Applying Environmental Value Chain Analysis to Product Take-Back Systems

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Abstract:

This paper concentrates on the application of Environmental Value Chain Analysis to product take-back systems. The analysis examines the information, money and product flows between players. The players of concern are the producers, government, consumers and recyclers. Within each of these groups, there are also internal value chains that influence other external interactions.

Examples from existing take-back systems (mandatory and voluntary) such as take back of consumer electronics in the Netherlands, take back of information technology equipment and packaging in Germany and company initiated take back systems are included in this paper. These systems show a wide variety in the positive or negative value proposition, type of recycling quotes and type of fee systems. With help of Environmental Value Chain Analysis, valuable lessons can be learned how to improve take-back and end-of-life systems. These examples also demonstrate how future take-back systems, regulated or voluntary, can benefit from previous experience. Some benefits are in the fields of:

- Improving lines of communication with parties involved (in particular, producers and consumers)
- Examining where financial burden is really being placed (fees passed to consumer, municipal waste, or producers)
- Structuring take back in such a way that ecodesign and design for end-of-life are fostered

Keywords: End-of-life, take back systems, ecodesign strategy

1 INTRODUCTION

Improving product environmental impact at all life cycles is an important topic for manufacturers of electronic and electrical products. The end-of-life is one stage of the life cycle stages gaining attention in the public realm and in the market. Companies must understand how to improve their products so that the environmental impact will be lower at the end-of-life, while also minimizing cost.

Environmental Value Chain Analysis is based on the concepts of Customer Value Chain Analysis and Supply Chain Management. Customer Value Chain Analysis seeks to identify pertinent customer and other stakeholders' interests, their value perceptions and the relationship between these parties in green product or process development projects [1]. Supply Chain Management seeks to reduce costs associated with managing the systems of suppliers. Combining the Customer Value Chain Analysis and Supply Chain Management as well as environmental topics, Environmental Value Chain Analysis (EVCA)

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illustrates the value relationships between the groups implementing environmental improvement programs.

2 TAKE BACK DISCUSSION

Instead of only relying on the 'producer pays principle,' a more realistic and appropriate option for future success is for joint responsibility by consumers, producers, governments, and recyclers. In such an approach, responsibility for a particular issue is assigned or attributed to the actor who can manage the item the best. Ecodesign, in general, and design for end-of-life are examples of items clearly the responsibility of the producers designing the products.

The reason for incorporating elements of Design for Environment is unique for each company. Some companies are defensive or cost driven in their reactions to external developments related to environment (i.e., social pressures, additional legislation or taxes). Others are proactive, seeking creative solutions that gain market share while reducing costs and risks. End-of-life systems should be structured in such a way that they drive all companies to better design for end-of-life.

Concerns about electronic waste has lead in several countries to legislation initiatives, particularly in Western European countries (both on European level and individual member states), but also in Asia and in some individual states of the USA (particularly Massachusetts, Minnesota and California). These legislative initiatives focus on producer responsibility and product take-back, controlled treatment of discarded products and recycling targets. In response to such proposals, the industrial world has expressed the wish to contribute environmental improvement; however, without imposing an unnecessary financial burden on society.

2.1 Europe

Legislation has been, or soon will be, implemented in several European countries (Denmark, Germany, the Netherlands, Austria, Sweden, and Switzerland). The Netherlands was one of the first countries to adopt producer responsibility and take-back legislation in 1999. Such legislation puts into operation the so-called producer responsibility principle and will extend all the way to the organization of end-of-life systems in the future. The intention of the legislation is that manufacturers and importers of products will systematically take products back and ensure that they are processed in an ecologically sound fashion. Most of the legislation proposes that take-back should preferably not incur any costs for the last user. If end-of-life costs are substantially negative, costs should be financed through a fee in addition to the price of new products. However, if the end-of-life costs are close to zero, it is preferred to have no additional fee. The latest EU proposal allows for both options. Its chief objective is to harmonize legislation in individual member states and to introduce similar Europe-wide systems. A remaining issue is 'historic' waste. As it is now, the current proposal includes both historic and new products with a five-year leeway for historic waste.

The European Union as well as separate member countries have consulted with the industry and other stakeholders to develop these end-of-life systems. Because of the complexity of the system and the financial burden caused by treating end-of-life products, reaching consensus has not yet been achieved in most cases.

The existing and impending systems in Europe have taken tremendous effort and time to be developed and implemented. Many of these difficulties resulted from financing issues and other emotionally sensitive topics, such competing goals, and misunderstandings, and relatively few technical items. Environmental Value Chain Analysis aids decision makers by eliminating the emotionality and focusing on the technicalities of actually organizing the product take-back system. By removing the emotionally charged topics, the technicalities play a more important role and tackling these issues leads effective decision making on product end-of-life systems.

2.2 Japan

The general consensus in Japan is that to tackle environmental problems, industry, administration and the general public have to act together to achieve breakthroughs. Coming into effect in 2001, the proposed legislation in Japan seeks to achieve proper disposal of products with a united effort from organizations related to the production, manufacturing, distribution, consumption and disposal of products. The legislation outlines the following actions: (a) reduce, recycle and properly dispose of products by means of self-imposed standard (independently set by producers, manufacturers, distributors, consumers, those enterprises in waste disposal business, etc) for the durability, recyclability, and environmental hazards of goods and products; (b) Encourage the trade of resources (generated from discharged goods and products), improve it's exchange route, and enforce the recycle of the resources; and (c) provide information about goods, products, etc. The Japanese Ministry for International Trade and Industry thinks it important to solve the problems of not only the manufacturing industry but also the cooperation between manufacturers, vendors, transporters, wastes dealers and consumers [2].

2.3 United States

Some individual states in the United States, such as

Massachusetts, Minnesota and California are particularly active in establishing landfill bans for equipment. The Massachusetts program targets electronic waste but especially CRTs. Effective April 2000, CRTs are prohibited from disposal through landfills and incinerators. Massachusetts is trying to promote a market-based approach through collaboration with industry, municipalities, environmental groups and the public. The improvements in recycling infrastructure have reduced the cost of recycling CRTs from $0.25/lb (1998) to $0.15/lb (1999) [3]. The Minnesota Office of Environmental Assistance is taking a more progressive approach, working with major electronics manufacturers and others to develop electronic products collection and recycling without relying solely on tax dollars to fund the effort. In 1998, one county in Minnesota spent approximately $0.5M recycling used electronic products [4]. Other programs in the United States, primarily at the state level, are smaller scale or not as well developed. According to the information available on government-guided programs, none of these existing programs are profitable; therefore there are many opportunities to improve the end-of-life systems. Extended producer responsibility looks like it will remain a charged topic, where others around the globe are providing examples.

Due to such legislative pressures, a growing number of manufacturers now design their products for remanufacture, recycling and repair, and help establish the recycling infrastructure. Smart marketers are turning these situations into opportunities to save money, enhance quality, and get closer to their customers [5]. Other programs have been established by individual businesses independent of other firms operating in the same industry. These programs include: Nike's Reuse-A-Shoe program; IBM, Dell and Hewlett Packard's computer-recovery programs; Hewlett-Packard's printer toner cartridge return program; several brand-name clothing return programs; a number of returnable transport packaging programs; and Saturn's bumper fascia return program [6].

3 ENVIRONMENTAL VALUE CHAIN ANALYSIS

The following figure demonstrates an external EVCA applied generally to the relationships among producers, consumers, recyclers and government. This diagram demonstrates the various types of flows between the players, focusing on information, products and money. The entire life of the product is examined -- from the producers, to the consumers and lastly to the recycling companies. It is important to distinguish the information flows as complaints, information exchange, top-down information and feedback. Complaints, sadly the most frequent, comes from dissatisfaction with communication, service, product or information provided. Appropriate exchange of information leads to mutual benefit of the participants. Top-down information is a limited transfer of information from a 'high' member of the chain to lower members of the chain (depending on the 'power' in the chain). Top-down usually offers information as the higher member requires. Feedback is the response of lower members to these requirements or to other requests.

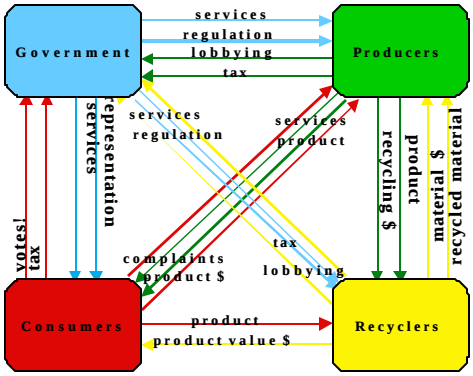

Figure 1. Example of External Environmental Value Chain Analysis

Apart from mapping the infrastructure and material flows, it is also necessary to know the individual goals of the players regarding the end-of-life treatments of products. Several possible goals are to minimize waste, make profits or limit costs, improve customer and shareholder perception or abide by regulation. Awareness of the, often conflicting, goals and objectives allows for the appropriate values to be placed on the EVCA diagram. In an example of Philips Consumer Electronics, the goals are mapped demonstrating the conflicts of interest of the members of the product development team [7].

3.1 Government

Concerning the product end-of-life systems, the government ideally works towards creating more transparency in the system. However, because there are numerous organizations within government representing environmental concerns, the end result may not achieve the intended goal. Recent environmental legislation in Europe is an example of the complexity of policy making.

Depending on how end-of-life systems are set up, government could have a large or small role in the system. Frequently, the involvement of government agencies depends on the profitability of the end-of-life systems. End-of-life systems making profit, such as Kodak and Xerox, are driven by market forces and are not regulated or overseen by governmental organization. On the other hand some products have

deficits at the end-of-life and need encouragement from government, such as the German packaging system has prescribed through rules and targets set by the federal government.

3.2 Consumers

Consumers have the crucial voice and the entire system revolves around their attitudes. Consumers vote for new leaders to voice their environmental concern. Consumers support products through their purchasing behavior. Additionally, consumers control the final disposition of the products, ultimately choosing to responsibly dispose of the product through the indicated channels or to irresponsibly dispose of the product in the trash bin or unauthorized dump. Consumer behavior is a complex topic, but research at Philips Consumer Electronics has shown there are seven distinct types of consumers when it comes to environmental issues [8]:

- Environmentally Engaged (E.E.)
- Environmental Optimists (E.O.)
- Disoriented Consumers (D.C.)
- Environment too Complicated (E.C.)
- Environmental Pessimists (E.P.)
- Growth Optimists (G.O.)
- Enjoy Life (E.L.)

This list shows a wide diversity of consumer attitudes that can lead to a diversity of behavior with respect to environmental issues.

In the end-of-life stage, consumers possess a product that no longer satisfies their needs, which they desire to dispose of. This process can cause discomfort to the consumer if they are unable to get rid of the product in a convenient way or have to pay for its disposal. Seemingly inconsequential for a company, this inconvenience to the consumer could result in negative consequences to the company that has produced the product. Hence, it is crucial from an image point of view for the company to place attention on the end-of-life stage as such rather than on just environmental impacts of distribution, for example, a stage that has little ramifications on customer satisfaction.

3.3 Producers

The group of producers includes suppliers, manufacturers and assemblers of products. There are other internal organizations that play roles in helping introduce products to the market including product management and development, marketing, sales, purchasing and logistics.

In the end-of-life field, producers must now start developing systems to bring their products back and recover value from them. Producers have sole control over the alignment of the supply chain, which increasingly is happening in industry.

Producers must work on their internal value chain, which addresses the values internal to the organization. The interaction between internal stakeholders is mostly focused on information flows, although just as important are the flows of product and money throughout the organization. Without proper development of the internal value chain, the external value chain is difficult to manage. There is significant cross-functional exchange needed within to the organization to develop a unified position to present externally. Appropriate organization of the internal value chain will help provide incentives for design improvements. Understanding and enhancing internal drivers for product designers can help improve product design with regard to the environment.

3.4 Recyclers

This group consists of the collectors, processors, and distributors of waste material, either disposing of waste or retrieving value from products and materials. Collection may be through retail or municipal infrastructure, may be through charitable donations, or may be through individual curbside pick-up. End-of-life processing options include repair, servicing, remanufacturing, recycling through shredding with or without disassembly, and disposal through incineration or landfill. Recyclers have traditionally managed to minimize the costs and maximize the profits by selecting specific materials to recycle, hence their focus has been on products that have high value such as gold, platinum, palladium, silver, copper, and even CFCs.

As more and more products are reaching the end-of-life, recyclers must operate on larger scales and must work longer hours to meet the demand of the products reaching obsolescence. Recyclers must be concerned with economy of scale, outlets for secondary streams as well as balancing investment in equipment and labor.

3.5 Others

Other players of relevance in the end-of-life system are distributors, retailers and pre-processors of waste. Distributors and retailers provide direct links between the customers and producers. An example pre-processor is photo-finishers, in the case of single use cameras, which provide a link between customers and recyclers. They are successful because they provide a service to the customer (develop film), which yields impetus for the customer to return the product.

These groups have little motivation to participate in product end-of-life treatment. Retailers make profit by having new products on their shelves or in storage, not by storing old products that have been returned from the customer. Hence, retailers generally have been very reluctant to participate in end-of-life

systems. The same holds true for distributors whose profits are linked to storage and transport of new products, rather than returned products. This can only be overcome by giving financial incentives; such as in the Netherlands where retailers are paid 2 NLG ($0.75) for handling old televisions.

4 EXAMPLES OF TAKE BACK SYSTEMS

4.1 Introduction

The following sections describe case studies analyzed using the EVCA method. The product end-of-life systems examined are essentially neutral or cost centers, thus the government is involved. These case studies serve two purposes:

1) demonstrate currently implemented end-of-life systems
2) identify opportunities for improving in end-of-life systems

These diagrams also reveal gaps in communication between partners. The differences and similarities in these diagrams are compared to evaluate which methods have been most successful from the standpoint of all four participants. These examples are simplified for this paper, and are to some extent only the tip of the iceberg. The processing of the relevant information of all the details is more crucial than the final picture reveals. Only with the final picture can the players sit down with an even playing field to work together to simplify and optimize end-of-life treatment systems to a win for all players. The following sections describe the product, financial and information flows for the particular product end-of-life system.

4.2 Television take back in the Netherlands

As a consequence of the new Dutch legislation on producer responsibility and product take-back, the branch organizations initiated a collection system for discarded white and brown goods. The following picture depicts the situation for a consumer electronics company and the collection of televisions from consumers.

Product

The collection system is based on several waste collection streams, stemming from municipalities as well as from retail outlets. The products are collected through the retailers and municipalities, then processed by existing recyclers. A new organization, NVMP, manages the recycling efforts.

Money

Although all financial flows go to the take-back organizer, the origin of the money is complicated; some costs are paid by the municipality collection organization, others paid by consumers or producers. The processing costs are paid by the NVMP. The manufacturers are therefore responsible for a fund that pays recyclers to treat end-of-life products mostly through material recycling. Consumers pay a fee when purchasing a new product, on the order of $2-$10 per product, to help defray the cost of collecting the product.

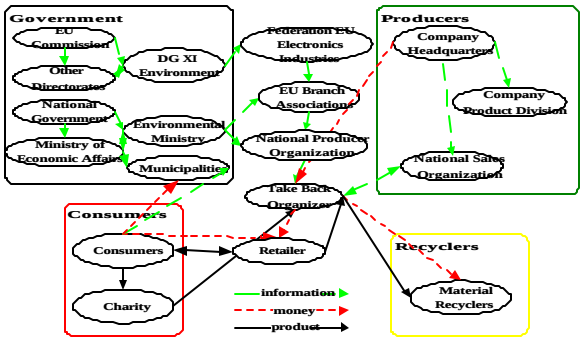

Figure 2. Television take-back in the Netherlands

Information

The information flow to develop and update the program is complicated. Different government organizations, industry branch organizations and consumer groups were involved in the discussions to establish and to operate the take-back system. With so many people involved in the organizing of the system, there are many redundancies and it is surprising that it is working in practice relatively well.

4.3 IT equipment take back in Germany (Proposed)

In Germany, the proposed product take-back system is not as complicated because less governmental intervention is necessary. Excluding the collection costs, the system is cost neutral for participants. The financial and information flows are more direct as compared to the Dutch take-back system. The goal of this system was to encourage recycling and reuse of electronic products.

Product

The collection of products is intended to be mostly through the municipalities and some retailers. The take-back organizer will not handle any of the products. Existing metals recyclers are reprocessing the products whereas in contrast to consumer electronic products as for instance the television, there is opportunity for reuse of the product.

Money

The difference between this system and the Dutch system is that the take-back organizer only handles the financial incentive paid to the retailers. Otherwise, the processing costs are paid by the company's national sales organization, which makes it basically a company specific system. The consumer pays the

collection cost to the municipalities through taxes.

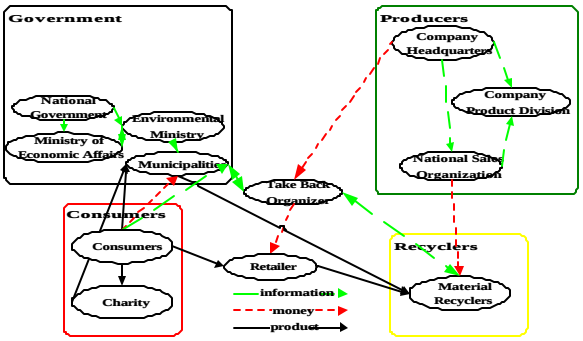

Figure 3. IT equipment take back in Germany

Information

The information flow to develop and update the program is less complicated than the Dutch system, mostly due to the lack of involvement of the collectivity of industry groups. The system has been developed through self-organization.

4.4 Packaging Take Back in Germany

Although not directly related to the take-back of electronics products, there are many observations to be made about the packaging take-back and collection system in Germany. Germany's Packaging Ordinance of 1991 was the first to shift the costs of collecting, sorting, and recycling used packaging from municipal government to private industry [9]. The motivation for this directive was a looming shortage of landfill capacity, which created a critical need to decrease the amount of materials sent to landfills by reducing the amount of waste generated and increasing recycling. Industry responded by establishing a nonprofit company, Duales System Deutschland (DSD), which licenses the Green Dot logo for a fee to the participants.

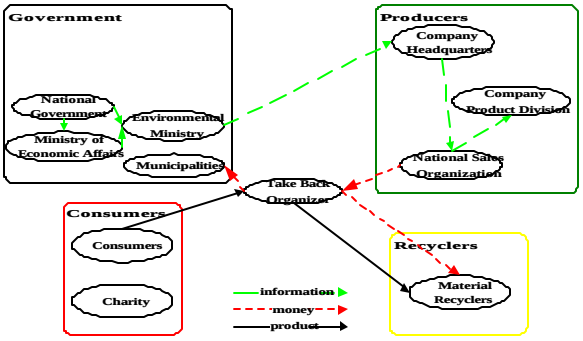

Figure 4. Packaging Take Back in Germany

Product

Any package bearing this symbol are collected, sorted, and directed to recyclers by DSD. DSD picks up 'green-dot' waste for free from households.

Money

Fees are based on the material and weight of the package and are paid by the producers to one central organization. The cost of processing the returned packaging is high, this is due to the fact that the government-prescribed recycling ratio is very high and incineration of fractions that are difficult to recycle is prohibited.

Information

Information flows in the packaging take-back system in Germany are rather centralized. After the initial government decision, there have been discussions but most information flows between the environmental ministry and the company headquarters. The government made the decision about recycling percentages and treatment guidelines, without examining the financial consequences closely. Therefore, the discussions started after the legislation was passed, rather than working in conjunction with industry during the development of the legislation.

4.5 Voluntary program at Siemens Nixdorf

In contrast to the previous product end-of-life systems, the following example shows a voluntary program established by Siemens Nixdorf, in anticipation of the proposed legislation in Germany.

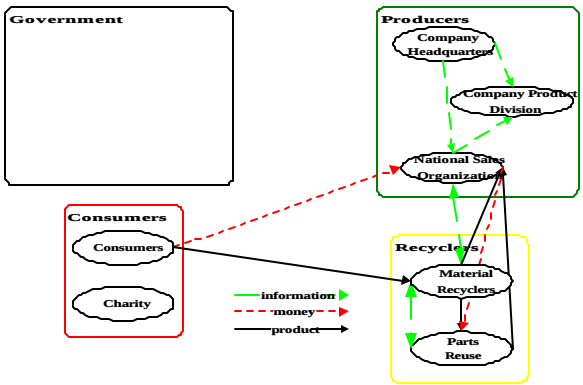

Figure 5. Voluntary program at Siemens Nixdorf

Product

The end-of-life products, mostly electronic equipment, flow directly from the consumer to the recycler. The in-house recycling company works with other component refurbishers to remanufacture parts to be returned to Siemens Nixdorf for reapplication. This system of harvesting service parts and reusing them in the repair of existing equipment has been quite successful, also from a financial perspective.

Money

Since there is no take-back organizer in this system, the external money generated from customers flows directly from the national sales organization. Depending on if recycling of the product category

produce a yield or a deficit, the in-house recycling company either credits or debits to the appropriate business unit. In this system, the incentives are linked directly to the business unit producing the goods, therefore giving strong encouragement to improve designs.

Information

Of the examples included in this paper, this system represents the most effective communication, providing direct links between the producing departments and the recyclers. There was no involvement from the government, as this is an industry initiated product end-of-life system.

4.6 Discussion of the examples

Originally, one of the prominent drivers behind take back was to require producers to be financially responsible for waste management, giving them an incentive to make less wasteful and more economically recyclable products [9, 10]. However, through the examination of the actual results of these systems, the proposed incentives are not provided by the systems in 3 of 4 of the cases.

In these systems, the financial system charges all producers equally, even if some products are cheaper to treat the end-of-life. Therefore, there is no incentive for companies to redesign products to reduce environmental impact. Financial incentive systems must be carefully detailed further, making sure that the metrics for comparing products is accurate and dependable, and the departments developing the products are charged or credited.

Such incentives will work well when the systems are structured in such a way that the departments held financially responsible can actually manage their efforts. For instance, recycling targets set by authorities should be possible to achieve in an eco-efficient way (e.g. by design). As well, collection costs should remain in the public domain because there are already eco-efficient systems in place.

5 COMPARISON WITH OTHER VOLUNTARY SYSTEMS

In voluntary product take-back systems, there are large differences between private and institutional consumers. Private consumers typically make purchases in small volumes and small monetary amounts. For private consumers, collection is difficult to organize effectively since private customers are anonymous and may be emotionally attached to products.

Kodak has developed an extensive remanufacturing organization for their single use cameras, remanufacturing over 60% of the product worldwide [5]. Because there are direct incentives for the product designers to reduce the remanufacturing cost, the cameras are actually designed so that 26 of the 27 parts that make up Kodak's single-use camera are either recycled or reused in a new camera (some components are reused up to 8 times). This program works well because consumers have an incentive to return the product at end-of-life, for film processing.

Hewlett Packard works with Micro Metallics to recover service parts and recycles useful materials from end-of-life products [11]. HP realizes great savings to the company by collecting products to harvest for service parts. To provide incentives for consumers to return their product, HP has started a program, Trade-in Trade-Up, that gives trade-in value to apply towards the purchase of new products [12].

Another example of voluntary system for OEMs but for institutional customers is Philips Medical Systems. Institutional consumers make large purchases with contracts associated with the high volumes and monetary values. Philips Medical Systems refurbishes and resells their medical equipment worldwide.

In all these cases, the internal value chain has been appropriately structured so that the design the product takes into consideration end-of-life environmental impact. This result is seen in a number of products released with lower environmental impact while decreasing the operating costs of the company. It is suggested that for the cases of section 4, reorganization the internal value chain will allow producers to reduce costs, apart from the external concerns from the legislation.

Producers or organizers may have more freedom to control the take back of the products in voluntary systems as compared to mandatory systems. As shown in [13], EVCA applied to the voluntary systems demonstrate actual environmental impact reduction in the end-of-life treatment of the products. Mandatory product end-of-life systems must be defined well in order to learn from the experiences and to build in the same improvement drivers into their systems.

6 IMPLICATIONS FOR DECISION MAKERS

As discussed in section 4.6 and 5, new product end-of-life systems should aim to be transparent, reap the end-of-life value and provide incentives to improve. Either through legislation or voluntary mechanisms, end-of-life systems must reduce the confusion and complexity associated with product end-of-life. The examination of the current product end-of-life systems shows often lack of agreed goals, weak lines of communication, and little room for improving the system in the future. In some cases, there are redundant mechanisms for collecting products,

leading to confusion from consumers and increasing end-of-life costs.

The structure of the internal value chain must be such that the potential end-of-life financial and environmental value can be achieved. Understanding that product characteristics heavily influence what is possible at the product end-of-life. In all cases, tailor made solutions are necessary rather than generic ones across product sectors [14].

Finally, financial systems should be constructed so that incentives for improvements of design, collection and material recovery percentages are provided. When products have perceived end-of-life value, through materials or application, the incentives for product return exist naturally. Analysis of the examples and application of EVCA shows that the systems where financial responsibility and possibility to manage the item coincide, the best incentives are given for improvement. For the consumer, take back systems work best if take back is coupled to other items, for example, developing film, receiving rebates for new products, linking fees to purchase of new products and deposit systems.

7 CONCLUSIONS

The EVCA process proves that making simple diagrams showing the flow of money, products, and information in the proposed end-of-life systems can improve end-of-life systems. This makes the issues to be agreed by stakeholders transparent and therefore will contribute to better structuring of envisaged take-back systems. This will work out in increased environmental gains of end-of-life systems and lower costs. Examination of the existing or proposed systems can reduce the need for pilot programs and increase the success of current programs.

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