient than another does not automatically lead to product substitution. This is due to 'freeze-in' (or 'lock-in') of inferior (less ecological friendly) technologies. *Timing* is important and can lead to the victory of a technology that is not optimal. This so-called *path dependency* is a general phenomenon in technological innovation, but applies also to 'ecological' innovations" (Boons, 2002, p.495).

However, Solum & Brattebo (1999) recognize that in the change process of the current socio-economic structures, technical change is often not the critical obstacle, as compared to the changes required in the social processes.

♦ **Economic factor**

The organizations or actors in the industrial system are business entities, which means, their primary goal is to make profit. The economic behavior of individual actors is rationalized towards utility maximization, i.e. *maximizing benefits and minimizing costs*. However, "it is not assumed that a socially optimal outcome will result from the interactions of actors in the product chain." Individually rational behavior may lead to an increase in social costs (Boons, 2002, p.503).

♦ **Social and political factors**

A lot of discussions among the researchers have focused on processes of change induced by economic and technological factors. However, Brito (2001) points out "there is a growing evidence that *institutional considerations* are likely to be particularly relevant" (p.150). Carpenter & Feroz (2001) argue that institutional theory is complementary to economic theory in general, and resource dependency theory in particular. "Institutional theory views organizations as operating within a social framework of *norms, values, and taken-for-granted assumptions* about what constitutes appropriate or acceptable economic behavior…. They are rewarded for doing so through increased legitimacy, resources and survival capabilities" (p.565). Therefore, there are two types of incentives to reward individual network members to contribute to the collective action: *monetary* and *social* (Brito, 2001).

Each of these actors has their own interest, which might be determined by non-economic factors such as organizational values, politics, and institutional norms (which the author describes as *intra-organizational factors*). The production and consumption of a product involves the activities of a number of actors. Therefore, changing a product is a social process involving several actors, such as consumers, suppliers, and even external actors like governmental agencies and environmentalists. This is *social embeddedness* of economic activities (Boons, 2002). The existing relations between actors in the product chain may provide barriers to change. "Such barriers may result from the fact that actors do not, and have no incentive to, share information about their products and production processes. Another possibility is that imbalances in the power distribution within the product chain lead to the implementation of options that are close to the status quo (incremental rather than radical)" (Baumann, et al., 2002, p.420). Therefore, *inter-organization coordination* between the actors in the product chain is important to introduce the environmentally positive change.

In addition, organizations are influenced by pressure from social forces in their environment. Examples of such pressures are laws, regulations, and societal norms. Governmental authorities are one of the important external actors, influencing the product chain by setting laws, regulations, taxes, strategies and infrastructures. This is not part of the market mechanism (Røine, 2002c), but is particularly important in adjusting the increased social costs from the externalities resulted from industrial activities. Some examples of other external actors that may be influential are environmental groups and industry associations.

After discussing the influencing factors to the environmental positive change, the author would like to add one more stage, **the diffusion stage**, to make the linear change process into a change cycle. If an environmental positive change is successful, its experiences should be extended and disseminated to induce the next change. "Diffusion" is used to describe "how innovations are adopted in different firms over time" (Hildén et al., 2002, p.23). According to Hildén et al. (2002), diffusion is affected by many factors, including: information and learning, characteristics of potential adopters, characteristics of technology, fixed resources and the effect of adoption on output prices. "The effects of environmental policy instruments on innovations and their diffusion are one of their most important features, especially in the long term" (p.23).

3.3 Influence of Environmental Policy Instruments

In the previous section, we mentioned the 'political factor' as one of the influencing factors to the environmental positive changes. Government is an important external actor[17] *intervening* the activities of actors in various product chains in the industrial system. Some people apply intervention theories to "describe how the policy is intended to be implemented and function" (Hildén, 2002, p.21). Intervention theories consist of the following elements: various *actors* including the decision-making entities, the implementing agencies and the target addressees; the administrative *inputs* and *outputs*; and the *outcomes* as actions taken by addressees when faced with intervening outputs.

Hildén et al. (2002) categorize environmental policies into three main types, based on the degree of authoritative force involved: *regulatory instruments, economic instruments* and *information*. Regulatory instruments aim at "alteration of the set of options open to agents". Economic instruments aim at "altering the benefits and/or costs of the agents". Information as a policy instrument aims at "altering the priorities and significance agent attached to environmental issues" (Hildén, 2002, p.19).

Hildén et al. (2002) also divide the effects of environmental policy instruments into three levels: first, anticipated and unanticipated effects; second, whether effects occur inside or outside the target area; and third, the qualitative categorization of the effects. Other than intervening the activities of the actors, the implementation of environmental policy can also influence the social structures mentioned in chap. 3.1.1. These structures then directly or indirectly stimulate or support an environmentally positive change or restrain it from happening.

Three general categories of systematic environmental policy evaluation were distinguished: 1) *outcomes*, 2) *process*, and 3) *institution*. "Each of these comprehends a variety of evaluation criteria in its turn" (Jänicke & Weidner, 1995, p.13). However, "any choice of criteria reflects a value judgment. While value choices can never be avoided, they should be expressed as explicitly as possible. Two general approaches are recognized: a descriptive and a prescriptive approach. In the prescriptive approach, the evaluators select the criteria" (Hilden, 2002, p.17).

Jänicke & Weidner (1995) choose to use a different approach from the traditional top-down approach to evaluate the outcome of environmental policy. They start with "the real impact – *ecologically positive change*, and go on to look for its reasons, which could be a special policy or other influences". From the change, they seek the intervening factors. They consider this *from-effect-to-cause* method having the

[17] External actors here refer to "actors outside the product chain, who do not have a direct participation but nevertheless influence the decisions taken by the actors" (Garcia, 1999, p.11).

advantage of the openness to possible causes, and point out that the top-down approach tends to ignore non-governmental influences that might be important. The process of successful environmental protection is much more complex than what people can tell from a linear, means-to-ends perspective (Jänicke & Weidner, 1995).

The author thinks it is reasonable to adopt the from-effect-to-cause approach for the purpose of this research, and discuss the drivers and barriers of a change together with the related environmental policy in order to see the contributions of the policy.

3.4 Analytical Framework

3.4.1 Developing the Analytical Framework

Based on the theoretical perspectives and discussions presented above, the author develops an analytical framework for this research to understand the contributions and influences of a certain environmental policy to an observed environmentally positive change.

1) Observing the change process:

The change process may be observed and divided into four stages proposed above: the initial stage, the formation stage, the operation stage and finally, the diffusion stage.

2) Identifying the drivers and barriers to the change

Among all the drivers and barriers, the author focuses on identifying *the triggers to the initiating actors* and *the influencing factors to the change process.* And discussion will be made in the diffusion stage of experiences.

3) Discussing the contributions of a certain environmental policy to the drivers and barriers

Finally, to understand the role of a certain environmental policy on promoting an environmentally positive change, the author aims to discuss its contributions to and connections with drivers and barriers identified above.

Figure 3-1 shows the process flow of the proposed analytical framework.

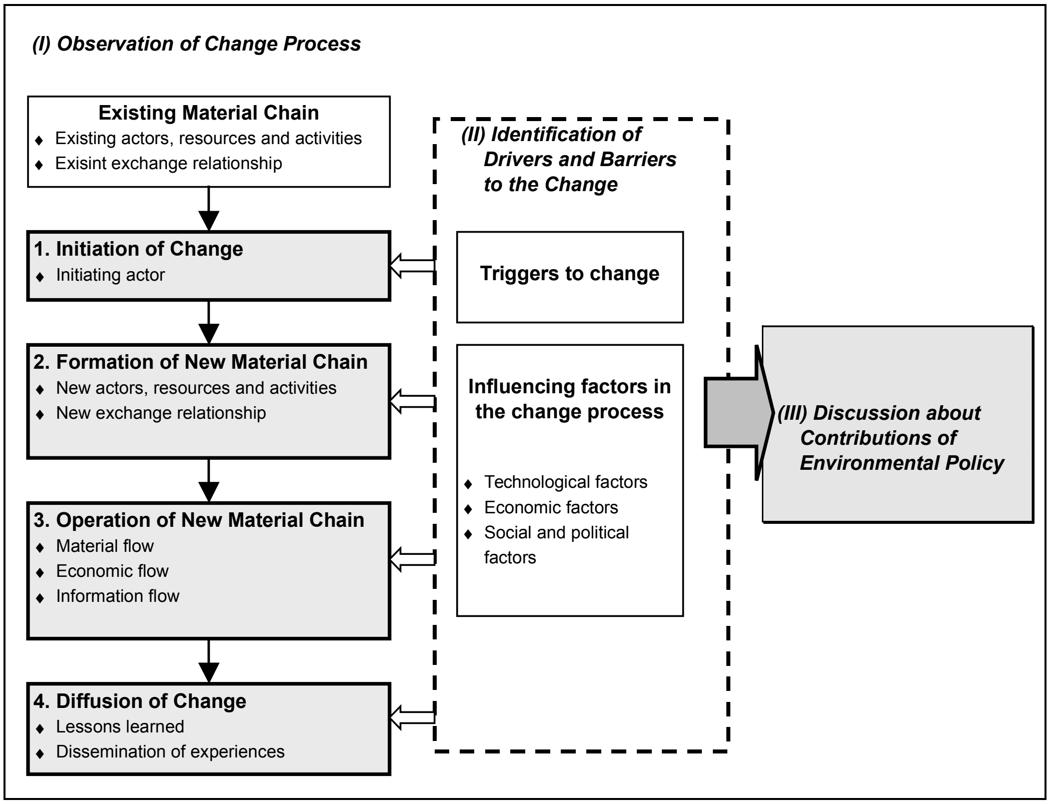

Figure 3-1 Proposed Analytical Framework

3.4.2 Adopting the Analytical Framework

Once the analytical framework is established, the author adopts it to the research context as following:

1) Observing the change process of using recycled plastics in the material chain:

In this research, the author chooses two Norwegian cases of using polypropylene (PP) in chairs. The material chain is the unit of analysis.

2) Identifying the drivers and barriers to the change:

Before further discussion, the author would like to mention that the drivers and barriers identified here are not the ultimate list, but to facilitate the analysis of understanding the role of EPR in the change.

Triggers to change: The change in the material chain is initiated by one actor or the joint decision of several actors. The initiator(s) may be identified during the observation of change process. The author would like to examine the cases with two triggers proposed by Boons (2002) are *the external pressure* and *the wish to use ecological arguments in their marketing.*

Influencing factors in the change process: From initiation to the happening of the actual change, there are different factors influencing the change process. The following factors were first identified as 'barriers' to carry out solutions for environmental problems (see chap. 3.2). In the cases selected in this research, such barriers might have existed, but have to some extent been overcome. Therefore, we discuss these barriers as influencing factors. Based on the background discussion in chapter 2 and the previous sections of this chapter, the author adds some details into each category of influencing factors, laying the basis for analysis and discussion of the cases studied. During the process, the author recognizes that these factors are to some extent interrelated. However, without categorization of factors, the complexity of the analytical work would be too high.

For the *technological factors,* the author summarizes the technical concerns and constraints into different stages in the material chain of recycled plastics (see Figure 3-2). Though out of the boundary of the defined material chain, sorting has been identified as a crucial step in plastic waste management. Thus, the author decides to include the sorting stage in the discussion.

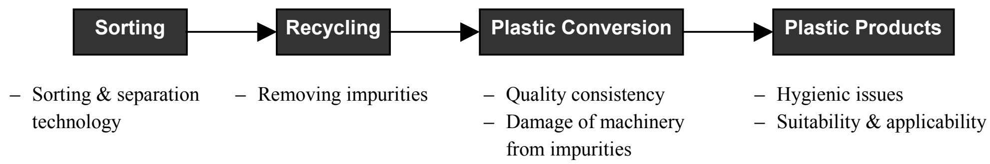

Figure 3-2 Technical Constraints and Concerns of Using Recycled Plastics

For the *economic factors*, the author summarizes the possible benefits and costs of using recycled plastics in Figure 3-3.

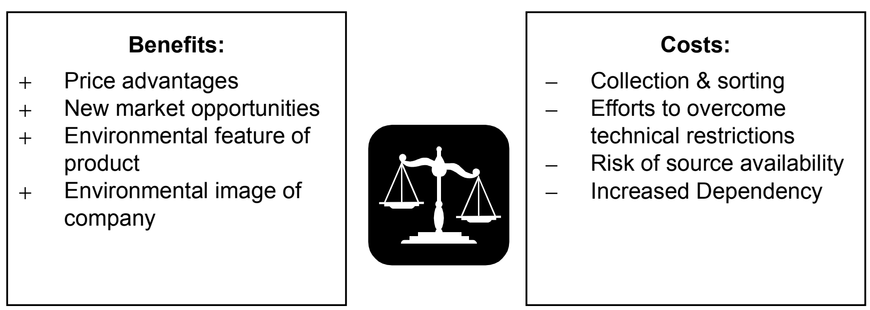

Figure 3-3 Benefits and Costs of Using Recycled Plastics

The price advantages of recycled plastics have a high correlation with the cost of collection and sorting. New opportunities, environmental feature of products and environmental image of company together form market benefits, from which the actors expects higher sales or higher consumer willingness to pay to increase their revenues. To deal with various technical constraints mentioned in Figure 3-2 results in additional cost. Virgin plastics offer a much higher variety in terms of performance feature than recycled plastics. When the technical issues have been settled for the specific applications, another challenge is the reliability of sources. The plastic users require that the plastics be supplied in reliable high volumes and have very consistent processing and performance properties. No plastic user is ready to spend the time and money to qualify a new material for an application unless they can be assured that the material supply is reliable (Arola & Biddle, 2000). Another item on the list of costs is the increased dependency (Boons, 2002) on certain material suppliers (recyclers). For analysis and discussion, the author proposes to group the above-mentioned benefits and costs into the following:

- ♦ Price advantage and the cost of collection and sorting
- ♦ Market benefits
- ♦ Efforts to overcome technical restriction
- ♦ Risk of source availability
- ♦ Increased dependency

The author thinks that in general, the *social factors* can be examined by two main categories: *organizational* (or intra-organizational) and *inter-organizational*. Within one organization, the transformation activities are carried out. Their decision-making is determined by their own interest, their subjective perception and value judgment. However, since the organizations are in fact embedded in the society, it is not always easy to say if an influence is purely intra-organizational. When a change involves the activities of several actors, there are transfer activities taking place between organizations. The change process would be influenced by the information flow and the inter-organizational coordination. In addition, *political factors* may interfere with the change process when external actors outside of the material chain, e.g. governmental authorities, environmental groups and industry associations, exert their influence. From the above discussion, the author decides to look at the following items for the social and political factors:

- ♦ Organizational status
- ♦ Perception
- ♦ Information flow and inter-organizational coordination
- ♦ Influences of external actors

Finally, from the lessons learned by the actors and the dissemination of experiences, the environmentally positive change may be diffused. Diffusion can be affected by factors like information and learning, characteristics of potential adopters, characteristics of technology, fixed resources and the effect of adoption on output prices.

3) Discussing the contributions of EPR programmes to the identified drivers and barriers:

In order to reach the purpose of this research, the author discusses the contributions of EPR policy instruments in promoting the use of recycled plastics. To evaluate the effect of environmental policy, some researchers would set up criteria, either descriptive or prescriptive, to carry out the task. However, in the case of this research, the actors in the selected material chains are not the target actors to be bound by EPR programmes. Therefore, it is difficult to set criteria as in the traditional policy evaluation. The author adopts the from-effect-to-cause approach mentioned in previous section and tries to link EPR implementation with the identified drivers and barriers of the change to use recycled plastics.

4. Material Flow of Plastics in Norway

According to Mader (1997, p.23), "All plastics are tailor-made; their properties are optimized for each application." Such feature of plastics makes it a popular material among designers and users, but it also generates a more complicated scenario for the end-of-life treatment of this material.

In this chapter, the material flow of plastics in Norway will be briefly examined. First the author presents data about the production and consumption of plastics, and then the situation of plastic waste and its management.

4.1 Plastic Production and Consumption in Norway

The plastic industry in Norway consists of *plastic producers*, who produce the polymer raw material, and *plastic converters*, who process the plastic raw material into products or components that are either semi-fabricated or finished.

In an overview put together by Plastindustriforbundet (the Norwegian Plastic Industry Association) in year 2000, the six major plastic producers in Norway, who are quite internationally active in both production and sales activities, produced about 2 million tonnes of polymer raw material per year, creating revenue of 7,600 MNOK (million NOK[18]), of which 70% is from export. There are about 500 plastic converters nation wide in Norway. They process around 270,000 tonnes per year of plastic raw material. About 250 companies, half the number of the plastic converters, mainly deal with the further processing of thermoplastics and consume 250,000 tonnes per year of plastic raw material. A considerable part of their business goes for exporting as well (Kildahl, 24 July 2002).

The statistical figures show that the import of plastic material in Norway rivals export. In the first 6 months of year 2002, the import of plastics in both primary and non-primary forms amounted to 2,456 MNOK in value, while export amounted to 2,475 NOK (Statistics Norway, 2002a).

According to APME, in the year 2000, plastics consumption of plastics processor's in Western Europe (EU countries plus Norway and Switzerland) was 36,769,000 tonnes, an increase of 3.4 per cent from 1999. Among this quantity, Norway consumed 295,000 tonnes, about 0.8 per cent (APME, 2002).

Looking at the plastic consumption in Western Europe by industry sector, packaging, which accounted for 13,717,000 tonnes or 37.3%, was the largest sector. The others, in the order of percentages, were: other household/domestic 21.3%, building and construction 18.9%, electrical and electronic 7.3%, automotive 7.2%, large industry 5.4% and agriculture 2.6%. The author did not get access to corresponding figures for the Norwegian condition.

4.2 Plastic Waste in Norway

According to APME (2002), the total post-user plastic waste in the Western European countries summed up to 19,540,000 tonnes, in which 66.8% came from municipal solid waste, 20.9% from distribution and industry, 4.2% from electrical and electronic sector, 3.9% from automotive sector, 2.8% from building and construction and 1.4 % from agriculture. In this report, the total plastics waste collectable in Norway amounted to 179,000 tonnes.

In Norway, the amount of plastic waste has been rising steadily throughout the 1990s. Between 1986 and 1998, the quantity of plastic waste generated in Norway has increased by 52% (Statistics Norway,

[18] NOK is the Norwegian Kroner. 1 USD=7.5622 NOK (http://www.dn.no/borsmarked/pValuta.jsp) [18 September 2002]

2001). A more recent statistics shows that the increase of plastic waste generated has been eased (see Figure 4-1) (Statistics Norway, 2002b).

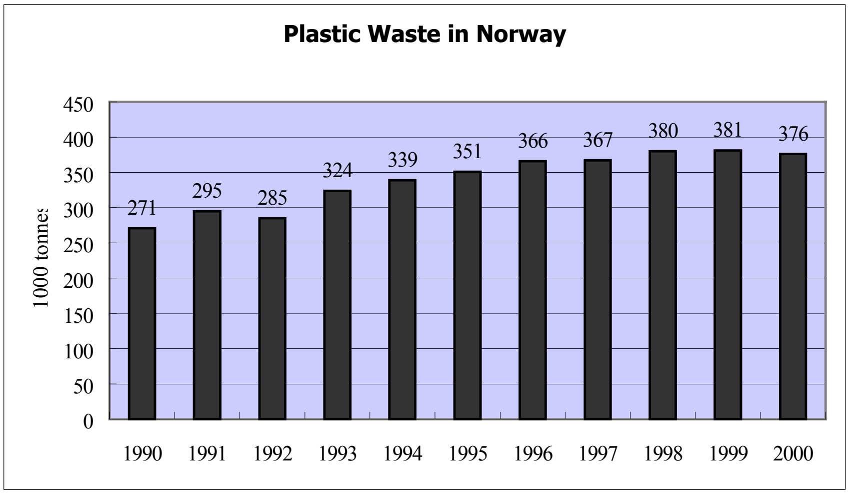

Figure 4-1 Plastic Waste in Norway, 1990-2000

Figure 4-2 shows the plastic waste by product categories. In year 2000, the plastic waste generated was 376,000 tonnes[19]. Categorizing the amount according to product type, the main product types are packaging (35%), furniture and household products (22%), constructions and buildings (14%), and EE products (11%).

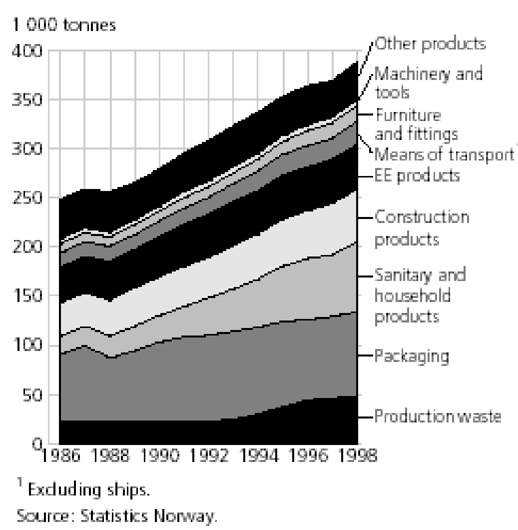

Figure 4-2 Plastic Waste in Norway by Product Categories, 1986-1998 (Statistics Norway, 2001)

In the system of plastic packaging organized by Plastretur AS (the material company, or PRO), the plastic packaging that ended up as waste in Norway in 2001 was 107,000 tonnes. This figure includes

[19] The waste figures from APME and Statistics Norway differ to a large extent. The author tried to understand this with both organizations. The possible reasons can be different coverage scope and waste defintions (for example, APME figure does not include for instance PP sacks and plastics in textile products) and the different data source and quality. (Rubbens, 14 August 2002) (Skullerud, 28 August 2002)

agricultural film and foil, but excludes EPS (extended polystyrene), packaging of hazardous waste, refundable beverage packaging and refuse sacks as well as bag that are not classified here. If we breakdown the quantity to the four main areas this system (more introduction in chapter 5.3.2) covers, domestic households produced 56% of the plastic packaging waste, trade and industry 33%, agricultural 8% and fish farming 3% (Plastretur, 2002a).

4.2.1 Collection

The Norwegian industries have to take care of the collection and disposal of their industrial waste. More freedom is proposed in the Norwegian waste policy for the industries to choose their waste management agent so that such flexibility may lead to competition and optimization. As to the household waste, the local authorities have to take the responsibility for the materials unless the product groups are operated or regulated otherwise. The collection of municipal solid waste is handled by the municipalities, after the primary sorting at households. In Norway, the local authorities may choose its own collection scheme according to the need of the local region (Plastretur, 2002a). To offer some examples, in the city of Trondheim, there is a curbside system in which every household has three different bins for the disposal of their waste, one for paper, one for environmental waste, e.g. plastics, metal, woods, and one for the rest fraction. In the most densely populated area the inner city of Trondheim, the igloo bring scheme was introduced in 2000 (Eik, et al., 2002). In the Drammen region, Bergen and Stavanger, citizens bring their waste to collection points in a drop-off program (Plastretur, 2002a).

Various regulations or EPR programmes may drive the flow of part of the plastic waste streams. For the deposit refund system of PET drink bottles, there are reverse vending machines in shops for collection. Plastic waste in electrical and electronic equipment (EEE) is collected when the products are taken back to the distributors and producers.

4.2.2 Sorting/Separation

As to the plastic packaging, we may look at it from different sources categorized by Plastretur AS. Plastic packaging from trade and industry, agriculture and fish farming is sorted at source by waste owner into defined categories, delivered to a receiving depot and checked there, and then sent for recovery. Waste collected from households is sent to one of the four regional sorting plants, Søre and Sunnmøre Reinhaldsverk (SSR), Trondheim Renholdsverk (TRV), Agder Renovasjon and Interkommunal Renovasjon i Salten (IRIS). All the sorting is done manually to ensure good quality, but it is labor intensive and relatively costly.

As to post-consumer plastics in product groups like soft drink bottles, EEE waste and end-of-life vehicles, more descriptions of these programmes will be made in chapter 5.

4.2.3 Recovery

Recycling that is financially profitable has been traditionally taken place without much governmental interference. "In the Norwegian plastic production and manufacturing industry, the degree of utilization of its own waste plastic was estimated to be high", stated in a report published in 1991 (NMoE, 1991). However, the report also recognized that it was primarily the high cost of collection, separation, cleaning and transportation that made the major part of plastic recycling financially unattractive. The lack of interest also came from the high requirements for material quality and low tolerance of impurities for the production facility in plastic industry. After years' joint efforts of the government and the industries, the plastic recycling has begun to grow. Below is a more detailed discussion about each phase of plastic waste management in Norway.

According to Plastretur (2002b), the production of 1 kg of plastic consumes 2 kg of oil, and when plastic is combusted, it only recovers energy up to 0.5 – 1.0 kg of oil. Therefore, mechanical recycling is environmentally gainful. However, when collection and sorting cannot be made economically or environmentally feasible, recovery of the chemical content and energy content should be implemented.

Out of the 367,000 tonnes of plastic waste in 1997, only 2% went to material recovery, while the majority went to landfill (60%), 14% incineration, 3% exported, and remaining 20% unknown or other treatment (Statistics Norway, 2001). The statistics for year 2000 shows that material recycling has increased to 21,000 tonnes (6%) of total 376,000 tonnes, and the energy recovery is 15%. (Statistics Norway, 2002b) If we look at the figure from APME (2002), out of the 179,000 tonnes of total plastic waste collectable in 2000 in Norway, 14.6% was recycled and 43.1% was energy recovered.

In the system of plastic packaging run by Plastretur, 20,300 tonnes (21%) was recycled, and 61,800 tonnes (65%) was energy recovered. The total recovery rates went up to 86%[20] (Plastretur, 2002a). This quantity excludes 3,000 tonnes of EPS (extended polystyrene), among which 1,000 tonnes (33%) was recycled and 200 tonnes (7%) was energy recovered.

In Norway, there are about 20 recyclers, for both packaging and non-packaging plastic waste. There is cooperation with a number of Swedish recyclers as well (Plastretur, 2002b). Under the Plastretur system of collecting, sorting and recycling plastic packaging, agreements were made with recyclers in other countries in order to allow competition and improve efficiency. In 2001, 57% of plastics recycled happened in Norway, while the rest, particularly foil and PP sacks, was recycled abroad (Plastretur, 2002a). The applications of recycled plastics are continuously being developed, with partial or 100% recycled content. Some examples of the products include carrier bags, crates and pallets, construction material, chairs and benches, fleece jackets and so on[21].

[20] The author found some discrepancy in the denominator here. This is a result of an ongoing analysis of how much plastic packaging there is in Norway. The denominator will be 107,000 tonnes from year 2002. (Oland, 16 August 2002)

[21] On Plastretur's website, more information can be found. http://www.plastretur.no/produkter.html

5. The Norwegian EPR Programmes Influencing Post-Consumer Plastics

In this chapter, we look at various EPR programmes in Norway relating to plastics. First, the author tries to find the relevance of EPR concept in the Norwegian waste policy. Consequently, we look at the current EPR programmes implemented in Norway and more detailedly on those which are related with the material of plastics. It is not the purpose of this thesis to examine the effectiveness and efficiency of those EPR programmes themselves. However, understanding of the mechanism and background of those programmes is essential for further discussions.

5.1 Norwegian Waste Policy

In Norway, the Ministry of the Environment (abbreviated as NMoE) is the government unit in charge of the environmental issues, including waste management, and the Norwegian Pollution Control Authority (abbreviated as SFT in Norwegian) is its executive body. Various legal instruments and economic instruments have been introduced and implemented in Norway to combat the problems of waste. The Pollution Control Act of 13 March 1981 and the Product Control Act of 11 June 1976 represent the most important legal instruments concerning waste management (Royal Norwegian Ministry of the Environment, 1991). They authorize further actions, particularly the Product Control Act, which provides necessary authority to introduce regulations concerning the responsibility of enterprises for their own products.

By definition of the Norwegian Pollution Control Act, waste is defined as discarded objects of personal property or substances, excluding waste water and waste gases. The amount of household waste generated per person per year has risen from 174 kg to 328 kg between 1974 and 2000, or by 89% (Statistics Norway, 2001). However, the quantity of waste for material recycling has risen so much that the amount of waste for final treatment- landfilled and incinerated as waste, has declined, despite the rise in the total amount of household waste generated. From 1992 to 1998, the recycling of household waste has increased from 9% to 34%, or from below 100,000 tonnes to nearly 500,000 tonnes (NMoE, 2000b).

In the Report no. 44 (1991-92) to the Storting[22], Relating to Measures to Reduce Waste, Increase Recycling and Ensure Environmentally Sound Waste Management, which was prepared by the Ministry of the Environment, it was stated that "*the Government believes that instruments must be introduced in order to ensure that commercial enterprises take on greater responsibility for the waste problems created by their products*" to emphasize the responsibility of producers, importers and distributors for the waste generated by their products, in addition to the waste generated during the production process. It discussed about using various economic instruments such as waste charges, waste taxes, deposit and return systems and product charges, in order to correct the market forces where the environmental costs and external effects are not fully reflected in prices. And when market mechanisms are deficient, legal instruments may be necessary to come into force to regulate the collection, recycling and treatment of waste. However, it is believed that "*the producers primarily have the best opportunity of reducing waste problems through product development and the use of return raw materials*."

Though Norway has never become a member of the European Union, Norwegian regulations on waste have closely followed the EU legislative development because the EU Directives and Regulations are binding on Norway through the provisions on waste in the European Economic Area agreement Appendix XX no. 5 (NMoE, 2002), for example, the Directive 94/62/EC on packaging and packaging

[22] Storting is the Norwegian Parliament.

waste. The national actions in European countries were also taken for reference, e.g. the German Dual system and the voluntary agreement for packaging in the Netherlands (NMoE, 1991).

In autumn 1999, the Norwegian government made a white paper about their environmental policy and submitted to the parliament as Report no. 8 (1999-2000) to the Storting on the Government's environmental policy and the state of the environment in Norway. Three specific goals or national targets have been set for the waste policy (see Box 5-1). Number two of the targets clearly states the overall recovery target of waste, which is 75%. In 1996, approximately 57% had been achieved. This report also mentioned the further development of manufacturer's responsibility, which would contribute to increased recycling, stimulate reduction in waste and reduced use of hazardous substances in products (NMoE, 2000b).

Box 5-1 Norwegian National Targets for Waste and Recycling

1. The growth in the quantity of waste generated shall be considerably lower than the rate of economic growth.

2. The quantity of waste delivered for final treatment is to be reduced to an appropriate level in economic and environmental terms. Using this as a basis, the target is for 25% for the total quantity of waste generated to be delivered for final treatment[23] in 2010.

3. Practically all hazardous waste is to be dealt with in an appropriate way; so that it is either recycled or sufficient treatment capacity is provided within Norway.

5.2 Current EPR Programmes in Norway

In the Report no. 44 (1991-92) to the Storting, it was stated that "*Norway's waste policy strongly emphasizes the responsibility of producers, importers and distributors for their products and packaging.*" To see this statement being realized, we may find several EPR programmes being implemented for different product groups. Below we shall have a brief introduction about some of those programmes, in both packaging and non-packaging categories.

5.2.1 Packaging programmes

Packaging waste accounts for a considerable proportion of the growing waste stream in Norway, like most other European countries. The EU Directive 94/62/EC on Packaging and Packaging waste sets various targets for the recycling of packaging waste. In a recent meeting of EU environment ministers in Luxembourg, accordance has been made to increase some targets and to be achieved by 2008. Target for plastics was one of them, increased from 20% to 22.5% (ENDS, 26 June 2002). In Norway, the EPR programmes on packaging waste mainly fall on the industrial agreement made between NMoE and the industries. In addition, there are deposit refund systems for refillable and one-way beverage containers respectively.

5.2.1.1 Deposit Refund System for Beverage Containers

Beverage packaging comes under regulations laid down by NMoE. Regulations relating to Return Systems for Beverage Packaging (10 December 1993) entered into force 1 January 1994, and the

[23] Final treatment refers to disposal and incineration without conversion to energy.

Regulations of 12 November 1987[24] was abolished at the same time. The Norwegian Pollution Control Authority (SFT) is the executive body, who can approve of the return system and stipulate the return rate.

Bryggeri- og mineralvannforeningen (BROM, industry association of Norwegian brewers and soft drink producers) is in charge of the deposit refund system for the refillable beverage containers, which are made of glass or PET. The system for glass bottles has begun for decades. The system for PET bottles has been established around 1990, copying the system model of glass (Undrum, 6 August 2002). The main purpose of this system, according to the administrative director of BROM, is to keep the cost low. The producers discovered that operating such system together to reuse the bottles is cheaper. BROM is only in charge of collecting figures and reporting, without financial or physical involvement (Undrum, 6 August 2002).

To promote recovery, the Norwegian government has introduced a packaging tax on all kinds of beverage containers except those for milk, juice and still water. The tax rate is 2.52 NOK per unit for plastics (PET) and 4.19 NOK per unit for glass and metal. However, the tax rate may be reduced depending on the return rate. If the return rate is less than 25%, the packaging users have to pay the full rate. If the return rate is 95% or higher, the packaging tax is completely exempted. Between 25% and 95%, the packaging tax may be reduced according to the scale of actual return rate (BROM, 2002). In addition, the one-way bottles are levied a base tax, currently 0.85 NOK per unit, which is fixed without reduction.

To encourage the use of refillable containers, until recently the one-way containers have been heavily taxed. However, the Norwegian retailers and brewers have wanted for long the possibility to use one-way beverage containers in addition to the refillable ones. After years of political struggle (Eik, et al., 2002), Norsk Resirk AS was founded in 1998 with 50/50 ownership of retailers and brewers to run the deposit refund system for the one-way beverage containers including steel and aluminum cans and one-way PET bottles. The system was started up on 3 May 1999 (Grytli, 1999).

According to BROM (2002), the return rate of refillable bottles has exceeded 95%, and therefore, there is no packaging tax the producers need to pay. As to the one-way bottles, the return rate is 91% for cans and 70% for one-way PET bottles. The current tax rate is therefore 1.22 NOK and 1.60 NOK[25] respectively (Norsk Resirk, 2002).

5.2.1.2 Voluntary Agreements

The Norwegian government suggested the introduction of a central packaging tax in 1994 in order to force producers and importers of consumer goods to re-consider their packaging consumption (Materialretur, 2002). The NHO (Norwegian Confederation of Industries) estimated that this tax would cost the business community between two and three billion NOK a year. To prevent the introduction of this tax, the industrial community decided to set up it own collection and recovery system. The government accepted the plan and signed the industrial agreement with the business community in September 1995 with tough demands. Should the business community not be able to fulfill them, it is possible that at some point of time, this central tax will be introduced. One important reference was the EU 94/62 Directive on Packaging and Packaging Waste.

Six material waste management companies or producer responsibility organizationos (PROs) were established for the recovery and recycling of packaging waste and five of them exist today: Norsk Returkartong AS is responsible for the recycling of beverage cartons and ordinary cartons (solid

[24] The Regulations relating to deposit schemes for beer, carbonated and non-carbonated beverages, non-alcoholic wine, fruit wine, wine and spirits

[25] For cans: 0.85+4.19x(1-0.91)=1.22, for one-way PET bottles: 0.85+2.52x(1-0.70)=1.60

board)[26], Norsk Resy AS for corrugated cartons (corrugated board), Norsk GlassGjenvinning AS for glass packaging, Norsk MetallGjenvinning AS for metal packaging and Plastretur AS for plastic packaging. The PROs are owned by the Federation of Industries and major enterprises in each field, including the producer of materials, the packaging users (the packers and fillers) and the retailers. Their objective is to ensure that the set recovery and recycling targets are fulfilled (Materialretur, 2002).

At the end of 1996, the six PROs founded the umbrella organization, Materialretur AS, which became the contract partner of the participating and fee-paying companies and has the function to collect fees from member companies in accordance with a fee structure based on the type and quantity of the packaging material used. However, Materialretur AS is not involved in the recovery or recycling of the different materials, which remains the responsibility of the PROs. Materialretur AS only distributes the collected fee to the PROs depending on the pro rata consumption of materials declared (Materialretur, 2002). Since 1 January 2000, Materialretur AS has been entitled to use the Green Dot as its financing mark.

In this system, the producers are financially responsible for the waste management, but not physically responsible, at least not individually. The PROs are formed to take the collective responsibility of collection and recovery.

The Norwegian collection and recovery system is working. In year 2001 the packaging material circulated in the Norwegian market was estimated to be about 405,500 tonnes, among which 339,000 tonnes[27] were recovered by the PROs (Materialretur, 2002). An independent survey commissioned by NMoE has calculated that the country earned 600 MNOK by collecting and recovering waste packaging (ENDS, 30 June 2000). The system has an effective mechanism supported by the business community, the local authorities and the consumers.

In Table 5-1, the author summarizes the Norwegian EPR programmes for packaging.

Table 5-1 Summary of EPR Programmes for Packaging in Norway[28]

Legislation (timing of the enforcement)	Regulations relating to return systems for beverage packaging issued in 1993, superseding the original version in 1987 Industrial agreement with government on producer's responsibility in 1995
Scope	All the packaging
Actual implementation	Deposit refund system for refillable glass and PET bottles Norsk Resirk, PRO for cans and one-way PET bottles, established in 1998, system run since 1999 The six material companies (PROs): Norsk Returkartong AS, Kartongretur AS*, Norsk Resy AS, Norsk GlassGjenvinning AS, Norsk MetallGjenvinning AS and Plastretur AS run the recovery system since 1995, though some of them were established before 1995
Scope of the PRO / negotiated agreement	BROM: in charge of reporting for the result of refillable beverage containers Norsk Resirk: steel/aluminum cans and one-way PET bottles Norsk Returkartong AS: beverage cartons and ordinary cartons Norsk Resy AS: corrugated cartons Norsk GlassGjenvinning: glass

26 After the merger in 2001 with Kartongretur AS, who was responsible for the part of ordinary cartons.

27 The figure has been calculated from the data provided on the website of Materialretur.

28 A similar table of summary of EPR programmes for packaging has been compiled for Germany, Austria, the Netherlands and Sweden by Tojo, et al. (2001).

	Norsk MetallGjenvinning: metal Plastretur AS: plastic
Recycling targets:	One-way PET bottles: 95% Steel/Aluminum cans: 90% Plastic other than PET bottles: 80% recovery (30% recycling) Corrugated cartons: 80% Beverage cartons and ordinary cartons: 60% Metal packaging other than cans: 60% Glass: 60%
Rates actually achieved	Refillable containers: >95% One-way PET bottles: 70% Steel/Aluminum cans: 91% *In 2001, (source: Materialretur)* Plastic other than PET bottles: 86% Corrugated cartons: 90% Beverage cartons: 49% Ordinary cartons: 62% Metal packaging: 56% Glass: 87%
Which costs do producers cover?	Bryggeri- og mineralvannforeningen and Norsk Resirk: covers the cost for the whole system Materialretur AS collects money from members and allocated to 5 PROs for collection, sorting and recovery
Resource collection method	Beverage containers (other than milk and juice): deposit-refund in shops (reverse vending machines) The rest: municipal collection system
Licensees / members and the number	Norsk Resirk: - Materialretur: manufacturers and importers who sell packed products. 1,962 licensees (2001)[29]
Funding mechanism	Norsk Resirk: deposits combined with administrative disposal fee Materialretur AS: license fees determined by weight or by unit depending on type of material. Minimum fee: 350 NOK/year

* Kartongretur AS has merged with Norsk Returkartong AS in 2001.

5.2.2 Non-packaging Programmes

In this section, the author introduces some of the non-packaging EPR programmes in Norway.

5.2.2.1 Electrical and Electronic Equipments (EEE)

As one of the first countries in the world, Norway has stipulated the Ordinance on Scrapped Electrical and Electronic Products in 1998 and made it come into force on 1 July 1999 (NMoE, 2000b), after NMoE and national suppliers' organizations entered into a sector agreement. The main purpose is to ensure the removal and safe disposal of hazardous substances in EE products and recycle the usable materials. The Ordinance enables users of EE products to deliver their waste to distributors that sell

[29] Source: Pro Europe. (2001). *The Management of Packaging Waste in Europe.*

similar products and to the local authorities free of charge[30]. Importers and manufacturers of these products have responsibility to look after the collection of EE waste from distributors and municipalities, ensure safe management of hazardous materials in these products and have the remaining materials and components recycled when it is environmentally and economically justified (the Ordinance).

Three non-profit management enterprises (PROs) were established: Hvitevareretur AS for collection and recycling of scrapped white goods, Elektronikkretur AS for collection and recycling of scrapped electronic products, and RENAS AS for the EE waste from commercial sector. The first two PROs dealing with consumer WEEE (electrical and electronic waste) established a collective system for logistics, recycling and profiling. The joint waste management system is called El-retur (El-retur, 2002). Figure 5-1 shows the operating process in the system.

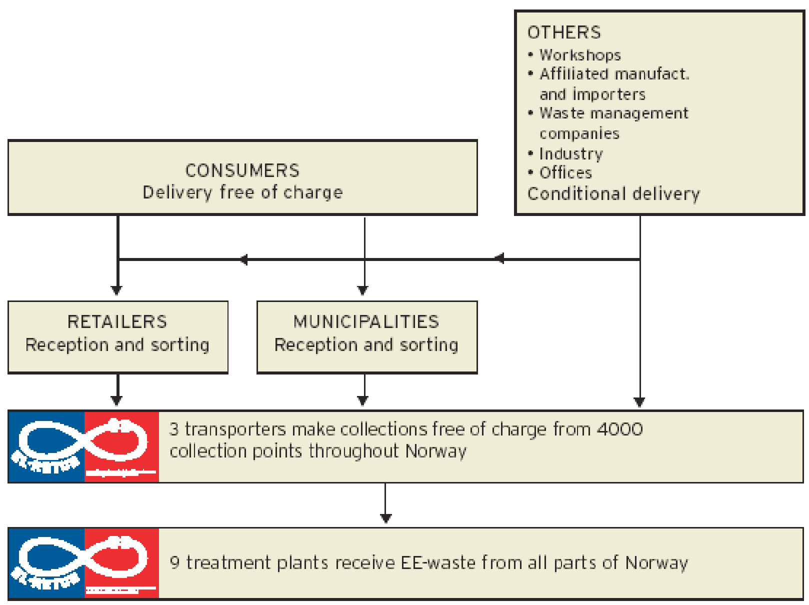

Figure 5-1 El-Retur System for Consumer EE Waste (El-retur, 2002)

In 2001, 32,446 tonnes of WEEE were delivered to processing plants for sorting, dismantling and recycling in El-retur system. The system has collected and processed 7.2 kg per capita of WEEE annually, which already exceeds the target of 6 kg per capita in the forthcoming EU WEEE Directive. In the sector agreement, the target is to collect 80% of all generated WEEE by 1 July 2004. There is no nationally agreed recycling target. El-retur will adopt the current proposed target of EU WEEE Directive: 70% for small appliances and 80% for large appliances. In 2001, recycling of 82% (74% recycling and 8% energy recovery) of WEEE collected was achieved. (El-retur, 2002)

About 70,000 tonnes of commercial EE waste are generated in Norway each year. In 2001, RENAS AS collected 28,194 tonnes and reached the collection rate of 41%. Of the scrapped products collected, up to 89% of waste will be recycled, 4% is to be converted to energy, and the remaining 7% are mainly toxic components to be properly disposed of (RENAS, 2002).

5.2.2.2 End-of-Life Vehicles

[30] The local authorities may charge for the service of receiving EE waste that is production waste, as compared to free of charge for consumer waste. (section 6)

In Norway, there is a wreck deposit scheme for car wrecks established in 1978 for vehicles under 3,5 tonnes. When a new car is purchased, a charge of 1,200 NOK is paid, suggested increase to 1,300 NOK in the national budget for 2000. When the discarded car is delivered to an approved reception facility, the car owner is given a deposit of 1500 NOK. This ensures that about 90% of all car wrecks become part of the return system. About 75% of the car wrecks by weight are recycled (NMoE, 2000b).

The EU Directive 00/53 on End of Life Vehicle (the EU ELV Directive) sets the recycling targets. By 2015, 95% by an average weight per vehicle and year is to be re-used and recovered, and 85% re-used and recycled. The interim targets by 2006 are 85% and 80% respectively.

Germany and Norway moved further towards compliance with the ELV Directive on 1 July 2002. Under EU law, manufacturers are now liable for costs of take-back of vehicles put on the market from 1 July 2002. Germany was the first among EU members to bring into force the ELV legislation. The Norwegian environment minister announced the details of new regulations aimed at implementing the ELV directive. Importers and producers are to be responsible for "recycling and environmentally friendly disposal… in accordance with arrangements we have made in other waste collection systems." Transfer of authority for the scheme from SFT to the industry began on 1 July 2002, when importers became responsible for all new vehicles. A national scrapping tax will remain in place at least until 2007 (EDNS, 2 July 2002).

5.2.2.3 Others

Some examples of other EPR programmes implemented in Norway include batteries, tyres and used lubricating oil.

The battery regulation stipulates that dealers must be willing to receive discarded lead batteries free of charge. Importers of lead batteries are obliged to organize free collection from the dealers and local authority facilities and to ensure at least 95% recycling. There was a voluntary agreement in 1993. The PRO is AS Batteriretur, who finances and organizes a nation-wide system for the collection and recycling. Since this scheme was started in 1994 the collection of batteries has been almost 100% (NMoE, 2000b). There is a covenant for rechargeable batteries in 2000 (Roine & Brattebo, 2001).

The tyre statute of 1994 stipulates a prohibition against the disposal of discarded tyres and gives the tyre industry responsibility for ensuring the safe collection and recycling of tyres. Consumers have the right to deliver their discarded tyres free of charge to tyre dealers, while tyre manufacturers and importers are obliged to fetch the collected tyres and ensure the recycling of the same. In 1998, 86% of tyres were collected for recycling (NMoE, 2000b).

Lubricating oil from a number of different usage areas is taxed. At the same time reimbursement is given when waste oil that comes from taxable lubricating oil is delivered. This scheme was introduced in 1994 and has led to the collection of waste oil increasing from about 54% in 1990 to about 73% in 1998 (NMoE, 2000b).

5.3 EPR Programmes Relating to Plastics

Among the above-mentioned EPR programmes, the author chooses the ones influencing the material flow of plastics for further discussions.

5.3.1 The Deposit-Refund System for PET Bottles

In the deposit refund systems for beverage containers, deposits are paid when the containers enter the system and refunded when the containers are returned. The actors involved are suppliers (the brewers and soft drink producers, or the bottle fillers), the traders (retailers) and the consumers. The consumers return the containers via the reverse vending machines in retailing points. And then the containers are shipped to suppliers by reverse logistics. Table 5-2 shows the deposit rates in the Norwegian system:

Table 5-2 Deposit Rates for Deposit Refund Systems of Beverage Containers

	Between trade and consumer	Between supplier and trade
Refillable =< 0.5 liter	1.0	1.2
Refillable > 0.5 liter	2.5	3.0
Cans and one-way PET =< 0.5 liter	1.0	1.0
Cans and one-way PET > 0.5 liter	2.5	2.5
Crates	16.0	16.0
Trays	40.0	40.0

Unit: NOK Source: Norwegian Brewers and Soft Drink Producers (BROM), 2002

The PET bottles, refillable or one-way, contain two parts: the PET bottle itself and the PP bottle cap. In the deposit refund system of refillable PET bottles organized by the brewers and soft drink producers themselves, the bottles are collected at retailing points and sent back to suppliers. The bottle caps are unscrewed and recycled, and the bottle is to be reused for 20 times. At the moment, the return rate is higher than 95%. As to the deposit refund system for one-way bottles, it is organized by Norsk Resirk, the PRO. Both the PET bottles and the PP caps are recycled after being returned. The current return rate is 70%. The reason why the rate is not high may be that the system is newly introduced, and consumers are not aware that they can get refund from it. However, compared to the refillable bottles, the quantity of the one-way bottles is small (Castillano, 5 August 2002).

5.3.2 The Covenant on Plastic Packaging and Plastretur AS

In this section, the author introduces the main EPR programme on plastics. The covenant was signed in 1995 between NMoE and the plastic packaging chain. The PRO, Plastretur AS, was then established to organize the recovery system.

5.3.2.1 The Content of the Covenant

On September 14th, 1995, the Ministry of the Environment and the Plastic Packaging Chain[31] including packaging producers, fillers and packers and distributors, signed the Agreement on the Reduction, Collection and Recovery of Plastic Packaging Waste (referred to as the Covenant on Plastic Packaging or the Covenant). The Covenant was to follow Report no. 44 to the Storting (1991-1992) in the fulfillment of the commercial sector's responsibility for waste from its own products, and to ensure compliance with the requirements in the EEA Agreement's Directive 94/62/EC on packaging and packaging waste.

The Covenant covers all plastic packaging, whether sales, group or transport packaging, for all kinds of goods, except the beverage bottles[32] which are covered by a deposit refund system and packaging containing hazardous materials.

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[31] Represented by representatives from the Norwegian Association of Branded Product Manufacturers, the Norwegian Wholesale Grocers Association, the Federation of Retail Grocers in Norway, the Federation of Norwegian Food and Drink Industry and the Norwegian Plastics Federation.

[32] The beverage bottles fall within the scope of Storting resolutions concerning environmental duties on packaging.

The main content of the Covenant is to define the obligations of the plastic packaging chain as follows (NMoE, 1995):

1. Establishment and organization of a material company. This material company is owned by the plastic packaging chain on a non-profit basis, to seek for methods of packaging waste collection and recovery which overall achieve the desired environmental benefits at the lowest cost while keeping the highest possible degree of competition. The plastic packaging chain itself is responsible to make sure that the collection and recovery system is financed and supported.

2. Reduction of packaging waste. The plastic packaging chain shall promote the implementation of waste reduction measures such as reduced use of materials and refill solutions.

3. Collection and recovery of plastic packaging waste. Through the material company, a system for collection and recovery has to begin to operate by 1 July 1996. By 1999, at least 30% of plastic packaging waste shall be material recovered, and at least 50% shall be energy recovered. Of EPS (expanded polystyrene) plastic, at least 50% for material recovery and 10% for energy recovery.

4. Information. Necessary measures shall be planned and implemented for the information of consumers and municipalities so as to ensure the implementation of the Covenant.

5. Annual reporting. The plastic packaging chain shall, possibly through the material company, see that annual reports are submitted to the State Pollution Control Authority concerning the degree of fulfillment of the obligations under the Covenant.

The Ministry of the Environment helps to provide the conditions under which the collection and recovery of packaging waste can be conducted efficiently, for example, to ensure communication and coordination of various parties involved and to carry out information campaigns.

5.3.2.2 Plastretur AS - the Producer Responsibility Organization

Plastretur AS is a private, non-profit company founded according to the requirement of the Covenant to be responsible for developing, organizing and executing plastic packaging recovery schemes for waste from four areas: *private households, agriculture, fish farming* and *trade and industry*. It is owned by the plastic packaging producers, the fillers and packers and the retailers with one third each. These shareholders have the following division of responsibilities: the plastic industry is responsible for developing a recycling industry, the fillers and packers are obliged to pay a license fee to Materialretur AS, and the retailers shall ensure that their suppliers pay the license fee (Plastretur, 2002b). The fee the fillers and packers have to pay has been reduced from 1.70 NOK per kg to 1.40 NOK per kg in 2002.

Plastretur plays an important role as "catalyst towards all parties of the recovery chain, but does not physically handle the plastic packaging in any way." They make contracts with the actors in the markets, set minimum prices for collection, and support sorting and recycling. They define quality standards, controls and revisions. And they are also involved in training of partners and communication activities to stimulate collection (Sundt, 2002). Figure 5-2 shows the actors in the Plastretur's packaging recovery system and the material and cash flow.

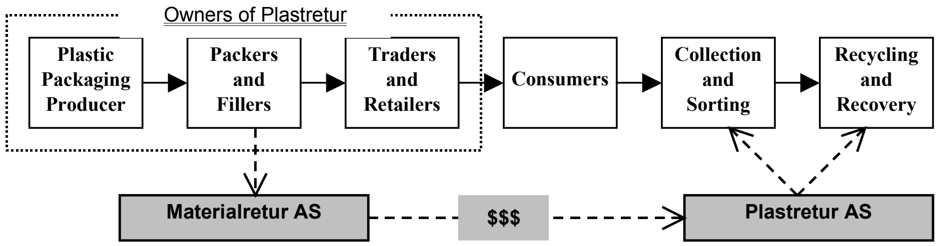

Figure 5-2 Actors in the Plastretur's Packaging Recovery System

The estimated quantity of packaging for 2002 is 107,000 tonnes, households 56%, trade and industry 33%, agriculture 8% and fish farming 3%. For packaging from households, Plastretur signed contracts with 168 municipalities (37%) and 4 manually sorting plants. For packaging from other segments, they made 110 contracts with local collectors to accept sorted packaging for free. Figure 5-3 (based on Sundt, 2002) shows the result of recovery from 1996 to 2001. Substantial improvement has been achieved.

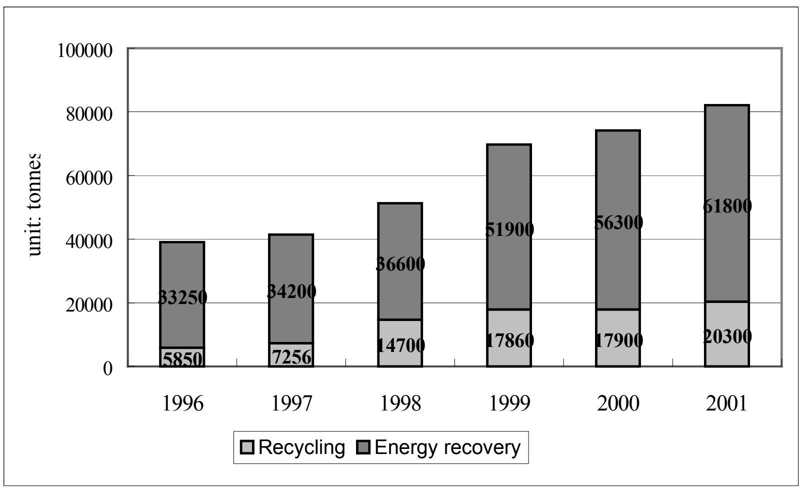

Figure 5-3 Recovery of Plastic Packaging in Norway 1996-2000

5.3.3 Plastics in Non-Packaging Programmes

Products under EEE and ELV groups contain a certain percentage of plastics. These products are composed of parts and components made from different materials and, therefore, are of high complexity in its end-of-life management.

Regarding the WEEE in Norway, in the El-retur system operated by Hvitevarertur AS and Elektronikkretur AS, 1,463 tonnes of construction plastics takes 18% of the sale of usable fractions in 2001, among 32,406 tonnes collected. However, the disassembled and removed construction plastics are among the list of items sent to the incineration plant (El-retur, 2002). In RENAS' environmental report 2001, it is mentioned that "plastic materials are processed in various ways according to the type of plastic and its composition. Some plastics are recycled as new products" (p.11).

In general, a car is 70.2% of ferrous content, 21.1% non-metals and 8.7% of non-ferrous metals. Plastics accounts for nearly 33% of the non-metallic components (Bellmann & Khare, 1999), which means about 7% of a car weight is plastics. Currently, around 75% of a car is recycled, most of which is the metallic fraction. Such figure is also valid in Norway (see Chapter 5.2.2.2).

Surveys show that only around 40% of the plastics used in a vehicle are fit for mechanical recycling. However, such level is further lowered by realities like insufficient quantities of suitable waste, low quality (purity) of waste and lack of market for recycled products to about 15-20% (Bellmann & Khare, 1999). The report of APME (2002) reveals that currently recycled plastics from the automotive sector is mainly PP from batteries and bumpers. To meet the recovery targets of the EU ELV Directive (85% by 2006 and 95% by 2015), the growing recycling of the non-metallic fractions such as plastics, glass, ceramics and textiles is to be expected.

6. Case Findings

In this chapter, after a brief introduction about the choice of cases, the empirical data of the cases about the change process of using recycled plastics in the material chains, the units of analysis, are presented, in order to accomplish the first step in the analytical framework: observing the change process.

In the framework (see Figure 3-1), the author divided the change process into four stages: initiation, formation, operation and diffusion. In sections 6.2 and 6.3, the data are presented with a seemingly different structure. In *general case description*, the author describes the flow of the change, and identifies the initiator of change in the material chain. Then, *key actors in the material chain* are introduced, where initiation of the initiator, among other things, will be discussed. *Formation and operation of the material chain* are put together for discussion since it is not easy to cut a clear boundary between these two stages. At last, the author summarizes *lessons learned by actors in the material chains* in order to see the possibility of experience diffusion.

6.1 Choice of Cases

Two cases have been selected for in-depth study of their historic background, their drivers and barriers and the interconnectedness of different key actors involved. The rationale for selecting the cases includes the following:

- Recycled plastics, polypropylene (PP) in both cases, were used for the product group of chairs. The plastic material moved from the product groups under the scope of EPR programmes into a material chain, the selected unit of analysis of this research (see Chap. 2.4), which is not bound by EPR, i.e. open-loop recycling.

- Both product applications with recycled plastics did not exist in Norway before. Therefore, there is *innovation* involved, which leaves us something to learn about the change process of using recycled plastics into new applications to replace virgin plastics.

- Plastretur AS, the PRO for plastic packaging, has used both of these cases to demonstrate the usability of recycled plastics. In the Norwegian version of their annual report 2001, there was an introduction of the case of seats in the Trondheim Ice Hockey Club (the TIK case). The case of HÅG's office chairs (the HÅG case) has been publicized on Plastretur's website. Thus, there exists implication that these cases are successful in some way.

- The two cases selected offer some different perspectives from their occurrence. The TIK case was on a one-time purchase basis, sponsored by Plastretur. The HÅG case of office chairs provides a good illustration for a successful commercial case, operated on a regular basis. The TIK case was initiated by the end-user, which is rather unusual, while the HÅG case was initiated by the product manufacture, as in most cases of eco-design.

Some of the descriptions in the following sections can be seen quoted directly from interviewees. If not specified, the sources of data is mainly from the in-depth interviews conducted with the key personnel involved in the relevant case from key companies or organizations, and secondary data such as company brochures, annual reports and websites assist to offer background information.

6.2 The TIK Case: The Use of Recycled PP for Chairs in Trondheim Ice Hockey Stadium

6.2.1 General Case Description

About 1300 chairs were installed in the Trondheim Ice Hockey Stadium before the ice hockey season began in 2001. Though simple in style, those chairs were not purchased through the normal process. They were made in recycled polypropylene (PP) instead of virgin PP, and such application did not exist before this case in Norway. *Trondheim Ice Hockey Club* (abbreviated as TIK from their Norwegian name) initiated and drove this case. Trondheim Municipality owned the chairs, since they are the owner of the Trondheim Ice Hockey Stadium. Plastretur AS sponsored this case financially.

The key actors in this material chain who are in the upstream of TIK include: *IFAS Sport AS*, the product designer, who owns the tool of this chair model and has been selling the model with virgin PP; *Polimoon AS in Moss* (hereafter called Polimoon Moss), the plastic converter, who molds the chairs for IFAS Sport; and *Strandplast AS*, the plastic recycler, who provides the raw material upon the order of TIK. Strandplast processed PP caps from the soft drink bottles into recycled PP pellets. Polimoon Moss then used these pellets to produce the chairs. These chairs were installed eventually in the Trondheim Ice Hockey Stadium (see Figure 6-1).

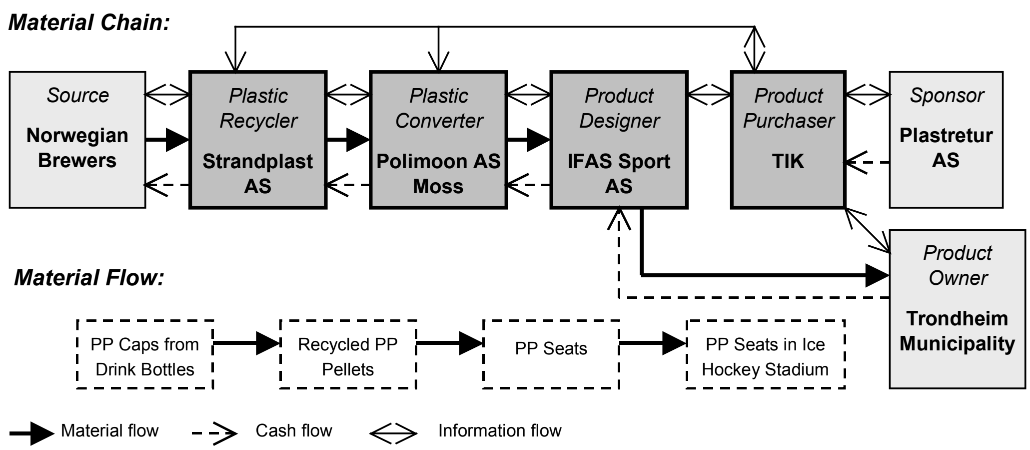

Figure 6-1 The TIK Case

The material flow of this case is like the traditional product chain. The material flows from the upstream actors to the downstream actors: (bottle caps from breweries) → Strandplast (about 1700 kg of PP pellets) → Polimoon Moss (1300 ARENA seats of recycled PP) → IFAS Sport → Trondheim ice hockey stadium. The cash flow is also similar to the case of a traditional product chain, i.e. upstream wards from the down stream actors: Trondheim Municipality → IFAS Sport → Polimoon Moss → Strandplast. However, it is not a normal commercial purchase because Plastretur sponsored TIK an amount of money to cover the additional expenditures like the installation of chairs.

The information flow is another unusual part of this case compared to a traditional purchase. It has been agreed during the interviews by all the key actors that TIK was the main driver of the case, though some has the perception that it was Plastretur who initiated it. TIK contacted all the key actors at different tiers of the product chain to understand the feasibility and drive the motivation of the other actors.

6.2.2 Key Actors in the Material Chain

In this part of the chapter, some introduction of the key actors in the product chain is presented, from downstream to upstream.

- **Trondheim Ice Hockey Club (the product purchaser/ the user)**

Trondheim Ice Hockey Club (TIK, from its Norwegian name Trondheim IshockeyKlubb) was founded in 1986 and became one of the 10 clubs in the Norwegian major league of ice hockey. The organization of TIK has two parts: the club itself and a limited company, TIK Aktivitet AS, which is in charge of TIK's finance and marketing. TIK is run independently from the Trondheim municipality. However, the Municipality owns the stadium and takes care of the maintenance. TIK only rents it from the Municipality. This is why the Municipality was the one paying for the chairs.

According to Iversen, the marketing director of TIK, most of the ice hockey clubs, or sport clubs in general, look very similar in their activities and images. To stand out from the crowd, TIK decided that focusing on environmental issues is a good link with sport, which enables them to differentiate themselves from the rest. "Linking sport and environmental issues is a very logical idea. It creates a healthy image of the club. And also, the sport of ice hockey gives people a very masculine impression. The feminine side of the environmental issues can help to offer some balance," said Iversen.

They became the first environmental club, 'Miljøklubben', in Norway. To keep this name, they have a lot to achieve. Their involvements are in three major categories: green purchasing, waste management and environmental education in primary school given by their ice hockey players.

- **IFAS Sport AS (the product designer)**

The company was founded in 1966. After a few shifts of ownership, the company is now owned by two Finns. It was in a bad situation financially and managerially, when the current managing director, Tvenge, entered the company in 2000. His first task in the priority was to stabilize the company's operation. IFAS Sport has three plants in Sweden and one in Finland. Their product lines have a broad coverage: from infrastructures in sport stadiums to small things like balls and pads, with prices ranged from 5 million NOK to 10 NOK. Of all the products, 40% is produced in their own facility, and 60% purchased around the world.

Their market is in Norway. They have currently 12,000 customers, who are institutions, schools and sport clubs, but no individuals. Their sales activities are to give out catalogues at least once a year and to offer product catalogue online.

At this moment, the company's main goal is to get financially stabilized and have smooth operations. Environmental activities are not in the list of priority. And there is no focus to use recycled materials in their products.

- **Polimoon AS Moss (the plastic converter)**

Polimoon AS is a business group in the field of plastic convertion and focuses on the design and manufacturing of plastic products and components to segments such as industrial and food packing, and components to the automotive and electronic industries. Their total amount of sales per annum is about 200 million EURO, 54% for packaging sector and 46% for components and systems. The group headquarter is in Oslo. The subsidiaries of Polimoon work rather independently for their daily operations, but the major purchasing is coordinated through the headquarter.

Polimoon Moss is a subsidiary of the Polimoon Group in the sector of components and systems. There are 92 employees at this plant. About 95% of the business in Polimoon Moss is for automotive industry, with major Scandinavian customers like Volvo, Saab and Scania. There are only two nonautomotive customers, and IFAS Sport is one of them. The main plastic raw materials they use are PP, ABS and PA (polyamide). Usually, they do not use recycled plastic from external sources other than their own recycled scraps. They are concerned about the quality consistency and the price of recycled materials. In automotive industry, their customers care about the cosmetics or the appearance of the product.

- **Strandplast AS (the plastic recycler)**

Strandplast AS is a family owned business established in 1969. They started from the agricultural plastic piping and began their recycling sector in 1986. These two sectors remain to be their business areas today, but more focus has been put in recycling sector. Strandplast has production facility both in Norway and Sweden. Currently, there are about 20 employees and the annual revenue is about 3.5 million NOK. Their raw material for recycling mainly comes from the breweries in Scandinavia, including their bottles, capsules and crates. Strandplast began to work with breweries in 1987. Depending on the price of virgin material, Strandplast pay the breweries an amount of money for getting their sorted post-consumer plastics. At the moment, they process about 500 tonnes of plastic waste per month, mainly PE and PP, and since recently PET[33] as well. Their products include granules (ground from the waste plastics, but not melted), washed or unwashed, and pellets (melted and extruded). The price of these various types of recycled material is about 50-75% of virgin material, depending on the grades. They do not consider their business as highly technology oriented. But due to the increasing demand on the quality of feeding plastic materials to machineries, they have to make improvements accordingly.

Their market of recycled plastic is rather international within Europe. The most important export markets are Germany, Italy and Spain (company brochure). There is one big Swedish customer, to whom they sell a lot of PP and HDPE and for whom they built the washing plant for the granules. As for the application of their products, it has a lot of possibilities, and very often they have to join the development process with their customers.

6.2.3 Formation and Operation of the Material Chain

In the Trondheim ice hockey stadium, there were no chairs but only concrete benches before this purchase. TIK decided to install the chairs and follow their environmental practices- buying product with recycled materials. However, this time it was not easy because the suitable chairs with recycled plastics did not exist in the market. The process was therefore more lengthy than buying chairs with virgin plastics. TIK contacted Plastretur for the information of possible suppliers. And since the case did not exist yet, Plastretur decided to sponsor TIK financially to make it happen. TIK also got a list of suppliers at different levels of the product chain from Plastretur to contact.

First, TIK contacted the product suppliers. Most suppliers showed low degree of interest to explore the possibility of using recycled plastics in their products, according to TIK's marketing director. IFAS Sport had a suitable model for TIK in their catalogue, ARENA, produced with virgin plastic, and offered the contact of Polimoon Moss, their supplying partner, for TIK to explore further instead of themselves.

TIK then contacted Polimoon Moss. They were a bit suspicious about using recycled material to produce chairs. One thing they mentioned to TIK was that it might cause damage to their machinery. The contact person in Polimoon Moss was not aware that another subsidiary of the Polimoon group, Polimoon Stjørdal, already had the experiences of using bottle caps for components of HÅG's chairs (see chapter 6.3).

[33] In 1999, Strandplast built a recycling plant for PET bottles, the same time when the deposit refund system for one-way PET bottles came into force (see chap. 5.2.1.1).

TIK traced further up to the level of material suppliers. They contacted Strandplast in Trondheim, who is geographically close. Strandplast said it should not be a problem to explore such application. Therefore, communications between the suppliers at different tiers began.

Strandplast prepared some materials for Polimoon to try and made necessary adjustment, especially for the color. At the end, it was pelletized PP from the soft drink bottle caps that they used. The bottle caps were collected with the PET bottles in the deposit-refund system in Norway. Collected bottles were returned via retailers to the breweries, where the caps were automatically unscrewed. Strandplast collected these caps, and turned them into granules. The technical development in this case was not very difficult. The problem for Strandplast was, however, the time constraints and the resulted high cost. "We had only 10 days from getting the order to delivery," said Strand, the executive manager of Strandplast. Some of their production was located in Sweden. The transportation for a small quantity of about two tonnes of material within the short period of time made the product cost even higher than double the amount of price at normal standard. Strandplast did not make profit from this case. At the end, they even had to increase the quoted price with Polimoon to cover their cost. The price ended up to be almost 50% higher than the spot price of virgin PP. But Strand mentioned that, given sufficient time, the cost would be much lower and competitive. They hope this case will bring them some marketing effect to cover the loss.

For Polimoon, their impression was that recycled materials are more expensive, and it was in a way proven in this purchase. Normally, their customers would not accept it, but this is a special case. The end-user wants it and pays for it. The possible technical concern of using recycled PP is that there are different grades of PP and the recycled material has to be controllable and fall within a defined range of melt index. In the TIK case, it turned out to be fine. Coloring is another issue. The color of the chairs resulted to be different from TIK's expectation, but TIK found it acceptable in the end. The recycled material for these chairs did not have UV additives in it. It would be a problem if it were for outdoor purpose.

IFAS Sport sells several different models of stadium chairs. ARENA, the model TIK chose, is the simplest and cheapest one. IFAS owns the tool, i.e. the mold for injection molding, for the chairs and contracts Polimoon to run the production. In the TIK case, despite the production cost went marginally higher from the raw material, IFAS Sport sold the chairs at the price about 30% lower than normal to TIK, since they were persuaded by TIK that there might be marketing effect for future opportunities.

Trondheim Municipality is the actual owner of the chairs, since they own the stadium. TIK made the purchase proposal to the Municipality to buy the chairs. The Municipality only decided the upper amount of budget, the remaining decisions were made by TIK. Although the plastic material used in this case was not within the system which Plastretur was in charge of, but within the deposit-refund system instead, Plastretur still agreed to sponsor the case, with an amount that was slightly more than the total price of the chairs. The money was used by TIK for the transportation and installation of the chairs. The purpose, according to the information manager of Plastretur, was to demonstrate the feasibility of using recycled plastics and use it as a reference case to increase communications with the citizens.

6.2.4 Lessons Learned by Actors in the Material Chain

The actors showed different attitudes about the TIK case after it happened. TIK, the initiator of this purchase, had very positive comments. To them, they made one step further in their goal of being the "Miljøklubben" and gained confidence in using recycled materials. "There is a good market potential to sell such product to sport arenas," said Iversen, the marketing director of TIK, "95% of sport arenas in Norway are run by government. Using recycled materials is worthwhile both environmentally and economically."

However, IFAS Sport and Polimoon Moss were less optimistic. From the purchasing price of recycled PP which was higher than virgin PP due to time constraints, they had the impression that using recycled plastics is more costly. At IFAS Sport, although they were persuaded of the marketing effect and agreed to offer discount to sell the chairs, there is no further plan to promote chairs with recycled plastics or use this case as a strategy for environmental concerned customers. Their priority was to get financial stability of the company first.

"Recycled material is wanted, but no one wants to pay extra money for it", according to the marketing manager of Polimoon Moss, "to make the material usable, the sorting, cleaning and grading processes will make recycled plastics very expensive." Other than the prices, they also concerned about the quality of recycled plastics, the coloring issues and the impurities in the recycled plastics. From the TIK case, they learned that the technical requirements can be reached, but the price level is high. However, they feel using recycled plastics is a matter of time. Sooner or later, people need to use recycled materials to deal with the problem of scraps and wastes. For the marketing manager, the drivers of using recycled materials are: 1) if it is cheaper, then people naturally consider it; 2) if the authorities regulate the use; and 3) if the customer wants it and pays for it, which is the case for TIK.

As to Strandplast, who has 15 years' experience in plastic recycling, this was just another case in their business development. For them, the TIK case was rather uncommon for it was the end-user who contacted them first. However, the time constraints and the resulted economic loss made the experience less pleasant. Both Strandplast and Plastretur became the environmental sponsors for TIK after this purchase of chairs.

Plastretur sponsored TIK and used this case for marketing campaign. According to Oland, the head of communications at Plastretur, it is a good investment to sponsor such a case to make it happen, compared to spending the similar amount of money to buy a newspaper advertisement with limited coverage. Although the actual influence on the use of recycled plastics can not yet be evaluated, "we got quite a lot of media attention, and our sister organization in Germany might do something similar," according to Oland.

6.3 The HÅG Case: The Use of Recycled PP for the Production of Office Chairs in HÅG

6.3.1 General Case Description

HÅG asa is a Scandinavia's leading manufacturer of office chairs with outstanding environmental practices. In 1995, they began to work with their supplier of plastic components *Dynoplast* (currently *Polimoon AS Stjørdal*) for the possibility of using recycled plastics in their chair. After some product development and testing process, the Scio model[34] with recycled PP was introduced in the market in 1997. *Strandplast AS* was the supplier of recycled plastics (see Figure 6-2).

[34] In HÅG's product lines, Scio model and Capisco model, which is to be mentioned later, are office working chairs. Conventio model is conference chair.

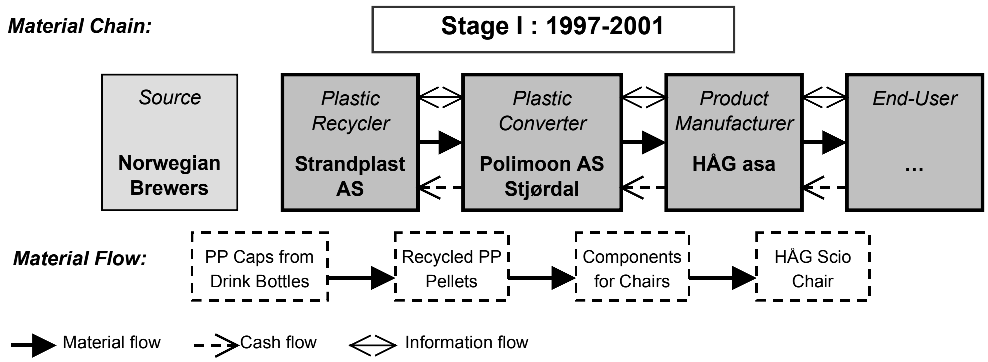

Figure 6-2 The HÅG Case – Stage I

The introduction caught much attention and inspired some people. Volvo Ecris[35] asked HÅG to produce 100 Conventio chairs with PP from car bumpers for a trial. From this experience, HÅG learned that to use this material for standard products, some improvements were needed for its performance. Together with *Plaståtervinning AB*, a Swedish plastic recycler, and *Lycro AS*, one of HÅG's suppliers of plastic components, a new mixture was invented- car bumpers and ketchup bottles at the 50/50 mixture ratio. A logistic system has to be established to supply this material. HÅG cooperated with Plastkretsen AB[36] and Bilproducentansvar AB[37] in Sweden in order to collect the bottles and bumpers needed. The Conventio model with this new mixture of recycled plastics was launched in 2001. The plastic component of the Scio model (newly launched as H03 model) has shifted to this new mixture and been produced at Lycro as well (see Figure 6-3). In the year 2001, HÅG used 575 tonnes of thermoplastics, and 24% of them were recycled PP (HÅG, 2002). Among all the end-users of HÅG's chairs, the author interviewed two of them to understand the importance of the environmental features of the chairs among the purchasing criteria. Telenor, the major telephone company in Norway, assigned an order of 8,000 chairs of Capisco model and H05 model in total for their new office complex. The Norwegian University of Technology and Science (NTNU) bought at least 500 chairs of H03 models for one new building.

[35] Volvo Ecris (Environmental Car Recycling In Scandinavia) is a joint venture between Volvo and three other Scandinavian companies, Stena Bilfragmentering AB, AB Gotthard Nilsson and Jönköpings Bildemontering AB. Their goal is to develop effective methods for managing end-of-life vehicles and promote and evaluate the market of recycled materials. It was developed in 1994 and ran a four-year trial program during 1994-1998.

[36] Plastkretsen AB is the PRO for plastic packaging in Sweden.

[37] Bilproducentansvar AB (Bil Prodentansvar Sverige AB) is the PRO for automobile industry in Sweden. It was founded in May 1999 with the aim of supporting the members in the field of producer responsibility and recycling. They have developed a network of receiving sites for scrap cars.

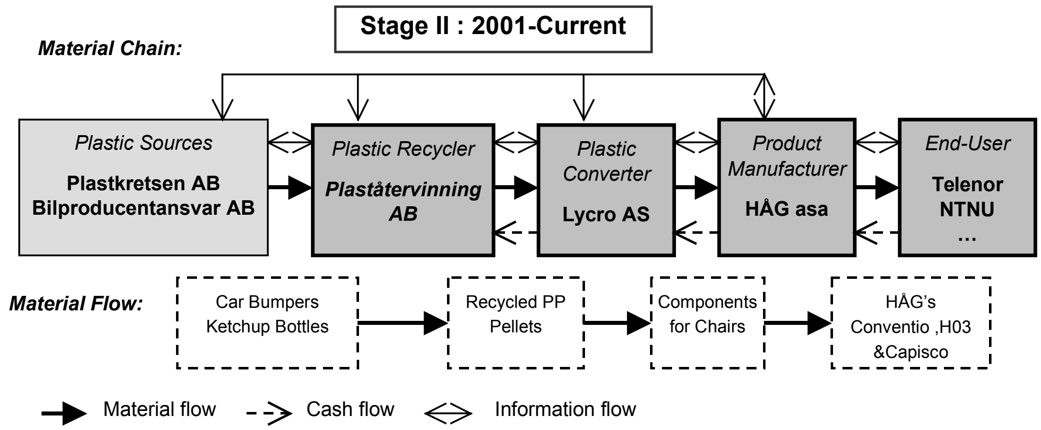

Figure 6-3 The HÅG Case – Stage II

The material flows move from the upstream actors to the downstream actors. In stage I (1997-2001): (bottle caps from breweries) → Strandplast (PP granules, about 90 tonnes per annum) → Dynoplast/ Polimoon Stjørdal (components of seats and backrests) → HÅG (Scio chairs) → end-users. In stage II (2001-current): (car bumpers from Bilproducentansvar AB and ketchup bottles from Plastkretsen recovery system) → Plaståtervinning (PP granuls, 90 tonnes in 2001, estimated 200 tonnes per annum 2002 onwards) → HÅG (35,000-40,000 Scio chairs and 40,000-45,000 Conventio chairs, and parts in Capisco chairs) → end-users.

The cash flows are from downstream actors to upstream actors, the reverse order as in the material flow. There are no subsidies from actors outside the product chain other than the monetary relationship between Plaståtervinning and Plastkretsen, the Swedish PRO for plastic packaging (see description of Plaståtervinning in the next section).

The information flows differ in stage I and stage II. In stage I, the product manufacturer, HÅG, cooperated only with their first tier supplier, Dynoplast/Polimoon Stjørdal, who then contacted their material supplier Strandplast. This was more similar to a traditional product chain. We may assume that it is because Dynoplast also had an active environmental strategy to push for the use of recycled plastics and the channel of material supply existed already.

However, in stage II, the product manufacturer, HÅG, took a much more dominant position in influencing the whole system. They contacted the potential material supplier, Plaståtervinning, themselves, gathered all the key actors for an initial meeting and was involved in setting the logistics system with the Swedish material sources.

6.3.2 Key Actors in the Material Chain

Some introduction of the key actors in the product chain is presented here. HÅG is the most important actor, both in stage I and stage II. After HÅG, the actors are introduced from downstream to upstream, first stage I and then stage II.

- **HÅG asa (the product designer and manufacturer)**

HÅG was set up in 1943 and is today a company engaged in developing, producing, marketing and selling work, visitor and conference chairs. The company's headquarter is in Oslo, Norway, but most of the company's employees are attached to the production at the Røros factory. In addition, HÅG has sales companies in Sweden, Denmark, Germany, the Netherlands, France and the USA. In the year

2001, the operating revenues of HÅG were 580.3 MNOK (million NOK) (HÅG, 2002b). HÅG was listed on the SMB list at Oslo Stock Exchange in 1992. 75% of HÅG's sales income comes from markets outside Norway (HÅG, 2002a). HÅG Røros produced about 250,000 chairs in 2001. Now it is the only factory for the whole company. The main processes are processing of steel and finishing of metal components as well as upholstery, assembly and packing. They also have an epoxy coating plant for finishing.

The vision of the company is *to be different and better*. HÅG has chosen a differentiation strategy in order to stand out from the competitors. And their mission is *to provide the best seating solutions by bringing movement and variation to the workplace* (HÅG, 2002b) Box 6-1 explains more about their product concept.

Box 6-1 HÅG's Product Concept

In 1979 HÅG introduced a new concept - **Balans** - in collaboration with Peter Opsvik and Hans Christian Mengshoel. This new concept got the world to understand that a chair is not a chair, and opened up a whole new way of thinking about the design of chairs and the sitting function. For the first time, Balans represented an alternative sitting position and put a question mark against the traditional seating culture developed over thousands of years. By altering our body position we could stimulate movement and get a more natural sitting position (HÅG, 2002a).

HÅG is actively involved in environmental issues. Their environmental philosophy is "*HÅG's objective is to be a sustainable company, and the make this visible through product solutions and priorities which help to reduce the total consumption of resources based upon ecological understanding*." They integrate the environmental perspectives in the organizational culture and the overall performance of the company, including product development, production, supplier development, product sales. In Box 6-2, some of HÅG's environmental practices have been compiled from their annual report 2001.

Box 6-2 HÅG's Environmental Practices

- HÅG asa is ISO 14001 certified, and HÅG Røros became EMAS registered in 1996 as the first Scandinavian furniture producer.
- HÅG has published environmental report as part of the annual report since 1995.
- HÅG has an Environmental Manager with technical and coordinating responsibility. Each unit has a local Environmental Coordinator, participating in the group's environmental forum. All Line Managers have environmental responsibility.
- HÅG's product development procedures integrate environmental criteria. They continuously tests new materials and recycled components. They use recycled plastics in Conventio, Capisco and H03 models, removed glass fiber from the plastics in the H05 model to increase its recyclability and use environmental friendly textiles and woods from FSC-certified (Forest Stewardship Council) sources.
- HÅG's production at Røros has limited impact on the external environment. Consumption of energy, water and raw materials, waste handling and transportation are monitored for continuous improvements.
- HÅG looks at the environmental development of their suppliers, who must specify their environmental impact and are evaluated accordingly.
- HÅG takes the producer responsibility in managing their end-of-life products. Their objective is that no HÅG chairs are to end up in waste dumps. Second-hand chairs are often sold or passed on. The company has return systems in Scandinavia and Germany.

- ♦ HÅG's cooperation with various bodies for environmental improvements: participating in the development of Nordic green label for furniture, participating in the research programme 'Productivity 2005' at NTNU/SINTEF[38] Trondheim and forming corporate network with Tomra Systems[39] to reduce consumptions of virgin materials and to educate the general public about the gains of using regenerated plastics.

HÅG began to look into the environmental issues about 10 years ago. According to their environmental manager, one of the initial influences came when their German market asked information about what kind of packaging material they used and if it was recyclable or not due to the implementation of the German Packaging Ordinance. The environmental manager used to be a designer herself. Now she is the only person in the organization carrying the title of 'environment'. Environmental responsibilities are spread to different divisions and functions throughout the entire organization.

♦ **Polimoon AS Stjørdal (previously Dynoplast, the plastic converter in stage I)**

Polimoon AS Stjørdal is a subsidiary in Polimoon Group (introduced in Chapter 6.2.2) in the sector of packaging. The company used to be Dynoplast Stjørdal, under the Dyno Group. In 2000, the plastic division of Dyno Group was sold and became Polimoon.

Polimoon Stjørdal used to have a sector of technical plastics, for electronics industry and customers making furniture and lamps with a turnover of 13 million NOK. In 2001, there was a strategic re-organization. Most of the tools of the technical sector were sold to another company. In return, they bought some facilities to strengthen their packaging sector, which is their main focus now. Polimoon Stjørdal has around 130 employees and the annual turnover of about 150 million NOK.

Now their business covers the following areas: direct packaging for food and some industrial products, secondary packaging like crates and boxes, catering equipment in the airplanes and parts for military products. The first two packaging-relating areas weigh about 70% of their total business. The raw materials they use are mostly thermoplastics, among which PP and PE are the main categories. After the re-organization, the number of raw materials reduced and it is easier to manage the logistics.

The plant got their ISO14001 certification 3 years ago. As to the use of recycled material, since the 1960s, the plant began to recycle their production scraps and their damaged bottle crates. Currently, they also buy recycled material from external sources, mainly Strandplast, both PE and PP. Price is the major concern. When the price of virgin material is high, they turn to recycled material when the product applications allow. But if the price of virgin material is low, they still use virgin material.

♦ **Strandplast AS (the plastic recycler in Stage I)**

The description of this company can be referred to in Chapter 6.2.2).

♦ **Lycro AS (the plastic converter in stage II)**

Lycro is a company with 30 years' experience in the field of plastics machinery and injection molding. Lycro's business can be categorized into the international part and the Norwegian/ Nordic part. Their international market is involved in the piping industry and spreads to many countries all over the world, including machines, molds and injection molded parts. This part accounts for 30% of the turnover. Another 70% falls on tool designs, tool manufacturing and molding of technical plastics. This

[38] NTNU is the Norwegian University of Technology and Science. SINTEF is the Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology.

[39] Tomra Systems currently has over 40,000 reverse vending machines installed in 40 countries on four continents. Its mission is 'helping the world recycle'. It designs and operates cost-effective systems that make it attractive for people to return used beverage containers for reuse or recycling. (www.tomra.no)

part is for customers in industries like furniture industry (HÅG), fish industry and electronic industry in the Norwegian and Nordic market. The turnover of the company is approximately 7 million EURO. Lycro got their ISO 14001 certification in 2001.

Usually their customers decide what plastic materials to use and what color they want. They try to encourage customers to use recycled plastics, but it depends on the applications and product demands. The materials used in Lycro are mainly thermoplastics, about 500 tonnes per year. PP is the most used type, and PE and PA (polyamide or nylon) have also some portions. For the parts of the piping industry, there is no use of recycled plastics. This is mainly due to the international specification and product standards. There are about 10-15 suppliers of plastic materials, only one of whom supplies recycled material (Plaståtervinning AB). Communication is going with some other suppliers of recycled materials for the concern of the material sufficiency from a sole supplier. They recycle their production scraps.

♦ **Plaståtervinning AB (the plastic recycler in stage II)**

Plaståtervinning AB is a family owned business founded in the early 1980's. Their main focus in the beginning stage was recycling of PE. In 1994, while EPR came to Sweden after the implementation in Germany, Plastkretsen AB, the Swedish PRO for plastic material, contracted 3 companies to process the plastic packaging. Plaståtervinning was one of them.

Plaståtervinning receives plastic waste from different sources, including shops, industry, county councils, farms, households. They have collaboration with both Plastkretsen AB in Sweden and Plastretur AS in Norway. Currently, there are two main production sites of the company, one in Arvika and one in Töcksfors, with around 40 employees. In Arvika, they process PE from Swedish sources. In simplified words, the process of mechanical recycling includes chopping or grinding, washing, drying and preheating, melting and extrusion into pellets. In addition to selling recycled PE pellets, they also produce finished products like refuse bags in different sizes and qualities. They make garbage bags and carrier bags by multiple-layer extrusion mixing virgin plastics and recycled plastics (for example, 10% virgin + 80% recycled + 10% virgin) to improve the material strength and get a better color.

The plant in Töcksfors was recently established in 1998 for the recycling of PP, from the request of Plastkretsen, when the capacity to digest PP waste needed to be established. It was the first recycling plant for PP in Sweden. (Andersson, Lasse. 20 June 2002). The sources of the PP are mainly the packaging recovery in Sweden contracted by Plastkretsen, and partly from Plastretur in Norway, additionally also the caps from breweries and some industrial waste. Car industry may be the next possible source. Another reason why they decided to build a new site for PP was that mixture of PP into the production of PE would cause quality problem. From recycled PP they only produce granules, but no finished products. "Our raw material supply is redundant, and the market is available out there. It is our limited production capacity that is the bottleneck," said Leif Andersson, the owner of Plaståtervinning. The annual capacity of PP production is about 2,000 tonnes at the moment. They have plans to install some new machinery and triple the current capacity in the near future.

Plaståtervinning is paid by Plastkretsen to process the incoming post-consumer waste at a fixed price 4.5 SEK per kg, and Plaståtervinning pays Plastkretsen the fluctuating market price for secondary material. The difference may be regarded as subsidies. Since the PP plant was in operation, the price of their recycled PP has been kept the same without fluctuation. When the market price is under 4.5 SEK per kg, Plastkretsen helps to sustain the operation of the recyclers. But from a business perspective, this monetary relationship also stifles the free market mechanism of recycled plastics and prevents recyclers from earning more when the market price is high (Andersson, Leif. 20 June 2002).

6.3.3 Formation and Operation of the Material Chain

♦ **Stage I (1997-2001): HÅG Scio Chairs with bottle caps:**

According the environmental manager of HÅG, the idea of using recycled plastics in HÅG's chairs initiated in 1995 and was inspired by the EPR on plastic packaging. HÅG cooperated closely with Dynoplast (the previous Polimoon Stjørdal), who had an aggressive environmental strategy, the same as HÅG. Dynoplast held the tool for the Scio model and produced the plastic components. After some testing and development process, they decided to use the bottle caps from breweries. The caps were made of PP, with a thin layer of EVA (ethylene vinyl acetate) for better sealing with the bottleneck. This EVA content increased the strength of the recycled material. Scio model with recycled material was introduced in 1997. The recycled material was of satisfactory quality and replaced all the virgin material used previously for this model, about 90 tonnes in 1998. An LCA (life cycle assessment) was conducted to show its environmental benefit.

As in the TIK case, Strandplast collected these caps from the deposit-refund system of PET drink bottles and turned them into granules, which were then sold to Dynoplast. Dynoplast then used the PP granules to mold the chair components: the seat and the backrest, for HÅG Scio chairs.

The cooperation did not stop after the ownership of Dynoplast changed and the company became Polimoon. It was until Polimoon Stjørdal had their re-organization and decided to sell most of their technical sector, including production of HÅG's components, that HÅG stopped their production at Polimoon Stjørdal. HÅG owned the tool of injection molding and decided to move it to Lycro for production. Lycro was another component producer they worked with at that time.

Scio model has been renamed H03 and launched in the end of 2001. This chair line, which is 100% recyclable, is positioned for the lower price segments. Now the seats and backrests are produced at Lycro, with plastic material recycled from car bumpers and ketchup bottles, which will be discussed in following section.

♦ **Stage II (2001-current): HÅG Conventio Chairs with car bumpers and ketchup bottles:**

After the Scio model with recycled plastics from bottle caps was launched in 1997, HÅG used this environmental feature for marketing campaigns. The idea of turning plastic waste into a new, fancy chair was noticed by people of interest. Once a HÅG staff met some representatives from Volvo Ecris, who are involved in promoting reuse and recycling of end-of-life vehicles. He explained the use of recycled bottle caps in HÅG's Scio chairs (HÅG, 2001). In 1999, Volvo Ecris asked HÅG to produce 100 Conventio chairs with their plastic waste from Volvo's automobiles. HÅG tried with car bumpers for these 100 chairs, but it turned out to be too soft to become a standardized product. HÅG began to contact the Swedish plastic recycler Plaståtervinning AB, introduced by Volvo Ecris, for further development to improve the strength of the material. There was an initial meeting of various actors involved: HÅG, Lycro, Plaståtervinning and someone from the Swedish car industry, in HÅG's production plant in Røros. Then the cooperation was kicked-off. After some trials and tests among a few options, they came up with the formulation of plastic material of car bumpers and ketchup bottles, at a mixture of a 50/50 ratio, for their Conventio model. After the composition was decided, the color had to be fixed.

In order to get sufficient raw material, HÅG's purchasing department cooperated with Bilproducentansvar AB and Plastkretsen AB in Sweden to set the logistics scheme so that the specific types of post-consumer plastics could be sent to Plaståtervinning AB and be processed into raw materials for HÅG's chair. The materials are currently from Sweden: the used car bumpers from the 90 collection stations under Bilproducentansvar AB, and the collected ketchup bottles from the packaging recovery system under Plastkretsen AB. To ensure the availability of the materials, HÅG is establishing the possibilities of using similar post-consumer plastics from Norway.

Conventio, HÅG's conference chair model, was launched in a fair in Stockholm in Spring 2001 and caught a lot of attention. In 2001, about 90 tonnes of the new mixture was used in production of

HÅG's Conventio chairs and Capisco chairs. They expected the demand of this 'new' material to be about 200 tonnes in the year 2002.

According to Lycro, the component manufacturer who began to work with HÅG since 1991, they produce about 70 different parts for HÅG to-date. Conventio series and H03 series (previously called Scio) are 100% made of recycled plastics, and partly for Capisco series. The recycled material is cheaper than the virgin material, and both HÅG and Lycro benefit from it. When the production of H03 (previously Scio, see stage I) was moved to Lycro, HÅG aimed to choose one type of recycled plastics for all, instead of keep both bottle caps and the new bumper/ketchup bottle mixture. According to HÅG purchasing manager, it saved resources doing so.

8,000 chairs of HÅG's H05 model and Capisco model combined were bought for Telenor's new office complex, which was HÅG's biggest contract in Norway. The purchaser in Telenor revealed, "HÅG was chosen because the have *the best 'total concept'*. HÅG has, in an ergonomic aspect, a unique product mix. They had the highest score on the environmental declaration. And HÅG had, from our point of view, the best logistic model for this project. It is difficult to compare prices when the product mix is not 100% equal. Compared to the target price we set for each supplier individually, HÅG offered the lowest price." (Hjorth, 15 August 2002). For the purchaser in NTNU, who recently bought 500 chairs of H03 model, the main reasons to choose HÅG's chairs were: they last, they are easy to use, and they have good ergonomic features. "HÅG's chairs are not the cheapest, but considering the life-cycle cost, they are worth it." The purchaser is aware of the use of recycled plastics in the product. "Though it is nice to know of it, such feature is not the priority. It comes after usability and price."

6.3.4 Lessons Learned by Actors in the Material Chain

According to the HÅG's environmental manager, "from this experience, we learn that it is not more expensive to produce environmentally… We should not look at environmental issues as threats, but *opportunities*." One of their major German competitors tried to create green products among the product range, but it did not last long. Another tried to establish ecological design standards, but it was difficult to put them into practice. HÅG did not try to segregate 'green products', but instead, they integrated environmental features into their normal product line, replacing virgin materials with recycled materials.

"The buyer-seller relationship for recycled plastics is unconventional," HÅG's purchasing manager commented, "but we proved it is possible." Both models of Scio (H03) and Conventio were designed for virgin plastics. It would be easier if they had been designed for recycled plastics from the beginning.

According to the development manager in Polimoon Stjørdal, who participated a lot in the development of this case, HÅG was an interesting customer to work with, a lot of ideas and challenges. But at the same time, they perceive that, just like a normal business entity, HÅG was also price-oriented. The recycled materials they used were cheaper than the virgin materials. And the bumper/ketchup bottle mixture was cheaper than the recycled caps.

According to Lycro, HÅG initiated the use of recycled plastics for their environmental focus and for the marketing purpose, but it resulted in good economic benefit as well.

The purchaser at NTNU commented, "HÅG is a clever company. They learn eagerly. They have a good product, a good culture, and good marketing campaign. Norwegian companies should learn from them."

7. Analysis and Discussion

In the previous chapter of case findings, the step I of analytical framework is accomplished. The first three sections of this chapter (7.1 to 7.3) carry on the tasks laid out by the framework. The author integrates the analysis of step II and step III in each section: first identifying the drivers and barriers and, in between, discussing the contributions of EPR. The ultimate aim is not to give a comprehensive list of drivers and barriers, but rather to explore if EPR has been of influence, and if yes, to understand how. In section 7.4, a summary of EPR influences will be made, based on the information already presented in previous chapters and sections.

7.1 Triggers to Initiate the Change

In the TIK case, the ice hockey club is the initiator. Although TIK was not involved in the production of chairs, they are not really the 'end'-users. They have customers who are the sport fans or even the sponsors of sport activities. According to TIK's marketing manager, all sport clubs are similar, and TIK tries to "stand out from the crowd". They think a good environmental image is a proper link to sport, to enhance the healthy image. The author considers such link logical as well. However, a logical link like this does not necessarily become prevailing simply by being logical.

In the HÅG case, the chair producer HÅG is the initiator. Their customers are the chair users. Their vision is to be different and better. HÅG has a strong corporate environmental strategy in general, covering various aspects of their operations and activities.

In both of the cases, the initiative of the change to use recycled plastics was derived from the organizational environmental strategy. And the environmental strategy came from *the wish to use ecological arguments in the marketing*, i.e. there is perceived customer demand on the environmental performance of their products or services. Both of the initiators emphasize the differentiation from other similar actors (not necessarily competitors). When the author is impressed by the initiators' dedication to environmental issues, it is also noticed that such issues have not become part of the common practice for the majority.

When both the initiators, TIK and HÅG, were weighing the potential costs and benefits before taking action to use recycled plastics, they were not aware of the actual economic benefits of using recycled plastics. It came as a positive side effect[40]. We may say that it was mainly their strong resolution to realize the organizational goal that initiated the change.

There is no sign that external pressures or governmental regulations of any kind have influenced the decision making of the initiators in both cases. **It does not seem that the implementation and outcome of EPR programmes has contributed much at the initiation stage as a trigger.** However, according to HÅG's environmental manager, the generation of their idea to use recycled plastics was inspired by the EPR programme on plastic packaging in 1995.

7.2 Influencing Factors in the Change Process

In this section, the author analyzes the influencing factors in the cases studied, based on the issues identified in chap. 3.4.2.

[40] In the TIK case, although the price of recycled plastics was higher than virgin plastics, the purchasing price of chairs was lower and fell within the budget level.

7.2.1 Technological Factors

When technological factors are considered in the cases of using recycled plastics, we may discuss it along the processing steps as shown in Figure 3-2.

Sorting. All the plastic converters in the case studies recycle their internal scraps. This shows that clean fraction of plastics is highly usable. The plastic materials in the waste stream are usually mixed of different plastic types or even other types of materials. Separation is particularly important in cases where contamination is not allowed, for example, the appearance PP would result in inferior quality of recycled PE, which we learned from Plaståtervinning.

In both cases, the post-consumer PP came from different EPR programmes, i.e. PP bottle caps from deposit refund systems, car bumpers from automotive collecting stations, and ketchup bottles from packaging recovery system. The trouble of sorting is much lowered. Separation at source before the post-use materials are collected can greatly ease the process at the sorting stage. **EPR programmes help to establish channels and infrastructure for collection and separation of clean fractions, and thus contribute to reduce the necessity of high-technology sorting.**

Recycling. After proper sorting, the recycling process of plastics itself in the cases does not involve sophisticated technology. The mechanical recycling includes several physical processes. The recycler Strandplast mentioned the growing precision of plastic machinery, which makes the tolerance of impurities decrease. They built a washing plant to meet the demand of a major customer. Still, it is not high technology oriented.

Plastic conversion and plastic products. Quality consistency is important for using recycled plastics in commercial applications. The recycled materials need to have consistent quality, such as melt index and material strength. Several plastic converters expressed such concern during the interviews. When the composition of the waste stream changes, the inherent properties of the recycled plastics will change, too. In the TIK case, which was only a one-time purchase, it is not a problem. For HÅG, who uses the recycled PP on a continuous basis, the potential variation in the composition of the incoming car bumpers and ketchup bottles may be concerned. However, the material content of bumpers and ketchup bottles is out of control of actors in the material chain of this study. It is based upon the decision of the 'producers' of cars and bottles. Although EPR programmes do not put limits on those producers for what type of plastics to use, **the mechanism of EPR programmes help to bring post-consumer plastics of similar quality together**, e.g. PET in bottles or technical plastics in EEE and ELV.

Coloring has been an issue mentioned by both recyclers and users. The pellets produced from recycled plastics have dark and relatively unstable color. This makes it difficult for its applications where light colors or high standards for aesthetics or appearances are required, for example, in the automotive industry, which Polimoon Moss is involved in. In the TIK case, the color turned out to be different from the expectation, but TIK found it acceptable at last. In the HÅG case, the seats and backrests made by recycled PP are wrapped by textiles so it is not too problematic.

In terms of material features other than color, the results of both cases show that recycled PP has high suitability in the application of chairs. Thus, we may expect that recycled plastics has high potential to be used in other applications, similar to chairs or not. However, the author thinks there is *technology lock-in* (mentioned under technological factor in chap. 3.2) of using virgin plastics. People are used to it since it appeared first in the market, and have developed different products and practices based on what virgin plastics can offer. Mentioned in chapter 2.3.3, the existing specifications or standards sometimes unnecessarily limit the use of recycled plastics. Such discrimination is a result of *path dependency* of technology for virgin plastics. To deal with this problem, the EU Communication (Oneworld, 1998) proposes the solution of standardization, in order to improve the position of secondary raw materials.

In order to find out the suitable mixture of recycled plastics, the plastic recyclers interviewed in the cases have to be involved in the product development process. There is a lack of product standards for recycled plastic pellets. Compared to virgin plastics, it is rather difficult to make adjustment in the properties of recycled plastic pellets due to the limitations from the incoming materials. Therefore, although the plastic recycling is not high technology oriented, it requires high coordination to make it happen. Discussion about this will be made in chapter 7.2.3.

7.2.2 Economic Factors

When economic factors are considered in the cases of using recycled plastics, the author makes discussion according to benefits and costs grouped in chap. 3.4.2 from Figure 3-3.

Price advantage & the cost of collection and sorting. From our case studies, author confirms that normally recycled PP has certain price advantages over the virgin PP. In some Norwegian recyclers, price of recycled plastics is about 50-75% (Strand, 6 June 2002, and Røine, et al., 1998) of virgin plastics price depending on the quality of the recycled product. The price of virgin plastics fluctuates with the price of crude oil, the raw material for virgin plastics. Therefore, some plastic converters like Polimoon Stjørdal choose to use recycled plastics when the price of virgin plastics soars high if the application allows.

Such price advantage of recycled plastics has a lot to do with the low cost of collection and sorting for the recyclers. The plastic recyclers in both cases are not involved in activities of collection and sorting. The materials sent to their plants are fractions of different types of plastics already sorted by the upstream actors. In the cases studied, the plastic materials came from different EPR programmes, where producers are financially and/or physically involved in the end-of-life management of their products. Therefore, we may say that **EPR programmes allocate the responsibility of waste management to the producers in the upstream product system so that the cost of collection and sorting does not become a burden for the material chain using recycled plastics.**

In the TIK case, Plastretur, the Norwegian PRO for plastic packaging, sponsored the end-user (TIK) to make it happen, lowering the cost for the initiator. However, this may not be considered as the normal case.

The market benefits. Among the actors in the material chains, the market benefits are most likely to occur for the product manufacturers who carry the brand and make communication with the end-users. They expect the market benefits to turn into more revenues from higher sales volume and higher customer's willingness to pay. Based on this rationale, the author thinks it is interesting to see that HÅG positions the H03 model produced with recycled PP for the lower price segments. This is because they integrate the resource efficiency in their overall product line, instead of just creating one or two green products targeting customers with green demands. A lot of product manufacturers may wonder, would the green features of their product pay off? From the two end-users interviewed in the HÅG case, the author finds out that the environmental feature with recycled PP in HÅG's chairs is appreciated, but not the prioritized reason why they choose the product. The price and usability come first in the consideration, particularly the usability, since a chair lasts for years and a good ergonomic feature brings comfort. Therefore, the author is not able to observe the existence of higher willingness to pay for the recycled content.

Efforts to overcome technical restrictions. In the cases studied, the technical requirements were eventually met. However, compared to using virgin plastics, the R&D (research and development) process for using recycled PP is longer. The plastic converters and even product manufacturers have to get involved in numerous trials and material tests to find the proper kind of recycled 'raw material' or mixture of 'raw materials' with the recyclers. This lengthier process results in higher costs for product development.

In addition, it was mentioned by HÅG personnel that virgin plastics tend to be favored by designers or product development staff because virgin plastics offer more possibilities in material performance. If they have to use recycled plastics, the design capability is restrained. Compromises in design can result in costs, too. This may be a concern for other design-oriented companies of HÅG's kind.

Risk of source availability. Source availability is what potential user of recycled plastics would worry about. In stage I of the HÅG case, the bottle caps from the deposit refund system were used. In stage II, the logistics system has been set up with the cooperation of Bilproducentansvar AB (the Swedish PRO for ELV) and Plastkretsen AB (the Swedish PRO for plastic packaging). **EPR programmes have contributed to creating and/or securing the source availability of the incoming post-consumer plastics.**

Increased dependency. HÅG and Lycro expressed their concern about the increased dependency on the current recycler Plaståtervinning as sole supplier. Communications and efforts are on-going to explore the expansion of sources. However, due to the limited amount of recyclers and their specific capability, this is probably not easy. Most of plastics recyclers are small and medium sized companies (SMEs), while producers of virgin plastics are usually huge, multi-national enterprises. Taking recyclers in our cases for example, Strandplast has the total annual capacity of 6,000 tonnes, and Plaståtervinning produces 2,000 tonnes of recycled PP per annum. In Norway, the six major plastic producers together produce 2 million tonnes per year (see chap. 4.1).

7.2.3 Social and Political Factors

The social and political factors are discussed according to the items listed in chap.3.4.2.

Organizational status. Some organizations are actively involved in environmental issues, like TIK, HÅG and Dynoplast (previous Polimoon Stjørdal)[41]. Organizational culture may change when the ownership is transferred or when the focus of the management level is shifted. After re-organization, the product focus of Polimoon Stjørdal changed, which made them stop the cooperation with HÅG. IFAS Sport was not yet financially stable, so environmental development is not of their main interest at this stage. Even if they did not perceive that it costs more to be green, which they do now from the TIK case, they need to allocate the limited company resource to the most important priority. Therefore, we may say that the decision of using recycled plastics in one organization is influenced by its organizational culture, product focus and management priority.

The development of recycling activities in the recyclers has a close link with the implementation of EPR programmes. Strandplast takes care of the plastic waste from breweries. Plaståtervinning works for Plastkretsen, the Swedish PRO, and established their capacity to recycle PP from their demand. **EPR programmes increase the demand of recycling activities, and therefore, support the existence and operation of the recyclers.**

Perception. Different attitudes towards recycled plastics may be found among the actors: positive, negative or neutral. The positive attitude is mainly from TIK and HÅG, the initiators, since they can relate it to the marketing benefits from environmental features of using recycled plastics. The perceptions of the plastic converters are either suspicious (worrying about damages to machinery and performance) or neutral (using it when price is low and application allows; regarding it as just another type of raw material). The author thinks this has something to do with their previous experiences with recycled plastics. Lack of experiences or unsuccessful experiences tends to result in hesitation. Other than the perceptions about the quality and usability, the converter in the TIK case has the impression that recycled plastics is more expensive, due to the cost of collection and sorting. There is a lack of

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[41] It is not implied that the current Polimoon Stjørdal does not have good environmental practice. The statement here is based on the perception of HÅG, their customer.

updated information about the latest progress of the recycling industry. From the definition about institutionalization mentioned earlier in chapter 2 (see footnote 5, page 11), the author thinks that using recycled plastics is not yet *institutionalized* among the plastics users.

However, the author discovers that even if the actors are not actively involved in using recycled plastics at the moment, there is expectation about the increased use of recycled plastics (Polimoon Moss) as the solution for the problem of increasing scraps in the near future. The customers of Polimoon Moss are mainly in the automotive industry, and thus, it is reasonable to assume that the implementation of EU ELV Directive has some linkage with such expectation.

Information flow and inter-organizational coordination. The material flow and cash flow of the cases studied are not different from the conventional product chain, but the information flow is unique in both cases. The initiators in both cases, TIK and HÅG, are also identified as the communicators, taking the dominating role to communicate with all the key actors. In the TIK case, TIK contacted Plastretur to get the list of plastic suppliers so that TIK could explore the possibility further. **The PRO provides crucial information to the key actor in the material chain.** In the HÅG case, the product manufacturer HÅG was involved in setting up logistics scheme with their potential sources of post-consumer plastics: Bilproducentansvar and Plastkretsen. **PROs here are even directly involved in the arrangement of material flow of post-consumer plastics.**

In both cases studied, a strong pull from the demand side can be observed. But it is understood during the interviews with recyclers that usually, after plastics collection and sorting, a considerable amount of efforts must be devoted by the plastic recyclers to finding appropriate applications for the recycled materials. The actors in the demand side are persuaded of using recycled plastics, instead of actively seeking the opportunities themselves.

In the HÅG case, the stage I and stage II show different patterns of inter-organizational coordination. In stage I, HÅG cooperated with the plastic converter, who also had active environmental strategy. Therefore, HÅG did not have to get involved further upstream. The initial process in stage II was more troublesome for HÅG. They called for an initial meeting, gathering different tiers of suppliers to seek joint efforts for development. To do this, HÅG has to be a relatively powerful actor in the material chain.

Influence of external actors. In the change process observed from the cases studied, no obvious sign of direct political intervention from the governmental authorities can be observed, and nor can the author see influences from environmental groups or industrial associations. The actors in the material chains were not regulated or required to change by external actors, although Plastretur can be considered an external actor influencing the TIK case.

One category of EPR implementation includes setting a target of minimum amount of recycled content or secondary materials per product. However, since the cases studied are open-loop recycling, the actors are not under the direct binding scope of such EPR mechanisms.

7.3 The Diffusion of Experiences

In chapter 3.2, the author discussed the factors influencing diffusion: information and learning, characteristics of potential adopters, characteristics of technology, fixed resources and the effect of adoption on output prices. The experiences of using recycled plastics may be extended by the actors involved in the cases to other business opportunities or diffused to other firms through different marketing campaigns or channels of information dissemination.

In the TIK case, IFAS Sport and Polimoon Moss revealed that they had no plans in the near future to extend the experiences they learned from the TIK case. The author thinks the diffusion were hindered for two reasons discussed in chap. 7.2.3: the misperception that recycled plastics is much more expensive than virgin plastics, and the organizational priority of IFAS Sport to stabilize their financial situation before looking into environmental issues. However, Polimoon Moss admitted that from the TIK case, they learned that technical requirements could be reached by using recycled plastics. And IFAS Sport agreed to offer discount to TIK with the expectation that there will be some opportunities to come following the marketing effect. It seems that if the misperception is clarified, and the organizational financial status is improved, use of recycled plastics in these actors may increase.

According to Polimoon Moss, the first driver of using recycled materials is the price. If it is cheaper, people will naturally consider using it. From the recyclers in the cases, we learned that the recycled PP has indeed price advantage over virgin PP. However, such information is clearly unknown to some potential users of recycled plastics. The barriers of low transparency and lack of reliable market information mentioned in chap. 2.3.3 may be observed.

Plastretur played an important role in the TIK case. They sponsored the case for their own market campaign to demonstrate the usability of recycled plastics. The story of the HÅG case can also be found on Plastretur's website. As mentioned in chap. 2.4, Plastretur has the stated goal to build up a sustainable market for recycled plastic packaging. These market campaigns can be regarded as their actions towards realizing this goal. **EPR organizations like Plastretur sometimes play the role in disseminating information of the successful case to drive further change, although the influence of such efforts is not yet clear in the market.**

In the HÅG case, we may clearly see that the success of stage I has driven the change in stage II. The idea of using recycled PP in bottle caps has inspired people in the automotive industry to offer bumpers as another material source. The success of the case is then spread further by active actors in stage II other than HÅG, to drive innovation in other firms of the same interest.

Lycro tries to encourage their customers to use recycled plastics, but mentioned that such decision highly depends on the requirements in the product application. The final decisions of using recycled plastics mainly come from the product manufacturers, sometimes the plastics converters and very rarely from the demand of end-users. The plastic converters usually have to follow the product specification or design made by the product manufacturers. They make the choice of materials based on the customer demands. They do what the customers want and are ready to pay for. That is why recyclers like Plaståtervinning usually go out and seek business opportunities at the product manufacturers.

From the interviews with recyclers and converters in the cases, the author may perceive the *inertia to change* (see chap. 3.2) among the potential users of recycled plastics. Being informed of the successful experiences is one thing; taking actions to change is another. This forms a barrier in the diffusion stage.

7.4 Influences of EPR Programmes to the Market Development

In this section the author discusses and summarizes the influences of EPR programmes to the market development of recycled plastics, based on the Norwegian EPR context and the case findings in previous chapters and previous sections of this chapter. When issues in the market are to be examined, the author proposes to discuss them on the *supply side* and *demand side* respectively. Actors in the material chain, the unit of analysis for this research, can be also divided into the two sides from the standpoint of recycled plastics in the material flow. The plastic recyclers are on the supply side, following the previous product systems under EPR programmes; and the plastic converter, the product manufacturer and the end-user of the product, together, form the demand side (see Figure 7-1).

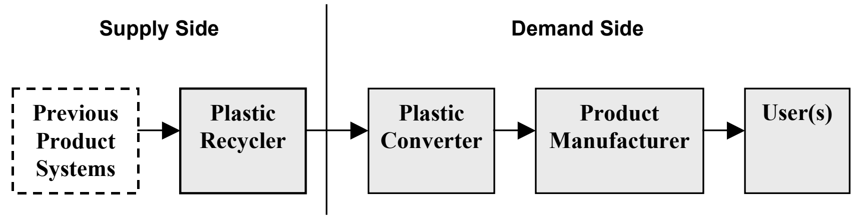

Figure 7-1 Dividing the Material Chain into Supply Side and Demand Side of the Market

7.4.1 On the Supply Side

EPR policy instruments extend producer's responsibility, financial or physical, to the post-consumer stage of a product. The producers have to look after the end-of-life management, including collection, sorting and recycling, either entirely or partially. Let's take the Norwegian EPR programmes mentioned in chapter 5.3 as examples. In the deposit refund system, the producers (the brewers and the retailers) collect the PET beverage bottles, separate the body and cap of the bottles and send them to recyclers (the raw material in the TIK case and stage I of the HÅG case). Because of the market value, the brewers can even get some money from their 'waste.' In the packaging recovery system, the fillers and packers pay, and Plastretur allocates the money for the arrangement of collection, sorting and recovery for plastic packaging. In the EEE systems, the mechanisms help to gather the usable plastics. The collection of ELV has been in operation since long, but we may expect the newly implemented ELV scheme with strict recycling target to attract more resources from the producers to reinforce plastic recycling. Currently, about 75% of an ELV is recycled, mainly its metal content. Looking at the recycling target set by the EU ELV Directive (see chap. 5.2.2.2), we may say that one of its major aims is to encourage plastics recycling. Summing up the above, the author concludes that **EPR programmes highly reduce the cost of collection, sorting, transportation and processing for the successive material chain after the EPR product systems. And thus, the price of recycled plastics can be more competitive.**

The monetary relationship of Plaståtervinning and Plastkretsen, the Swedish PRO for plastic packaging, shows that in some EPR programmes, we may find mechanisms helping to sustain the price level of recycled plastics, particularly when the price of virgin plastics fluctuate low. Thus, **some EPR programmes establish mechanisms that may help to stabilize price fluctuation of recycled plastics.**

Among the 20 recyclers in Norway, some were established because of the Norwegian packaging covenant or after the signature of the covenant (Oland, 16 August 2002). Strandplast built their PET recycling plant in the same year when one-way PET bottles were introduced with the deposit refund system (see Footnote 33). The Swedish recycler Plaståtervinning built their PP recycling plant from the demand of Plastkretsen. **These EPR programmes increase the recycling activities and supported the existence of some recyclers.** In the EPR programmes introduced in chap. 5.3, consistent flow of post-consumer plastics is collected to be further utilized. Therefore, **EPR programmes help to increase the quantity and ensure the consistency of material supply to the recycling system.** However, during the interview Strandplast mentioned their dependency on the direction of policy. Their operation may be influenced if the government decides to change the current mechanism, e.g. refillable or one-way PET bottles.

In the Norwegian packaging recovery system, Plastretur defines the quality standards, controls and revisions for their contracting partners. It helps to increase the usability of post-consumer plastic packaging. Plastretur's arrangement of trainings and communications also improve the skills and operations of actors in the packaging recovery system. Thus, we may say that **EPR programmes also make the recycled materials more usable**, other than just available.

Under many EPR programmes, the PROs are formed to take the collective responsibility to develop, execute and monitor the recovery systems. Examples in Norway are Plastretur for plastic packaging, Norsk Resirk for one-way PET bottles, and the three PROs for post-consumer EEE. These organizations form channels through which actors like TIK can get information about current status of recycling activities, including the list of recyclers. **EPR programmes may improve the information availability and transparency on the supply side of the market.**

7.4.2 On the Demand Side

From the cases studied and the related interviews, the author concludes that the influence of EPR programmes on the demand side is not significant. The trigger of the actors was mainly due to market reasons. Though actors on the demand side can be encouraged to use recycled plastics if they learn that mechanisms of different EPR programmes help to secure the availability of sources, not all the key actors interviewed in the cases studied were aware of the EPR implementation which influenced the recycled plastics they used.

However, one thing worth discussing is the fact that Plastretur decided to sponsor the TIK case for their own marketing campaign in order to show the general public that recycled plastics is well usable, so as to promote the practice of recycling. They assume when citizens know that recycled plastics can be turned into products, they are more willing to participate in changing their behavior towards recycling. Plastretur has begun to gain awareness about the importance of the demand side. Since the application in TIK case did not exist when Plastretur decided to sponsor, their monetary sponsorship also fostered the innovation. But such practice is not considered conventional.

On Plastretur's websites, several product applications with recycled plastics[42] are demonstrated. The author regards this as an attempt to change people's negative perception about using recycled plastics, in order to lower the resistance to use recyclate in new product. Therefore, **some PROs in EPR programmes take the role to collect and disseminate information about successful product applications with recycled plastics for driving the demand of the materials**.

7.4.3 Summary and Concluding Remarks

The author summarizes the above-discussed influences in Table 7-1. Obviously, EPR programmes have strong influences on the supply side of the market, but only far less significant contributions on the demand side.

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[42] See http://www.plastretur.no/produkter.html

Table 7-1 Summary of Influences from EPR Programmes in the Market of Recycled Plastics

Supply Side	Demand Side
– EPR helps to release the cost burden of collection, sorting and processing – EPR may provide mechanism to stabilize the price of recycled plastics – EPR increases the quantity, and helps to ensure the consistency of quantity and even quality of recyclate – EPR may improve the visibility of the recyclers	– Some PROs demonstrate successful product applications with the attempt to low the resistance of using recyclate

In cases of open-loop recycling, though EPR does not have direct binding force on the actors, particularly those on the demand side, various EPR programmes contribute to construct the social structures (see chap. 3.1.1) which make the change process of using recycled plastics possible. The outcome of the political structures of EPR programmes in the EPR product systems improves the physical and economic structures for the actors in the material chains using recycled plastics. The mechanism of EPR programmes also changes people's behavior towards recycling and people's perception, and thus influences the cultural structure.

Despite the contributions, some barriers identified in chap. 2.3.3 do not seem to be affected by EPR programmes. When some people in the society are working towards closing the material loop, the primary production of virgin plastics continues to offer the users options of cheap materials with diverse performance.

Regarding limited applicability of recycled plastics, the change process of the cases studied shows that such limitation is sometimes not technological, but perceptional. In spite of the usability of recycled plastics, it does take more efforts in coordination and product development for actors to make it happen. The discriminating product standards again demonstrate the fact that people are used to what virgin materials can offer. The imbalanced power between the large producers of virgin plastics and small and medium sized plastics recyclers may add difficulty to change. Although we may see the attempts of some PROs trying to provide market information and improve the transparency, these areas still need a lot more efforts and coordination of different actors in the material chain and influential external actors.

8. Conclusions and Recommendations

The author concludes this research by answering the research questions stated in the purpose of this thesis:

RQ 1: *How is the demand to use recycled plastics triggered in the material chain?*

From the case studies, the demand to use recycled plastics from the initiating actors in the material chain is mainly derived from the wish to use ecological arguments in their marketing and to differentiate themselves from other similar actors.

RQ 2: *Once the change is initiated, how do actors in the material chain accomplish the change process of using recycled plastics?*

A complex set of factors influence the accomplishment of the change process following the initiation. The author discusses them in the categories of technological, economic, social and political factors. The level of technology involved in the cases studied was not high, and the economic outcomes seemed to be acceptable, if not satisfactory, for all the actors. The information flow and inter-organizational coordination, however, is regarded by the author as the most crucial and challenging part of the change process in the cases.

RQ 3: *How have various EPR programmes contribute to the above?*

The initiation of the initiating actors in the cases studied did not seem to be triggered by the existence of EPR programmes.

However, implementation and outcome of EPR programmes have various contributions to the change process that followed, in each category of influencing factors. For the technical factors, the collection and separation in EPR mechanism reduce the necessity of sorting technology. For the economic factors, the major contribution of EPR is to reduce the cost from collection, sorting and processing for the actors in the material chains following the EPR product systems, and to ensure the source availability. For the social and political factors, some PROs established in EPR programmes may provide useful information of recyclers to actors of interest or get involved in the arrangement of the wanted materials, which contributes to ease the information flow and coordination of actors.

Moreover, some PROs show the attempt to disseminate successful experiences of using recycled plastics to drive further change.

Finally, with regard to the influences of EPR policy instruments in the market development of recycled plastics, the study shows that various contributions of EPR programmes may be observed in strengthening the supply side of the market, but their influences in driving the demand side are far less significant. However, the author can see PROs like Plastretur begin to play the role in disseminating successful product applications with recycled plastics, in order to increase the acceptance of recycled packaging.

In countries where EPR programmes are implemented to promote recycling, the supply side of the market is obviously enhanced. However, to supplement such effect of the EPR programmes, the author thinks more attention should put to drive the demand of recycled plastics. Only when the supply side and the demand side are of more balanced status, the material life cycle of plastics can be extended smoothly.

How to build up the demand side of recycled plastics itself is a big question, which requires a lot of further research. Here, the author would only suggest some directions. The capability to drive the demand side may be built both within the EPR programmes and outside of the EPR scope:

♦ **Build the capability with EPR mechanisms and institutions:**

The possibility of strengthening the mechanism to encourage the use of recycled materials in products directly covered in EPR programmes, i.e. closed-loop recycling, should be further explored, such as the requirements of minimum recycled material content. In addition, PROs, the organizations in charge of running EPR programmes, may play a more concrete role in providing information and disseminating experiences with the resources they possess to promote the use of recycled plastics.

♦ **Build the capability outside of EPR mechanisms and institutions:**

Practices in some existing market-driven initiatives may provide a good reference. For example, establishing organizations dedicating to the market development of recycled plastics. Such organization can play the role to work in partnership with business, industry and local government and provide manufacturers with programmes of technical assistance in business development, product marketing and so on.

In the EU Communication on improving competitiveness of recycling industry, the proposed solutions to the identified key problems (discussed in chap. 2.3.3) include *standardization*, *enhancing market transparency*, *driving innovation* and *harmonizing regulations* (Oneworld, 1998). Such solutions require high involvement and coordination of all actors in Figure 8-1.

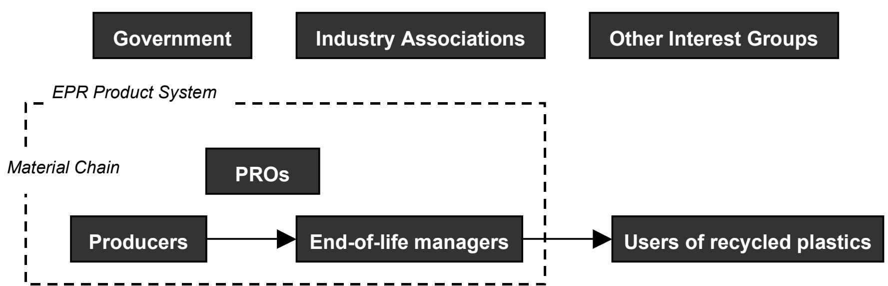

Figure 8-1 Involvement of All Actors

However, to achieve the goal of industrial ecology, i.e. to move towards a more sustainable pattern of resource utilization, such move may still seem incremental, rather than radical. Instead of positioning the use of recycled plastics to be different, as the TIK and HÅG in the cases studied, it should be aimed to institutionalize the use of recycled plastics into the daily practices of plastic users. Moreover, in the current economy, high material quality is pursued by producers to satisfy their customers and gain competitive advantages. The aesthetic requirements in automotive industry offer a good example. In some cases, the quality of materials is excessive for the function and purpose of the products. This, in turn, results in the product standards that discriminate recycled plastics. To deal with this issue, more radical changes in the current pattern of production and consumption seem essential.

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Abbreviations

APME	Association of Plastics Manufacturers in Europe
EEE	Electrical and Electronic Equipment
ELV	End-of-life Vehicle
EPR	Extended Producer Responsibility
IE	Industrial Ecology
LCA	Life Cycle Assessment
NMoE	Norwegian Ministry of the Environment
NOK	Norwegian Kroner
PE	Polyethylene
PET	Polyethylene Terephthalate
PP	Polypropylene
PRO	Producer Responsibility Organization
SFT	Norwegian Pollution Control Authority
TIK	Trondheim Ice Hockey Club (Trondheim Ishockey Klubben)
WEEE	Electrical and Electronic Waste

Appendix I: Definitions of Terms

From the 'Agreement of the Reduction, Collection and Recovery of Plastic Packaging Waste' or the Covent on Plastic Packaging (Norwegian Ministry of Environment, 1995):

Packaging: all products of whatever kind or material used for the containment, protection or delivery of goods from the producer to the user or consumer

Packaging waste: discarded and residual packaging from consumption, services and production

Sales packaging: packaging which at the point of sale constitutes a sales unit to the final user or consumer

Grouped packaging: packaging which at the point of sale constitutes of a group of sales units

Transport packaging: packaging conceived so as to facilitate handling and transport of grouped packagings. Transport packaging does not include road, rail, ship or air freight containers

Recovery: making use of waste materials by recovering the materials or by exploiting energy generated from them

Material recovery: utilizing waste in such a way that the material is wholly or partly retained, either for its original purpose or for other purposes. In direct material recovery the waste is used as raw material for similar products. In indirect material recovery the waste is converted to other types of products

Energy recovery: the exploitation of the energy in waste by means of incineration or the like

Waste reduction: the reduction of the quantity of packaging waste at its source by reduced consumption or changed patterns of consumption, changed production processes, and improved utilization of raw material and energy

The packaging chain: any enterprise which supplies raw materials for packaging, manufactures packaging, imports packaging, uses packaging for its products or sells packaged products.

Closed-loop recycling: A recycling system in which a particular mass of material is remanufactured into the same product. Also known as Horizontal recycling.

Open-loop recycling: A recycling system in which a product from one type of material is recycled into a different type of product. The product receiving the recycled material itself may or may not be recycled. Also known as Cascade recycling.

Appendix II : Major Types of Thermoplastics and Thermosets and Their Primary Applications

Major Thermoplastics	Primary Applications
Low density polyethylene (LDPE)	Pallet and agricultural film, bags, toys, coatings, containers, pipes
High density polyethylene (HDPE)	Containers, toys, housewares, industrial wrappings and film, gas pipes
Polypropylene (PP)	Film, battery cases, microwave-proof containers, crates, automotive parts, electrical components
Polyvinyl chloride (PVC)	Window frames, pipes, flooring, wallpaper, bottles, cling film, toys, guttering, cable insulation, credit cards, medical products
Polystyrene (PS & EPS)	Electrical appliances, thermal insulation, tape cassettes, cups, plates, toys
Polyethylene terephthalate (PET)	Bottles, textile fibres, film food packaging
Styrene copolymers (ABS/SAN)	General appliance mouldings
Polymethylmethacrylate (PMMA)	Transparent all-weather sheets, electrical insulators, bathroom units, automotive parts
Polyamide (PA)	Films for packaging of foods such as oil, cheese and boil-in-the-bag products, for high temperature engineering applications and textile fibres
Major Thermosets	**Primary Applications**
Phenolics	Adhesives, automotive parts, electrical components
Epoxy resins	Adhesives, automotive components, E&E components, sports equipment, boats
Polyurethane (PU)	Coatings, finishes, cushions, mattresses, vehicle seats

Source: APME (2001).