DRIVERS AND BARRIERS IN THE SUPPLY CHAIN – THE IMPORTANCE OF UNDERSTANDING THE COMPLEXITY OF RECYCLING IN THE INDUSTRIAL SYSTEM

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ABSTRACT

The basic objectives of current EU waste policy are to prevent waste and promote re-use, recycling and recovery to reduce negative environmental impact (2008/98/EC). In this paper, we focus on drivers and barriers for sustainable development by decreasing amount of waste and increasing material efficiency. Main target is to understand what are the most efficient drivers for environmental friendly decision making for reasonable consumption and use of raw materials.

Environmental control instruments usually mean those actions the regulatory authority uses to control and limit environmentally harmful behavior of companies. A major change in the environmental control system took place in the 1980s with the focus moving from specific environmental issues to the environment as a whole. The environmental control system i.e. the legal (administrative), economic and informative instruments focuses on prevention. Before and still, the legislation is one of the main drivers in improving material efficiency.

In this paper, we focus on drivers and barriers for effective industrial material use, and mainly on drivers. The objective of this study is to analyze how the drivers are working and are there any possibilities to influence on those. Our aim is also to introduce few examples of the existing supply chains and the drivers for better environmental performance and material efficiency. These examples are also compared with ideal reference scenarios.

Our main research question in this article is: “Are the financial issues the most important driver for environmental friendly strategic decisions?” In addition, retell the story from another perspective: “The most important barrier for environmental friendly innovations seem to be the investment cost, the high risk involved in committing capital to unproven technology.” Other drivers, like the corporate social responsibility, stakeholder pressure, and general public pressure, will also affect the final decision.

This article is based on research projects and literature.

Keywords: drivers, decision-making, environmental management, saving primary raw material, material efficiency, sustainable production, critical raw materials

INTRODUCTION

Natural resources and raw materials, such as metals and minerals are often taken for granted in today’s society. In the developed economies, European Union, USA, Japan etc., electronics stores offer an enormous variety of modern conveniences, including tablet computers and mobile phones. The production of these everyday items depends on a secure, sustainable, and reliable supply of critical raw materials. This is vital to both the EU and all

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industrial countries. Moreover, no country in the world is entirely self-sufficient when it comes to the raw materials. Furthermore, as the global economy grows, more raw materials are required (Euinsight, December 2011).

Thus, the great challenge faced by economies is to integrate the paths of environmental sustainability and economic growth. Social, economic and ecological thinking can be an opportunity for all actors. Making environmental friendly decisions, such as saving raw materials, using by-products and reducing waste, might be the win-win situation for companies, shareholders, consumers, communities and the environment. The long-term goal of the European Union is to become a recycling society that uses waste as a resource (COM (2005) 666). Therefore, the basic objectives of current EU waste policy are to prevent waste and promote re-use, recycling and recovery to reduce any negative environmental impact (2008/98/EC).

Environmental legislation is also designed to be one of the major drivers in improving material efficiency. According to the European Council´s new Waste Framework Directive (Directive 2008/98/EC), the waste policy should aim at reducing resource usage. At the forefront of this policy, are the means preventing waste and the re-use and recycling of materials. In addition, the ambitious goal of the EU is to cut greenhouse gas emissions (level at 2005) by 20% by 2020. To achieve this target there is a role for the environmental taxes to induce changes in businesses and consumers' behaviour.

In our research, we focus on drivers and barriers for effective industrial material use, especially on drivers. The main hypotheses of this article are: *are there any other drivers than economical drivers; are the drivers same for all the actors in production chain and are they effecting in the predicted manner?* Our objective is to analyse how the drivers work and whether there are there any possibilities to influence them. It is also noteworthy that few studies have been published in this area. In particular, the research question of the drivers for recycling is often unrecognized.

Thus, the most important driving green force seems to be money. The costs are the most important single issue, which was mentioned in interviews when asking about drivers and barriers for more effective material use. Investments and price of the raw material are also important in the management decision making (Pajunen *et al,* 2011). Therefore, in this article we focus on economical drivers and instruments, particularly taxation as a driver. As stated in Bosquet´s article (2000), the idea of the tax reform is shifting the burden from employment, income and investment to pollution, use of raw materials and waste. The question is: can environmental tax reform help the environment without hurting the economy? Jordan *et al*. (2010) have shown that in the 1990s policy-makers began to experiment levying taxes on forms of spending in few European countries, including Netherlands, Finland (for example waste oil), France, Germany and the UK.

In this article, our aim is to demonstrate the complexity of recycling in industrial systems. Additionally, we will show what are the main existing drivers for producers at present and if there are any possibilities to affect for reasonable consumption and use of raw materials. Currently, the only driver for companies is to sell more and improve on the economical performance against last year´s result. The target is to be the world´s number one in market share, for example, in new mobile phone market. Meanwhile, new phones are more and more technical. An undeniable fact is that there are no recycling systems or even technical solutions to recycle rare earth metals from mobile phones and other electronic devices. Hageluken *et al*. (2010) have demonstrated that global sales of mobile phones in 2008 were close to 1300 million units, PC´s, and laptops around 300 million units and still there are no recycling systems for valuable metals like gold.

Our targets in this paper are firstly, to present the sensitivity of recycling in industrial systems and decision-making process in it. Secondly, to describe the existing environmental responsibility inside the supply chain and discuss if it does it really exist. Finally, we want to demonstrate the necessity of Eco Design because of the limited global resources.

In the section *Drivers in industry – recycling perspective,* we will introduce a few business case examples of the existing supply chains and the drivers for better environmental performance, material efficiency and recycling. These examples are also compared with ideal reference scenarios. In addition, our target is to describe the decision making process in the one supply chain and show how sensitive the system might be. Only one decision may change the whole recycling system (Aarnio, 2006). Therefore, there is also great challenge to generate drivers, which focus on the most significant harmful environmental impacts.

The approach of this article is more behavioural and philosophical than technical. The point of view is economic and management. The study rests on literature material and qualitative material (ProDOE and Environmental Footprint research projects: interviews and workshops held 2009-2011). The research methods were qualitative

interview, participatory workshops and literature research (Alasuutari, 1993, Eskola and Suoranta, 1998, Denzin and Lincoln, 2005). Methodologically, the research work was based on participatory and case study research approaches. In participatory research (Cornwall and Jewkes, 1995, Macaulay *et al*, 2011) the participants have an active role in the research and lay people are involved to generate knowledge about issues, drivers, benefits, challenges that affect them in their daily lives. The format of the interviews was more discussion based than enquiry. The literary research is based on public documents and literature of the area.

In discussion part we summarize the ideas coming from research projects and recommend a solution for increasing the recycling rate of critical "high-tech" and high value metals. The relevance of this research is the finding how to increase recovery of these metals. Thus, our aim is to introduce a new financial driver for developing and designing electronic devices in a more recyclable, especially with relation to aforesaid metals. We will suggest the taxation model for no-recycling either there are recycling system for the rare earth metals or then there are no system. Taxation model of recycling is dictated by recylability. The simply target is to decrease amount of waste and increase recycling rate.

DRIVERS – RECYCLING PERSPECTIVE IN INDUSTRIAL SYSTEM

As the global economy grows, more raw materials are required: the World Trade Organization's (WTO) 2010 World Trade Report shows that natural resources represent about 24 percent of total global merchandise trade. Yet even as demand is growing, prices are becoming increasingly volatile due in part to uncertainty about future reserves. The European Commission has identified 14 critical raw materials[3] that are at high risk of being in short supply over the next decade, and which are crucial for European industry. These critical raw materials include rare earth minerals and metals are produced in only a few countries. Some of them are marked also by political and economic instabilities (Euinsight, December 2011).

Environmental control instruments usually mean those actions the regulatory authority uses to control and limit environmentally harmful behaviour of companies. A major change in the environmental control system took place in the 1980s with the focus moving from specific environmental issues to the environment as a whole. The environmental control system i.e. the legal (administrative), economic and informative instruments focuses on prevention (Ekroos *et al,* 2010, Hollo, 2009, Kuusiniemi (editor) *et al*, 2007, Kuusiniemi, (editor) *et al,* 2001). Regulations for environmental protection have generally raised the operating costs of landfill disposal and increased the difficulties of acquiring and developing new sites.

The concern about the environmental impacts of business has affected companies in many ways. The demand of sustainability in industrial processes will require changes to the management and operations of the company. Companies have to react to new regulations, which reflect increasing concerns about the socio-environmental impacts of business. As Peattie and Charter (1997) have argued, the green driving forces are affecting both in visible and invisible ways. (Refer Table 1)

Table 1. Formal and informal green driving forces

Formal driver	Informal
Legislation, standards	Greening consumers (demands)
Owner, shareholder	Public opinion, awareness, concern
Competitors	Greening competition
Internal pressure in organization	Brand, image
Saving (development of the production)	Scientific evidence; climate change etc.
Increasing importance of ethical investments	Media

As mentioned before, the main driver for environmental action in companies is very clearly economical; at first investments and secondly competitive advantage, new business opportunities and certainly cost savings. Also other possibilities were more or less related to business: green image values, possibility to develop the process

[3] These critical raw materials are antimony, beryllium, cobalt, fluorspar, gallium, germanium, graphite, indium, magnesium, niobium, platinum group metals, rare Earths, tantalum and tungsten.

and increasing the market share (Pajunen, 2011, Pajunen, *et al,* 2012). Environmental impacts are connected to flows of materials and energy, and the most important flows, at least for manufacturing companies, are closely linked to products. Therefore it seems urgent for management systems to encompass products and product development procedures (Ammenberg and Sundin, 2005).

Within the supply chain there are many stakeholders, such as shareholders, authorities, banks, competitors, contractors, supply and service providers, insurance companies, the media, politicians and auditors, that may have an important role and might influence the motives and opportunities to reach environmental improvements. Greening is forcing companies also to reconsider supplier relationships, because their total environmental impact is strongly influenced by the supply chain. For a company to act, sufficient incentives are needed, often in the form of economic benefits. Also large corporations might have a major impact on their smaller suppliers. If the starting point is the model of ideal supply chain, we can create the picture where the target is same for all to actors. In this case the hypothetical target is responsible consumption, minimum waste production and functional recycling system. (Refer Figure 1)

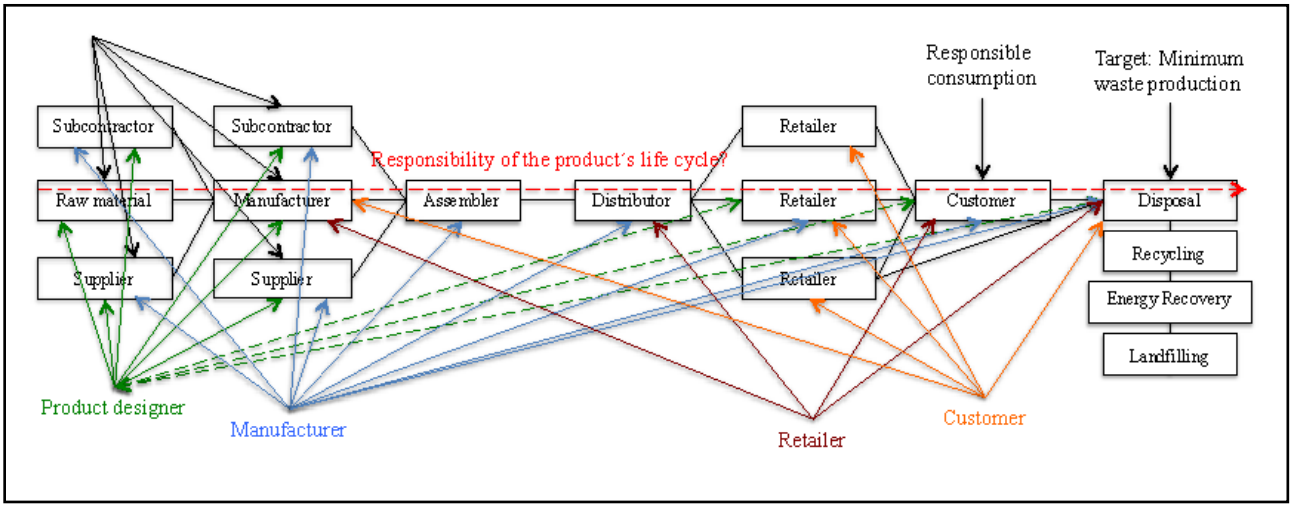

Figure 1. Drivers and decision making in ideal world.

The sensitivity of the decision-making in the supply chain is important to understand. If one part of the supply chain does not co-operate, “play the game”, the industrial system collapses. It is crucial for success, such as functional recycling system, that all of the actors have responsibility of the whole product´s life cycle, including end of life phase. Sinding (2009) argues that traditional environmental policy encourages companies to have an environmental strategy of their own. He wants companies to apply and approach an inter-organisational environmental management. Products and product development has to take place through the entire supply chain, not only in one individual company. In addition, communication with stakeholders and customers emphasizes proactive environmental strategy and other way round. It keeps ahead of legislation and customer demands for improvement, and participation in discussion regarding environmental issues. Alternatively, it is obvious that poor environmental strategy and performance can put company at a massive competitive disadvantage (Peattie and Charter, 1997).

The first case example comes from the fast food industry. This simple example has been chosen for showing the vulnerability of recycling systems. In Finland, the fast food industry started to experience the effects of new stricter legislation (Directive 94/62/EC). There were demands for the recovery of packaging waste, but practical experiences showed challenges in the packaging waste management (Aarnio, 2006). The company in case conducted research and system development to improve recycling rates and reduce the production of waste. The work involved all stakeholders and ended in developing standardized packages and a collection system encompassing all the restaurants of the company and recycling system to match the high recycling targets. (Refer Figure 2) Target (1) in this research and development project was to increase recycling and reduce the production of waste. The driver (1) was legislation and aim to decrease environmental impacts. (Refer Figure 2) Research project reached expected results (1); waste to landfill dramatically decreased and reuse increased.

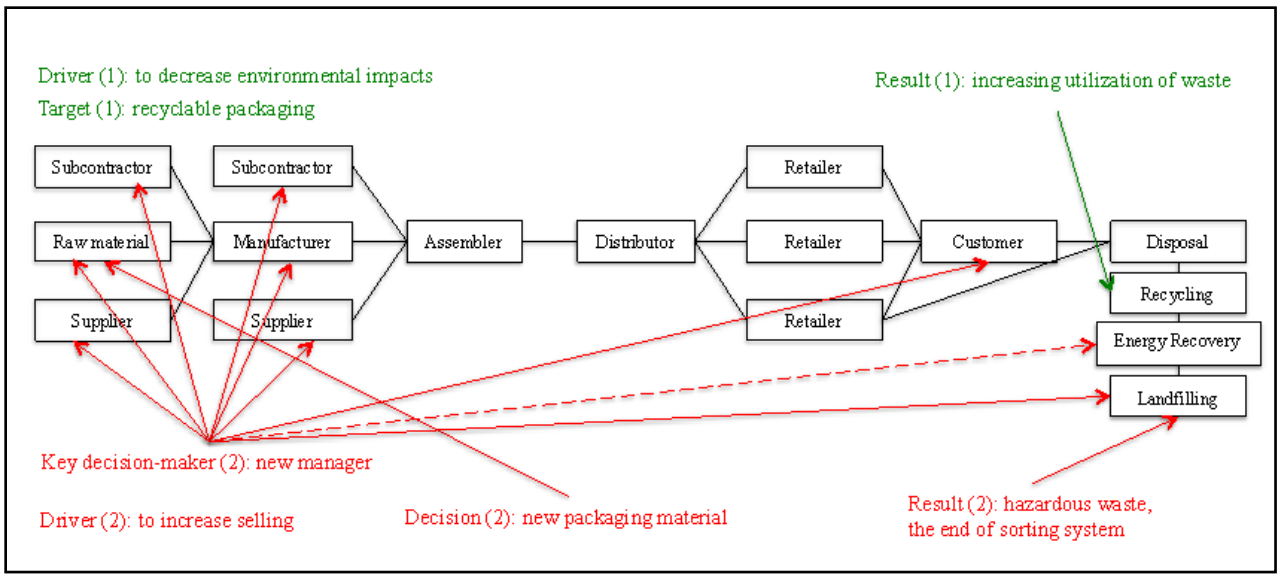

Figure 2. Drivers and decision making in food industry chain.

A single decision changed the whole system as depicted in Figure 2. The new manager of the fast food restaurant chain came outside EU. One of his targets (2) was to increase salad sales. His way to achieve the appointed target was to change the package and packaging material of the salad portion from liquid packaging carton to plastic. After the decision of the new salad package, the recycling system was unable to function efficiently any more. No system to manage the new plastic waste fraction was developed disrupting the old system. Because of the decision, the amount of hazardous waste was increasing, waste fractions were sorted incorrectly and the result was that all the material ended up in landfill.

The problem in the end of life phase of the electrical devices is that scrap metal is not homogenous. Electronic devices contain a wide variety of materials. Some of them are valuable and some are toxic or hazardous, some are both. If the end of life of device, the scrap ends to landfill or is not treated in environmentally responsible way, there is a high risk of environmental harmful damage. In addition, the scrap contains valuable resources that can be recovered and reused, reducing the need to use natural resources, new virgin metals (Hagelyken and Corti, 2010). However, at present there is no functional recycling system for electrical devices. The existing waste and recycling system exist, but the problem is that non-homogenous scrap.

In supply chain of mobile phone are many small or medium sized (SMS) companies. The above we have stated the importance of the demands of the large company of the chain and will to co-operate within supply chain companies. If the manufacture demands sustainability and environmental responsibility from its suppliers, SMS companies are out of necessity; if they want to co-operate in the future they have to respond to these demands. (Refer Figure 3) At present, the most important driver (1) is increase product selling and target is to be the first one in mobile phone markets. If the most important driver is to recycle mobile phones and target is to save raw materials, the picture is different. Currently there are no suitable separation and refining processes for recovering the indium from the display units and the rare earth metals from the background illumination. These substances have not been included in materials recycling so far (Buchert *et al*, 2012).

Engineers have an important role in environmental friendly decision-making processes. They have to make decisions, which have lifelong influence and even longer on environment and society. Life cycle thinking and eco design are course of action towards more sustainable production. However, as long as the most important barriers for radical innovations appear to be the cost of investment (Moors *et al,* 2005), there are not powerful incentives for change. Nevertheless, increased public pressure has led many companies to improve their environmental performance voluntarily by environmental policies and management systems (Harding, 2002).

Economical drivers are effective. When the price of waste is increasing, it is important to react and to find new solutions and procedures to handle the issue. Taxes and fees is one possible instrument to guide the industrial system. The idea of using economic instruments for environmental protection is coming up again when talking about decrease of harmful environmental impacts. The EU also encourages member states to increase the use of

a combination of regulatory and economic instruments. Economic instruments, such as taxes, competition for market shares, and prices of raw materials might be effective drivers to improve responsibility of the industrial actor to act and make decisions in more environmental friendly ways (Pajunen, *et al,* 2012). In particular, the potential of taxation is a part of a reliance on the use of economic instruments in environmental policy.

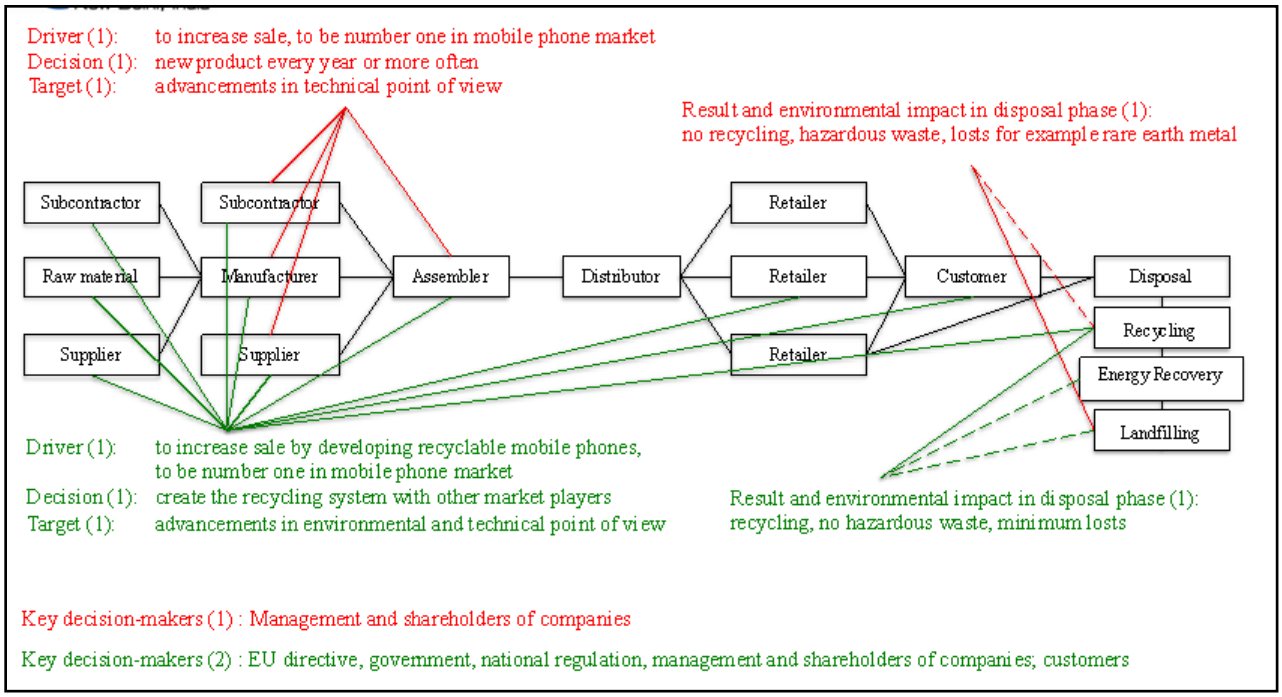

Figure 3. Recycling perspective in mobile phones supply chain.

ECONOMICAL INCENTIVE FOR INCREASING RECYCLING

In order to decrease environmental deterioration EU has defined in its waste policy that its member countries should, according to the Article 4, chapter Waste hierarchy, of the Directive on Waste (2008/98/EC), avoid producing waste. The priority order in waste prevention and management legislation and policy is (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g. energy recovery; and (e) disposal (2008/98/EC).

Environmental legislation is also designed to be one of the major drivers in improving material efficiency. According to the European Council Waste Framework Directive (WFD) (Directive 2006/12/EC) as amended by the new WFD (Directive 2008/98/EC), waste policy should aim at reducing resource usage. The use of approaches preventing waste and the re-use and recycling of materials is therefore at the forefront of this policy. The new Directive on Waste restates the order of preferred approach to the issue of waste called the waste hierarchy where the principle of primarily focusing on the reduction of the amount of waste produced and its harmfulness is argument by a secondary target of the recovery of waste by means of recycling, re-use and reclamation. Processes aimed at extracting secondary raw materials are included in this latter group. The priority order in waste prevention and management legislation and policy is (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g. energy recovery; and (e) disposal (2008/98/EC).

Finnish waste legislation is largely based on EU legislation. In some cases it includes stricter standards and limits than those applied in the EU as a whole. Taxes and fees related to wastes are generally included in legislation on taxation, although some fees are included in waste legislation. As stipulated in the Waste Tax Act 1126/2010, tax is levied on all waste deposited at landfill sites, provided that its utilisation is technically feasible and environmentally justifiable, and that by imposing the tax, waste can be made more commercially exploitable.

The economic instruments discussed in this research are the incentive-based and fiscal environmental taxes and environmental charges or fees. In contrast to regulatory or administrative approaches, market-based instruments such as taxes offer several advantages as a means of achieving environmental objectives. By influencing prices (through taxation or fiscal incentives), they give companies a longer-term incentive to pursue technological

innovations that further reduce harmful impacts on the environment. One general suggestion is that "an environmental tax reform shifting the tax burden from welfare-negative taxes (e.g. on labour) to welfare-positive taxes (e.g. on environmentally damaging activities such as resource use or pollution) can be a win-win option to address both environmental and employment issues." In this context, reductions in income taxes have an influence to ecotaxes. Every nation could use fiscal incentives to encourage green behaviour and facilitate R&D and innovation in companies. Evidence from tax reforms in the Nordic countries demonstrates such a win-win impact (The Economist, 2007).

Taxation can be used as a mean to fulfil the stabilization of the economy, resource allocation and income distribution. Function of the tax instrument can also be used to gather income and affect consumer´s and industry´s behavior. Finland has over ten years experience of the environmental taxation, especially on energy-related taxes (Vehmas, 2004). Several European countries have adopted a carbon or energy tax. Finland was the first one, enacted a carbon tax in 1990.

However, as in Vehmas´s article (2004) is stated, the difficulty is in finding clear evidence of the impact of environmental taxes. Is it even possible to identify the impact of specific environmental tax, while the changes in CO_2 emissions, energy use or industrial competitiveness can be the result of several other causes as well? A general conclusion based on existing analyses is that the taxes are usually so low that clear environmental impacts are difficult to find.

The Waste Tax Act (1126/2010) In Finland covers not only public but also private landfills. The tax rate will be increased from EUR 40 per ton of waste to EUR 50 per ton, according to proposal. Benefits of the reform of waste tax are not yet available; has it increase the recycling or utilization rate.

A proposal for increase recycling by using economical incentives is based on taxes and fees. (Refer Figure 4) The idea of the proposal is shared responsibility. Taxation falls upon the assembler company, such as a mobile phone company, and fees fall upon the consumer. In this case, assumption is that in assembling company is the key player in supply chain. Design and execution of the product is in there. Another key player is customer. It is individual choice to deliver phone to recycling.

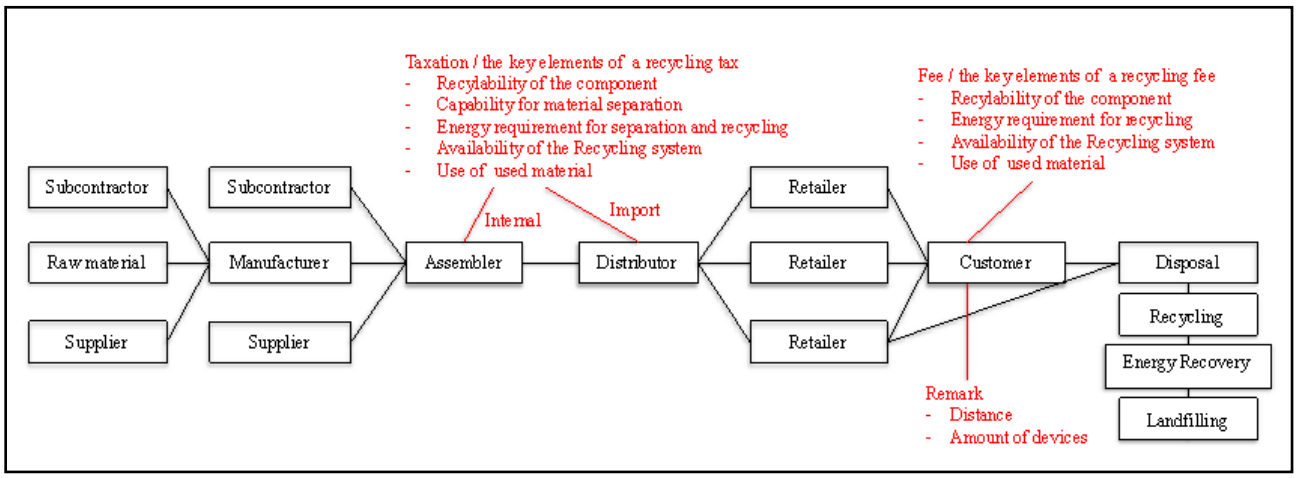

Figure 4. A proposal for resolving recycling issue by using economical incentives.

Engen and Skinner (1996) have shown that taxation has effects on output growth. Wherefore, it is reasonable to assume that suitable recycling taxation could be incentive towards more efficient recycling system.

DISCUSSION AND CONCLUSIONS

The impacts of economic policy instruments have been assessed in concentrated principally on energy and climate policy. However, research on the impacts of economic policy instruments should consider also sustainable development and material efficiency issues. The challenge is to develop economic policy instruments more incentive-based (Hiltunen, 2004). Economical and ecological way to think is already a routine for

companies. Saving the raw-material and reduce waste more effective is the win-win situation for company, shareholders, community and environment.

However, business opportunities are typically not clearly observable. It is up to an individual company to create them, to see opportunity where its competitors do not (Salmi, 2008). Over the past three hundred years, the mankind has compiled an impressive record of pushing back the apparent limits to population and economy growth by a series of spectacular technological advances (Meadows *et al,* 1972). There are no substantial limits in sight either in raw materials or in energy that alterations in the price structure, product substitution, anticipated gains in technology and pollution control cannot be expected to solve (Notestein, 1970). Today's industry is facing significant change from the process related environmental thinking towards product based environmental thinking. This change is already seen in the EU product policy.

Life cycle approach facilitates co-operation between companies in order to understand, identify and manage risks, opportunities and trade-offs associated with products, technologies and services over their entire life cycle, from material acquisition, manufacturing, and use, to end of life management. The shift to proactive life cycle based product strategies requires changes in business and operating policies and practices (Fawa, 2006).

There is over 10 year's experience of CO_2 taxation in Finland. However, no systematic procedure for developing energy-related environmental taxation has been presented (Vehmas, 2004). Not to mention anything about material efficiency or recycling. Experiences, recommendations and resistance of the Eco taxation reform is presented In Tikkanen´s (2005) thesis. A successful ecological tax reform needs co-operation between all of the actors of the society. Responsibility in supply chain and decision making in greener way takes time. We cannot change the habits directly and immediately. Real change requires hard work, time, attention to details and perseverance. In addition, the society plays the central role in creating and improving our habits (LaFollette, 2000). It is important to get all the perspectives of the issue. The recycling tax should not worsen business competitiveness. It should be opportunity and competitive edge towards sustainable industrial future. Actually, in fact, in Finland, the major challenge for the recycling system is not economical causes but long distances and sparse population.

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