Exploring Determinant Factors for An Extended Producer Responsibility Program in Taiwan

A Case Study of IT Products

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Abstract

While we benefit from the fast development of IT industry, we are facing the challenge of rapidly-growing amount of IT waste. Thus it is of significant importance to design an effective waste management policy. Extended producer responsibility (EPR) policies have been widely applied for various products groups around the world in the last decades. The thesis explores the implementation of EPR program for IT products in Taiwan. In order to enhance the understanding of the work in practice, examining of social, environmental, and economic aspects are presented. Features of the implementation and actors involved in the system are investigated in the thesis. From the research, following factors are identified as important in influencing an effective EPR program: target-setting, allocation of responsibility, monitoring, financial management, and social acceptability. Also, some improvements are suggested based on discussion of these determinates.

1. Introduction

While we are aspiring for sustainable development, which incorporates social, economical, as well as environmental development, the conflict between economic growth and environmental protection is a challenge for us. A common observable problem occurred during industrializing process is the growing amount of waste and resource extraction. Most of today's advanced industrialized countries are high-waste economy. In Taiwan, a densely-populated society, consumption of resources and waste problem severely threaten the carrying capacity of the island. The government in Taiwan aspires to build up a "Green Silicon Island", which implies a win-win situation for environment and economy, but it requires practical plan and action to realize it. The author is triggered to examine the policy instrument to improve waste prevention and waste reduction; more specifically, the waste from a major industry in Taiwan—the IT industry.

1.1 Background

The use of information technology (IT) equipment has grown significantly in production and it is already part of our everyday life. Taiwan's IT industry ranks fourth in the total production values in the year 2002, after USA, Japan, and China. In fact, the investment from Taiwan accounts about 50% of the production values in China. Furthermore Taiwan is one of the biggest manufacturers in desktop PCs and laptops in the global market (ITRI, 2004).

As the IT development is at a fast pace, what is new and modern today could be old-fashioned tomorrow. Therefore the massively growing volume of discarded IT equipment has become a bigger problem than ever. Take computer for example, in average 130 million computers are sold worldwide per year and computer sales is growing 10% every year (ENS, 2004). We can foresee this will generate a significant amount of waste in the coming years. In Taiwan, approximately 300,000 scrap personal computers are discarded each year. Computers, as well as most IT equipments, contain hazardous substances like cadmium, lead, barium, and mercury. What makes the end-of-life management of discarded IT equipment complicated is the hazardous substances in it which requires diversion from landfill or incineration.

As a response to the concerns in the end-of-life management of IT equipment, the EPA in Taiwan has established a recycling program for certain IT products based on the concept of Extended Producer Responsibility (EPR).

Extended producer responsibility as a strategy to underpin environmental policy is implemented in many countries worldwide, and various EPR programs are formulated for different product groups, e.g. packaging, batteries, vehicles, tires, and electrical and electronic equipment (EEE). The idea of EPR extends the responsibility of the manufacturer to the post-consumer stage of the product life cycle; thus manufacturers have to be concerned about the end-of-life management of the products in question. Changing design of the products would be triggered by producers in order to minimize the costs associated with end-of-life management of the products in question (Tojo, 2001).

This paper looks into Taiwan's EPR program for the end-of-life management of IT equipment. Taiwan has designed the recycling system based on EPR approach since 1988[1]. Furthermore Taiwan has been a large producer of IT equipment in the world market (see appendix). Therefore it is of significant interest to examine the system in practice. However, general speaking, research in EPR-based waste management of IT products is relatively scarce and incomplete. This paper can be a contribution to the understanding and analysis of existing system, and help to improve the current system.

1.2 Objective

The purpose of this paper is to make contribution to the understanding of the implementation of EPR of IT equipment in Taiwan, through the description and analysis of existing system. In light of achieving sustainable development, the thesis aspires to examine the EPR program from trans-disciplinary perspective, which could help to understand various dynamics and identify the determinate factors influencing the system.

Two major research questions guide the thesis

- How does the EPR program work for the specific product (IT) in the context of Taiwan?
- What are the determinate factors affecting a successful EPR program?
- How can the current EPR program be improved in environmental, economic, and social aspects?

In order to answer the research questions, it was necessary to get an understanding of the legal framework for the EPR system, and the allocation of responsibility among various actors. The practices were analyzed looking at three dimensions: 1) Economic – analyzing the financial mechanisms; 2) Physical – analyzing the material flows; 3) social - analyzing the attitudes of consumers and producers. These three dimensions correspond well to some common criteria for environmental policy evaluations: environmental effectiveness, economic efficiency, and social acceptability.

1.3 Scope and limitations

Scope

The concept of EPR refers to the fact that the producers bear the responsibility of their product through the whole life-cycle, from the upstream design stage to downstream end-of-life stage. This thesis focuses on the **recycling scheme for IT products**. In the Resource Recycling Act, recycling is defined as "*the act of reusing or recycling the renewable resources*"[2]. And in Hu (2002), it is pointed out the term "recycling" in Taiwan in fact includes three different activities: collecting, reprocessing, and

[1] According to Waste Management Law, Article 10, amended in 1988.
[2] EPA Resource Recycling Act, Article 3.

purchasing[3]. Hence, in the thesis, recycling scheme is broadly defined as management of waste starting from post-consumer phase, including the activities from take-back, collection, reuse, and recycling of the products. As the recycling scheme of IT equipment in Taiwan is to a large extent under control of the a governmental body—**Recycling Management Foundation** (RMF) — much discussion of the legal framework and work in practice is focused on RMF.

IT equipments refer to equipments such as PCs, notebooks, monitors, printers, scanners, that are familiar to consumers and directly used by consumers, and those that constitute or connect to computer appliances, like network units, printed circuits and various sections[4]. The focus of this paper is placed on discarded IT equipment, which is one of the target articles decreed by the Environmental Protection Administration (refer to EPA) in Taiwan[5]. Defined by EPA, the discarded IT equipments for recycling include notebooks, PCs, monitors, and printers. More specifically, producers have to pay recycling fees for following seven items which is target discarded IT equipment for recycling: **1) printers, 2) monitors, 3)main frames, 4)notebook, 5) power supply equipment, 6)disk drivers, 7)computer cases**.

This thesis is based on the recycling scheme in Taiwan, which is defined as three parts: 1) physical practice of waste management system (to be able to understand the flow of material); 2) financial and economic system (to be able to understand the flow of money); and 3) social system (in terms of acceptability of producers and consumers).

Limitations

The research faced difficulty in collecting data due to two major reasons. First, as the research was conducted in Sweden data collection to a great extent had to rely on sources available on Internet, and interviews have been conducted via telephone, as interviews face to face were not possible. Secondly, due to the sensitive business climate in Taiwan, first hand information from companies has been hard to acquire. Also government agencies and academic institutions have sometimes been reluctant to share information. This means that secondary data has been used to a large extent.

1.4 Methodology

The research is based on studies of literature and sources on Internet. Primary data has also been collected through telephone interviews.

Following methods are used: 1) literature review and information collecting; 2) single case study; 3) analysis of the compiled information

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[3] Purchasing refers to the reprocessed products or materials are back to the market again

[4]The IT products in Taiwan can be categorized in four groups: The first group is component products, like main frames, keyboard, graphic cards, power supply equipments, printed circuits, and so on; The second group is system products, like desktop computers, notebooks, workstations, servers, palm computers and so on; Group Three is the peripherals, like monitors, mouses, scanners, terminals, hard disks , diskettes and so on; Fourth group includes networking products, internet cards, data processors, ISDN cards and so on

[5] Article announced for recycling including packaging /containers, vehicles/motorcycles, tires, lubricant, batteries, WEEE, and IT equipment. Compared to IT, The recycling of WEEE focuses on four items: TVs, wash machines, air conditioners, and refrigerators.

Literature review and information collecting

A thorough understanding of the theoretical and practical aspects of EPR is essential to formulate good research questions. Furthermore, more specific and closely related information was needed in order to answer the research questions. Information concerning the legal framework and the three dimensions (i.e. the physical flow, the monetary flow and the social aspects) was required through a literature review and telephone interviews.

The case

The author attempted to understand and evaluate the practice of EPR program in Taiwan on a specific product by applying a single case study of the system in Taiwan, rather than to make a comparative study where the Taiwanese EPR would be compared to schemes in other countries. Though at the beginning a comparative study was taken into consideration, the author realized that the different approaches taken in different countries would make the comparison difficult. Both the legislation and the cultural and political context differ between countries, especially between Europe and Asia, and these make it difficult to evaluate EPR programs by comparison. In Fishbein (1998), it is argued that it is difficult to measure costs and benefits of EPR schemes, and even more difficult to compare them due to the differences in the scope of legislation, data collection methodologies etc. Therefore, individual case study is chosen for this research.

In this paper, the EPR-based waste management scheme in Taiwan is regard as a system. In order to have in-depth understand of how the system works, the author considers it necessary to define the sub-systems, or rather different parts of the system, before jumping into the whole system, and set system boundaries of each sub-system to be able to focus on the important dynamics and understand the flows and feedback. These three parts include the physical system, the economic system, and the social aspect, and these three are connected and interact with each other. In the economic system, the emphasis is placed on flow of money and the financial mechanisms of an EPR program. In physical system, the material flow from post-consumer stage to the final disposal will be examined, and analyzing it is needed in order to evaluate the environmental effectiveness of the EPR policy. Finally, in trying to cover also some of the most important social aspects, the author has looked at consumers' and producers' response towards the EPR scheme. Consumers and producers are chosen as the two major actors in social system. Consumers are the ones deciding what to do with a used product and their cooperation in take-back contributes to the material flow in the recycling scheme. Producers are the actors that have the greatest possibility to make changes to their products in order to meet the objective of an EPR scheme. OECD (2001) considers that influencing the products and the product system is critical to a successful EPR program, and producers are in position to influence various stakeholders as well as the environmental impacts of their products.

By examining these identified systems, the research therefore can present a clear picture of the whole system.

Analysis of the compiled information

This thesis is both descriptive and analytical. Analysis of the information is the essential backbone to gain an understanding of how the EPR scheme is implemented in practice, and to identify the important factors influencing the system.

According to Tojo, Lindhqvist and Davis (2001), factors affecting the results of EPR programs are: characteristics of the product, voluntary or mandatory EPR program, allocation of responsibility, financial mechanism, establishment of requirements, systems surrounding the products, awareness and perception of affected actors in society. The author consider these are the dynamics which can be incorporated in the three focus aspects—physical system, economic system, and social system.

Thus, the performance of the EPR scheme is analyzed from economic, environmental, and social perspectives. OECD (2001) has developed following performance criteria for EPR scheme: environmental effectiveness, economic efficiency, political acceptability, administrability, and innovative advancement. As the research examines the material flow, and financial flow in EPR scheme, the thesis can evaluate the program with two criteria suggested by OECD, which are environmental effectiveness, and economic efficiency. Furthermore, since EPR program's social impacts on two major actors-consumers and producers- will be examined, the criteria "social acceptability" will be added.

In examining environmental effectiveness of EPR program, specific criteria –collecting rate and monitoring work—are applied. The reason why recycling rate is excluded is due to research's lack of data on national level. The other excluded criteria is products' design change, which is in upstream of products lifecycle and therefore is not in the scope of the thesis. Regarding economic efficiency of the recycling scheme, focus is placed on fee rate and management of the fees. In social acceptability, producer's and consumer's acceptability will be discussed.

1.5 Reader's guide

The thesis is structured in the following manner:

Chapter 2 provides readers the background information about the EPR approach and the characteristics of IT equipment that influence the implementation..

Chapter 3 describes and analyses the recycling system, with focus on physical, economic, and social aspects.

Chapter 4 presents the main research findings according to the objectives of the thesis. Recommendations are also included.

Chapter 5 concludes the thesis and suggests topics for future research.

2 Extended producer responsibility for IT products

Some countries have implemented EPR program in IT equipment, though the type of products differs and it is often under the category of EEE (electrical and electronic equipment). Taiwan EPA differentiates recycling of IT equipment from EEE, which only refers to four home appliances-TV, air conditioner, washing machine, and refrigerator. And IT equipment includes notebook, monitor, printer, main frame, disk driver, power supply, and computer case. This chapter will first introduce the concept of EPR and how it is applied; secondly it will look into the environmental impact of IT waste, and finally present an summary of product characteristics that could affect implementation of EPR.

2.1 Extended producer responsibility

Extended Producer Responsibility (EPR), as defined by Lindhqvist (2000) is "*an environmental protection strategy to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal of the product."*

EPR consists of various types of responsibility that can be imposed on a producer, which is illustrated by Lindhqvist (2000) as model in Figure 1 shows:

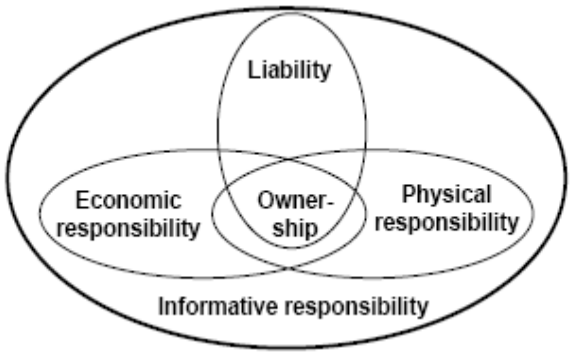


Fig 2 Models for Extended Producer Responsibility

"Liability *refers to the responsibility for proven environmental damages caused by the product in question. The extent of the liability is determined by legislation and may embrace different parts of the life cycle of the product, including usage and final disposal.*

Economic responsibility *means that the producer will cover all or part of the expenses, for example, for the collection, recycling or final disposal of the products he is manufacturing. These expenses could be paid for directly by the producer or by a special fee.*

Physical responsibility *is used to characterize the systems where the manufacturer is involved in the physical management of the products and/or their effects.*

The manufacturer may also retain the ownership *of his products throughout their*

lifecycle, and consequently be linked to the environmental problems of the product.

Informative responsibility *signifies several possibilities to extend responsibility for the products by requiring the producers to supply information on the environmental properties of the products he is manufacturing."*[6]

EPR is used as an approach to promote cleaner production and combat the increasing generation of waste and pollution. As the concept of EPR demands producer extend their responsibility on the product to the post consumer stage, it shifts the costs of waste management from the local authorities to the producer, and thus internalizes the environmental costs into product prices.

UNEP (UNEP, 2003) identifies the following key elements in EPR:

- Apply precautionary approaches in different activities regarding products and processes;
- Adopt the same operating standards regardless of location;
- Improve supply-chain management;
- Facilitate technology improvement and transfer;
- Contribute to environmental awareness in company locations;
- Communicate with different stakeholders

In the emergence and evolution of EPR, a shift from end-of-pipe approaches to preventive environmental strategies can be recognized (Tojo, 2001). As EPR program helps to establish the feedback loop from the downstream (end-of-life management) to the upstream (design of the products), it would stimulate producers to take into consideration the environmental impacts of the products in question in the design stage (OECD, 2001). In addition, to minimize the associated costs of waste management and keep the competitiveness in the market, a sensible producer could improve supply-chain management and communicate with relevant actors to acquire complete information.

EPR has been an essential principle in designing different waste management programs among OECD member states since the early of 1990's. Furthermore, European Union has established legislation based on EPR. In 2000, the European Parliament passed a directive requiring its member countries to institute an EPR program for end-of-life vehicles, and a directive for waste from electrical and electronic equipment (WEEE) has came into force in 2003. UNEP considers EPR as an environmental management tool which reconcile environmental protection and economic growth (UNEP, 2003), for it stimulates companies' awareness in implementing cleaner production.

EPR as a policy approach

To response the growing amount of waste, it's important for government to design a proper policy that can help to meet the objective of the waste reduction and waste

[6] Lindhqvist, Thomas (2002). *Extended Producer Responsibility in Cleaner Production*. IIIEE Dissertations 2000:2 Lund: IIIEE. pp. 38-39

prevention. Policy instrument in general are categorized as three instruments: 1) command and control, 2) economic incentive, and 3) informative instruments. Extended producer responsibility as a policy approach, could incorporate these three instruments.

Command and control instrument is to restrict or compel relevant actors' activities by using prohibition or obligation. On the contrary, economic incentive instrument is that government provides certain economic advantage as incentive to alter the values and activities of target group in order to reach the desired objective. Informative instrument is to educate or persuade people to enhance their awareness and thus perform certain activities. Following are examples of some policy instruments within these three categories which can help the implementation of EPR:

- Command and control: take-back requirements, disposal bans and restriction, product bans and restriction, minimum technical standards for waste facilities,
- Economic incentive: advance disposal fee, deposit-refund system, taxes on virgin material, subsidy toward waste recycling
- Informative approach: environmental information labeling, recycling information labeling

OECD (2001) defined EPR as a policy approach that provide incentives to producers to consider environmental impacts in the design stage. EPR program, in line with Polluter Pays Principle, helps to internalize environmental costs into product prices. Hence EPR as an economic incentive policy instrument is worth discussion; some examples are listed as following[7]:

- **Charge and tax** can be levied at different stage of products' lifecycle, including product charge, collection charge, disposal charge, and emission charge. Charge of advance disposal fees is most widely used for take-back program due to its practicality and feasibility (Tojo et al, 2001). Drawbacks are the difficulty in setting fees at right level and higher cost in auditing.
- **Subsidy** provides financial support to encourage environmental-friendly behavior, such as reward for waste recycling and prevention. However it may raise the financial burden of government and thus be against social justice and polluter pays principle.
- **Insurance**, in this case is recycling insurance, which can influence the behavior of producer through setting a recycling premium. It can be a mandatory insurance or mediated by market mechanism. But recycling insurance is a new concept and has to deal with a wide range of environmental uncertainties; thus it makes insurability and marketability difficult to predict.
- **Deposit refund system** can provide strong incentive to stimulate consumers to bring bake the waste product. But it's not suitable for products with long durability, and it may lead to unwanted transfer of waste products from other places.

[7] Concluded from (Shaw et al,2003) (Langrova, 2002) (Hu, 2002) (Tojo et al, 2001)

2.2 Environmental problems of discarded IT equipment

Computer waste is growing the most rapidly in the world. According to a waste management hierarchy, a favorable waste management at post-consumer stage is reuse and recycling. IT equipment, like most electrical and electronic products, is considered inappropriate to be incinerated or land filled as these hazardous substance required special treatment before disposal.

Computers are made from more than 1,000 materials, many of which are extremely toxic, such as solvents, gases, acids, brominated flame retardants, lead, cadmium, and mercury (SVTC, 2003). The main hazardous substances and their effects are summarized below:

- Cadmium: found in computer batteries and computer circuit boards. Cadmium has adverse effects on several important enzymes and can lead to bone disease as well as kidney damage.
- Lead: it's used in picture tubes, display screens, solders and capacitor. Lead can affect the central and peripheral nervous system and kidneys.
- Brominated flame-retardants: it's used on printed circuit boards, cables and plastic casings. It is chemically related to group of environmental toxins, PCBs, which have bio-accumulative characteristics and can cause reproductive disorders. Also, it has shown to cause liver and fetal damages. Some flame retardants have been detected in human blood of personnel working with recycling of electronics.
- Mercury: it's used in switches, relays, and some types of batteries. Mercury disrupts metabolic processes in the brain causing symptoms such as insomnia, depression, and irritability. (Johansson et al, 2000)

Dumping in landfill could lead to leaching of heavy metals and brominated compounds, which can contaminate the soil, surface water, groundwater and soil. Incineration could result in atmospheric emission of heavy metal, and the burning of PVC and brominated flame-retardants generated dioxins (Lin et al, 2002). In the recycling process, different recycling techniques would generate pollutants in different way. During extraction of metals, emission of NOx often occurs, which threatens the workers on site (Wu, 2003). As waste waster and emission usually contains heavy metals, secondary pollution may still occur if the pollution prevention is not well managed.

Large amount of computer wastes are exported from developed countries to developing countries where lack of proper recycling technology and facilities (like China, India, Pakistan). Silicon Valley Toxics Coalition reported that in a village in China, computer wastes are open burned; emissions and ashes are likely to contain high levels of brominated and chlorinated dioxins and other cancer-causing substances. Waste, air and food source are seriously contaminated; a water sample test

indicated lead levels were 2,400 times higher than WHO Drinking Water Guidelines[8].

To conclude, proper treatment to make computer waste less hazardous, safer to manage, storage, and recovery, is extremely important form an environmental perspective. To reach a sustainable waste management, EPR could be a useful tool in the design of waste policy as it can trigger producers aspire for more environmental-friendly design, including reduction of resource, being easy in dissemble and recyclability.

2.3 Characteristics of IT products influencing the end-of-life management

Useful resources in the product can make the recycling of the products more economically profitable. Some valuable material and useful resources in discarded products provide incentives to recycle them and thus in many cases, such as packaging and cars, recycling program has begun on a commercial basis before the enforcement of EPR program (Tojo et al, 2001). Computer appliance product contains precious metals like gold, silver, rhodium and palladium and other metals like copper, aluminum and iron are also can be recycled after the process of fragmentation and remelting.

The **size** and **weight** of IT equipments varies from one to another. In general, products of smaller size are often discarded in waste stream instead of being sorted out. In report from Davis, Lindhqvist, and Tojo (2001) has shown that small EEE has lower collection rate comparing with large EEE in some countries. IT products posses the same product characteristic as they have big variety and the size and weight of various items differ. The problems in take-back of product with such characteristic could be amended by convenient collecting system or providing financial incentives.

Products with longer **durability** make it hard to evaluate the collection rate and also to predict ultimate recycling cost. Comparing with packaging and non-rechargeable batteries, which have short life span, IT equipments are usually used for several years, and therefore there will be a delayed feedback when it comes to collection and recycling. This should be taken into consideration when setting collection target and the financial mechanism for EPR program.

Cost of end-of-life management is crucial in affecting the effectiveness of EPR program and the cost is affected by numerous factors, including the ones addressed above. The idea of EPR should make the cost reflect the environmental impacts of the product in question, that is to say, to internalize environmental cost, and thus it stimulates manufacturers to make products easer to reuse, recycling or disassemble. However, because **complex products** (e.g. IT, cars) have multiple components, and they have relatively long life prior to disposal, it is difficult to make the advance calculation costs for recycling which truly reflect the environmental impacts of the product in question (Lindhqvist, 2000). Therefore producers may be less encouraged to invest in green design.

[8] Exporting Harm-the high tech trashing of Asia, prepared by Silicon Valley Toxics Coalition (SVTC) and Basel Action Network (2002)

3. IT product recycling scheme in Taiwan

This chapter illustrates the IT product recycling scheme from economic, social, and physical practice perspective. The evolution of the legal framework of recycling scheme is presented first as background information, followed by detailed examination of economics of EPR program, waste management of IT recycling in practice, and social impact from and toward such EPR scheme.

3.1 Evolution of The Legal framework

Prior to 1988 in Taiwan, the collecting recycling was not defined by law and thus it was left to a free market until the Waste Disposal Act (refer to WDA) was amended. The legal framework can be divided into two stages: 1) 1988-1997 period, the recycling program was managed by private Producer Responsibility Organizations (refer to PROs), who carried the physical and financial responsibility of the recycling scheme. 2) 1997 onwards, governmental involvement in the recycling program changed the recycling scheme. A public foundation-RMF-was set up in 1998; from then on, producers are financially responsible for the end-of-life disposal of their products and don't need to fulfill the physical responsibility of take-back and recycling.

Before the decree of WDA, collection of waste material were carried out by vendors who walking from street to street and the collected materials are sold to dealers or directly to recycling plants where these materials are processed and sold to market again. The recycling system had already existed in society at that time but it was based on self-profit and such behavior was not associated to serve for public good. As economic took off, the rapid economic growth led to large amount of waste generated (waste generated grew 140% from 1975 to 1984) but however recycling business underwent hardship due to lack of labor continuing in the low-paid waste collection. Waste Disposal Act was decreed in 1974, aiming to improve waste management, and until amended again in 1988, the concept of extended producer responsibility for the first time was incorporated in WDA.

First stage: 1988-1997, private organization (PRO) based EPR program

According to Article 10-1 in WDA, discarded materials of the following properties should be recovered and treated properly by its manufacturers, importers, and sellers: 1) it's difficult to be collected and be disposed of, 2) it does not contain readily decomposable substances, 3) it contains hazardous substances, 4) it can be recycled. In this article, concept of EPR is incorporated since the responsibility of waste management is shifted from government to manufacturers, i.e. the recycling of the products is undertaken by manufacturers instead of tax-payers.

Based on the law, EPA took decision in the enforcement of collecting and recycling work. EPA decreed certain discarded item needed to be recycled and specific recyclers who are responsible for the work, and a target will be set for this item. PET bottle was the first item announced to be recycled, followed by tires, containers, batteries, vehicles, electrical and electronic equipment, and IT products.

The fact that producers were required to meet the collecting target, suggested producers have to take the physical responsibility and financial responsibility of their products. In general, there were three approaches for waste take-back and recycling, which were 1) carried out by original equipment manufacturers themselves, 2) assigned to a third-party, or 3) pooled take-back by PROs. And it is observed that PRO approach was chosen by most producers (Hu, 2002). During 1988-1997, private PROs managed the take-back and recycling program and had to meet the mandatory recycling rate under the monitoring of EPA in Taiwan.

However, such a recycling scheme was undermined due to government and market failure. Following reasons can be concluded[9] :

- EPA announced item for recycling one by one and thus different PRO was established to deal with the item in question. Large number of PROs without clear definition of allocation of responsibility, it turned out much of the take-back and recycling work was overlapped and keen competition in recycling lead to boost in prices of discarded material.
- EPA was inefficient in verifying and auditing PROs' performance. Free-rider problem came out while some producers didn't' really carry out the take-back and recycling. Some PROs even cheated in the performance to avoid sanction.
- Neither EPA nor PROs designed a proper take-back system; hence there were few collection points and consumers' access for take-back was scarce. In addition, for some article, economic incentive was provided but due to the fairly small economic reward, the public was reluctant in bringing back of discarded materials[10].
- EPA set collecting rate for some items but in fact it was set unreasonably because EPA didn't take into consideration the demand of secondary market. To meet the collecting rate, recycler processed large amount of discarded materials and therefore secondary material was facing over supply.

To response to the inefficient recycling scheme managed by private PROs, and EPA's difficulties in monitoring and enforcement, EPA in Taiwan formulated the Four-in-One Recycling Project and it came into force on January first 1997, aiming to incorporate efforts from four actors-consumer, collector, local government and foundation- in the recycling process. An alternative approach of recycling scheme was made: producers can pool the recycling fee and set up a fund and no need to meet the collecting target of their products. It indicated that producers can carry just the financial responsibility and not involved in take-back and recycling[11]. Instead of requiring PROs to meet the mandatory rate, producers were required to pay a fee to the foundation which aimed to cooperate with household, collectors, and local authority to strengthen the take-back and recycling work. Some PROs were

[9] From (Chou, 2001) (Liu, 2000) (Hu, 2002)
[10] The deposit-refund system for PET bottle came into practice in 1991. Although some argued deposit-refund system should be effective, the refund ranged from 2-4 TWD, which was fairly little when it was inconvenient for consumers to bring back.
[11] Waste Container Processing Requirement,12-2.

established or modified in response to the change.

Second stage: 1997 onwards, government (RMF) based EPR program

However, latter on, on March 28 1997, the amendment to WDA 10-1 made some fundamental change of the recycling scheme[12]: producers are obliged to pay recycling fee to the foundation which is under jurisdiction of EPA. It was debated whether the foundation should be public-run or managed by a private organization. During the transition period, eight semi-private foundations ware organized by EPA[13]. On July 1 1998, Recycling Management Foundation (RMF) is officially founded. RMF becomes the coordinator in the Four-in-One Recycling plan, working together the local waste collection agencies, the household, and the collectors.

Some IT products were officially designated by EPA as target article for recycling in October, 1997. In February 1998, EPA announced the recycling fees for the designated items and the recycling system was planned to come into practice in March. But IT equipment producers complained that they didn't get informed by the government about the new policy[14] .Under the pressure from IT equipment manufacturers and importers, the date of implementation was postponed to June. RMF established collection points and provided reward money to collection points and consumers for taking back of discarded items, and a third-party is contracted with RMF for auditing. Till 2001, the six designated IT products have a collecting rate about 85%, indicating an effective recycling scheme (EPA, 2001). In April, 2001, printer is added to the designated items for recycling.

To summarize, the simplifying of producers' responsibility and ambiguous role of government can be observed in the evolution of recycling scheme. Table 3-1 shows several important events concerning IT recycling scheme.

Table3-1 Important event in the evolution of IT recycling

Date	Event
Nov. 11, 1988	Concept of EPR was incorporated in Waste Disposal Act, Article 10-1,
Sep. 12, 1996	EPA announced its intention to included scrap IT products in the EPR recycling scheme
Oct. 18, 1997	Scrap IT products, comprising of six items were officially decreed as recycling items
Jan. 23, 1998	Foundation for scrap IT products management was established by EPA
Feb. 27, 1998	EPA announced the recycling fee for scrap IT products
Jun. 1, 1998	Official starting date for new recycling scheme for scrap IT products

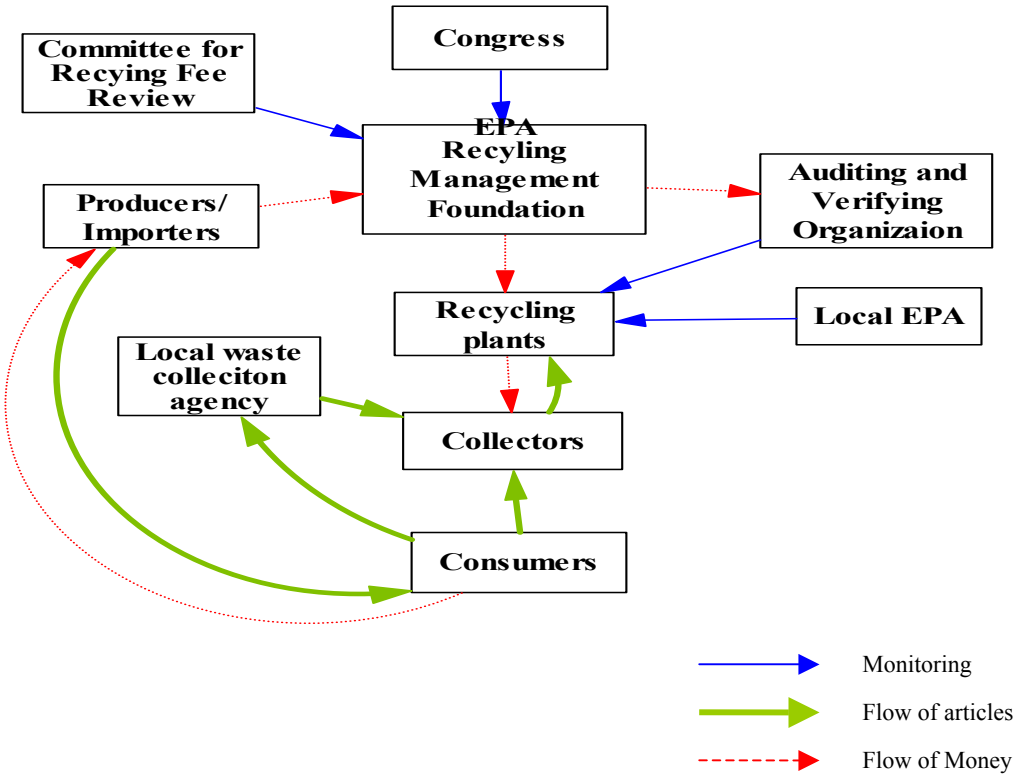
[12] According to WDA Promulgated and amended on March 28, 1997. Per directive number Hua-Tsong -(1)-Yi-8600077350

[13] The eight foundations were responsible for different items. They are general containers, batteries, vehicles, EEE, pesticide containers, lubricant oils, tires, IT products.

[14] From: http://www.gcaa.org.tw/env_news/199804/87042806.htm

3.1.1 Main actors and allocation of responsibility

An overview institutional framework is shown in Figure 3-1. EPA assumes the responsibility for the operation and management of RMF. EPA establishes a committee to determine and review recycling fee rate and subsidy. Monitoring of recycling program is carried by local EPA and Auditing and Verifying Organization, which is a third-party group authorized by EPA. Congress reviews the budget of the RMF.



Source: Shaw (2004)

Fig. 3-1 Institutional framework of recycling program

Recycling Management Foundation

Producers/importers of announced recycling articles are obliged to pay recycling fee according to numbers of sold articles to the RMF. RMF acts as an intermediary that is responsible for safekeeping and use of the fees collected, of which 40% is used to carry out the take-back and recycling work. The major uses are:

- Subsidizing the establishment and operating costs of recycling system, including collection, storage, transport, recycling process, and pollution reduction.
- Subsidizing and encouraging research and development on waste reduction, reuse, and recycling
- Expenses on auditing and verifying the recycled amount
- Auditing the producers' declaration sold volume

This foundation is under jurisdiction of Taiwan EPA. RMF can set up committee for consulting, fee rate setting, and authorized a third-party to audit the performance of

recyclers.

Producers

Defined by the Taiwan Waste Disposal Act, producer refers to manufacturers, importers, and sellers. Producers of IT equipment are required to:

- Register to the authority-concerned.
- Declare sales /importation volume; provide information about the material.
- Pay the recycling fee according to the sold volume to RMF.

Under the current legal framework, producers carry only the financial responsibility and not directly involve in the recycling program. The environmental awareness and how producers perceive their role in the system affects their willingness in participation. The idea of extended producer responsibility aims to promote changes in design phase of the product to a more environmental-friendly way since the producers are directly involved in the design and production process. Better environmental performance can be achieved if the producers acknowledge the responsibility and capability in leading some actual change instead of passively paying the mandatory fee to the recycling fund.

Consumers

The role of consumers in recycling program is crucial but it's not demanded by law. Various factors affect consumers' willingness in recycling, such as the economic incentive, environmental awareness, knowledge about recycling, convenience and so on. As consumers don't have mandatory take-back requirement, in order to change people's behavior, economic incentive and education can be applied. In the beginning government provided economic incentive to encourage consumers to bring back the scrap IT products. The consumers were entitled to rewarding money, 100 TWD [15]per piece, from the collection points, until RMF considered the general public's participation in recycling program has been developed and thus they stopped giving reward to consumers (Lin, personal communication).

Collectors and Local waste collection Agency

Take-back access of discarded products is managed by private companies and local government. Collectors include retailers, and collecting companies. Now the number of collecting companies is over than 50 (RMF, 2004a), and number of registered take-back retailers in 2001 is over than 600 (EPA, 2001). The access for consumers to bring back the discarded products in the disposal stage determines the environmental performance, and a wide-spread collection system will help the recycling system to reach higher collecting rate . Therefore at the beginning the government encouraged retailers, service station, and recycling plants registered as collection points by providing economic incentive. Subsidies to retailers ranged from 50 TWD to 90 TWD for different items, and there was also subsidy for transport the items to recycling plants, which is 50 TWD for all IT products[16]; now subsidies direct to collectors have

[15] Exchange rate: 1 TWD =0.0235130 Euro (XE.com, 2004)

[16] Subsidies to collectors are: 50 TWD for notebook, 70 TWD for monitor, 60 for computer main frame, and 90 TWD for printer.

been cancelled.

As for Local Waste Collection Agency, which is under jurisdiction of local government, it is responsible for collection of waste from the households and help EPA to implement the recycling. They don't grant reward money to consumers but provide take-back service for IT products on request. Collectors and Local Collection Waste Agency would bring the scrap products to warehouse or directly to recyclers.

Recyclers

Recycler in this thesis means the recycling plants where the take-back products are processed and recycled. There are eight private recycling plants for IT products and five of them also process EEE products (defined by EPA are TV, refrigerator, washing machine, and air conditioner,). Recyclers are subsidized by RMF in accordance with the processed amount of various items. The work and result are monitored by the Auditing and Verifying Organization.

Auditing and Verifying Organization

AVO is a third-party entrusted by Taiwan EPA through annual public tender procedure; it is responsible for monitoring recyclers' work and report to EPA. TÜV Rheinland Taiwan Ltd. (TRT) has been providing recycling certification and consultancy services in IT products since the year 2002. They provide services in the areas of inspection, certification, monitoring, and quality audits for recycling companies (TRT, 2004).

3.2 Economic of EPR system

An EPR system requires a recycling scheme for end-of-life management of obsolete products. The recyclers are subsidized by RMF. The government has to decide the reasonable subsidy to make the market of end-of-life management function, and according to the amount of subsidy needed, government announces the fee rate charged from producers. Thus cost of end-of-life management becomes a determinate factor in the setting of fee rate. The tale-bake and recycling mechanism is builds on two major factors: 1) the market value of scrap products and 2) subsidy from the government (Hu, 2002).This section first examines the money issue of end-of-life management and then illustrates the financial mechanism of the EPR program.

3.2.1 Cost of end-of-life management

The take-back and recycling system's work in fact is including three market:1) consumers and collectors, 2)collectors and recyclers, and 3) recyclers and secondary market. An overview of the money flow among actors is depicted in Figure 3-2.

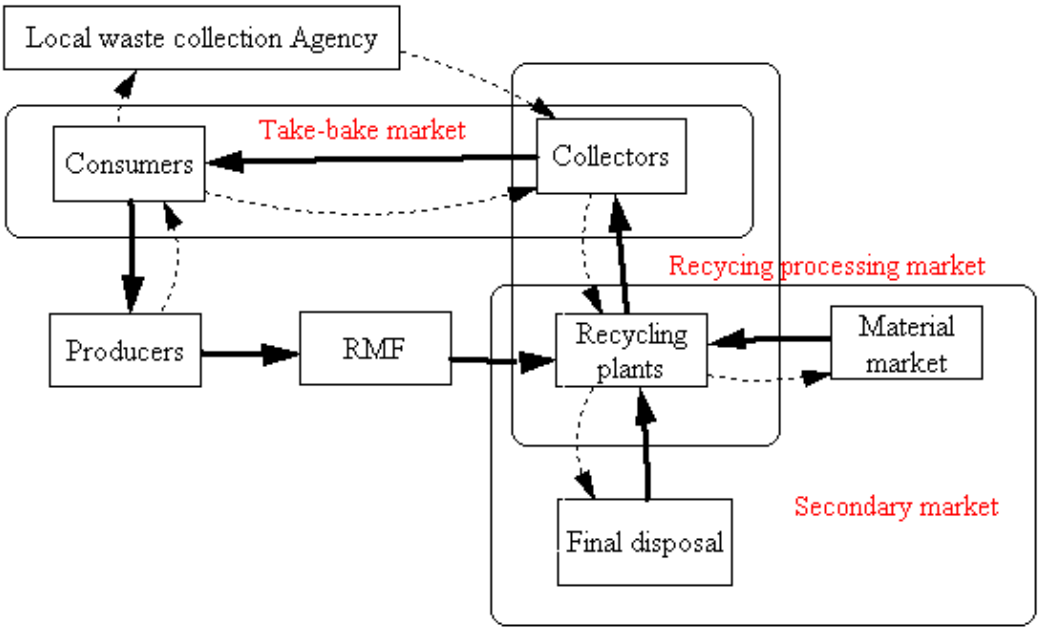


Fig. 3-2 Actors in recycling scheme

- Take-back market: in 2002, the government has cancelled the rewarding money to consumers, but many collectors provide economic incentive to attract the tack-bake products. Current rewarding money is 100-150 TWD[17] per piece.
- Recycling processing market: collectors supply the take-back products to recycling plants. According two interviews –one from collecting business and one from recycling plants, market price of take-back products is to a large extent influenced by the government subsidy to recycling plants (Chen, and anonymous, personal communication). These scrap products generate profit for recyclers in two ways-- sales of the secondary material, and subsidy from government. The demand of recycler is influenced by several factors, such as the supply and quality of discarded products, demand of secondary material, net profit of processing, and recycling technique.
- Secondary market: recyclers dismantle the discarded products; they can extract the pieces that can be reuse or process the rest part and turn them into secondary material. Demand of secondary material can come from product producers, or upstream material suppliers. Recyclers have to find a balance between the cost of processing and price of secondary material. The better quality of secondary material, the higher price can it be, but more efforts will devote into the dismantling, which implies the cost for processing will rise.

The recycling fees charged from the producers and the subsidies granted to recyclers are differentiated for different items, which is greatly relevant with the cost of end-of-life management**.** Cost of end-of-life management is comprised of collecting cost and processing cost, both of which respectively consist of such costs illustrated in

[17] Exchange rate: 1 TWD =0.0235130 Euro (XE.com, 2004)

Figure 3-3. And detailed expenses included in such costs are listed in Table 3-2.

Collecting Cost = cleaning and transport cost + storage cost + (reward to consumers*)
Processing Cost = transport cost + processing cost in recycling plant

*By law, collectors are no longer obliged to give reward money for returned discarded items. But some collectors give money to customers to get more discarded items in order to make business from it

Source: Hu (2002)

Fig.3-3 formula of end-of-life management cost

Table 3-2. Basic expenses in end-of-life management

Cost	Expenses included
cleaning and transport cost	• Cost of vehicles • Depreciation cost of vehicles • Car insurance • License tax • Wages • Cost of fuel
storage cost	• Cost of land+ infrastructure • Depreciation cost of infrastructure • Personnel cost • Administration cost • business tax
transport cost	• Cost of vehicles • Depreciation cost of vehicles • Car insurance • License tax • Wages • Cost of fuel
processing cost in recycling plant	Fix cost: • cost of construction • Depreciation cost of construction+ infrastructure • Wages • Administration cost • Cost of maintenance. Variable cost: • Operating Cost • Cost of final-disposal • Business tax • Cost of resources

Source: Hu (2002)

Looking the recycling scheme from a broader perspective, various transaction cost is included in the cost of end-of-life management as there are different actors involved (see figure 3-4). Some collectors give reward money to consumers in order to get more discarded IT equipment, which is of high value in the recycling business for its containing much valuable material, and some of which can be sold to the market again. Before the discarded items reach the recycling stage, there are transaction costs surrounding collection, sorting, storage, and in transporting them between actors. In Tojo et al (2001), it is argued that financial incentive can be used to counterbalance the transaction costs; in the system in Taiwan, subsidy also implicitly eases the transaction costs.

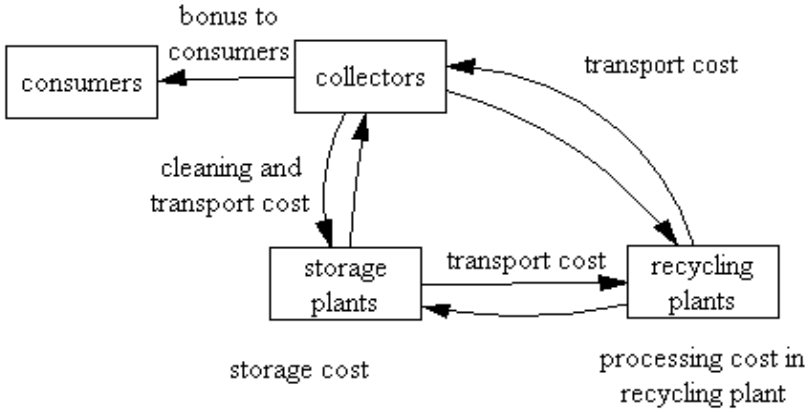


Fig. 3-4 money flow of end-of-life management cost in recycling business

3.2.2 Financial mechanism

An **advance disposal fees** system (it is most widely used in take-back program for complex products, also be called pension system or product charge) with differentiated fee rate structure is implemented in Taiwan. This advance disposal fees is made invisible and incorporated in the selling price. Different items require different advance disposal fees, and the producers/importers of IT products pay the total amount of fee according the sold volume (see Figure 3-5)

Total recycling fee = Total sold volume X fee rate
Total sold volume = (A_1+ A_2+ A_3- B_1-B_2)*

*A_1: Sold products made from original producer.A_2: Sold products made from other producer. A_3: Net imported volume.B_1: Products sold to other producers.B_2: Other deduction

Source: RMF

Fig. 3-5 Formula of recycling fee paid by producers

The financing of the whole system is mainly under control of Recycling Management Foundation. The fee rate is set according to the cost of end-of-life management and is reconsidered at least once a year by **Committee for Recycling Fee Review**. The calculation methodology for fee rate is not acquired, but in Shaw (2004) following factors are taken into consideration in rate setting: material type, weight, cost for recycle/clearance/disposal, cost for inspection, financial condition of the fund, amount of subsidies and other relevant factors. According to Chang, the setting fee rate is to a large extent based on the cost of end-of-life management for recyclers (Chang in RMF, personal communication).

Following is the fee rate of each item:

Table3-3 fee rate in 2004 (unit: TWD. Exchange rate: 1 TWD =0.0235130 Euro (XE.com, 2004))

Item	**Fee rate**	**Item**		**Fee rate**
Notebook	39	Power supply		8.2
Monitor	127	Computer case		8.2
Main frame	49.2	Printer	Matrix	151
			Laser	137
Disk driver	49.2		Inkjet	81

Source: RMF (2004b)

The main financial sources for RMF are the recycling fee collected from the producers, and the interests gained form the fund. The fund shall be used to subsidize the establishment/improvement of recycling system, and pay for the cost of certifications conducted by Auditing and Verifying Organization. An overview of the money flow of EPR program can be illustrated as following:

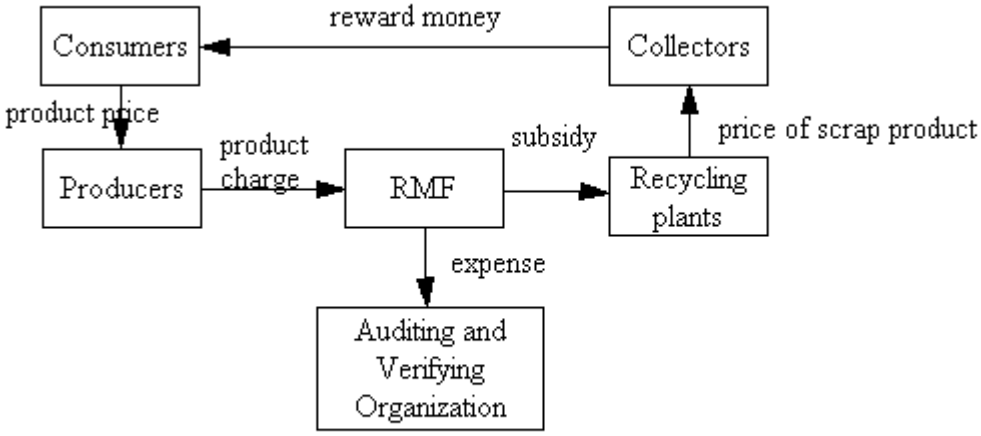


Fig.3-6 money flow of EPR system

As mentioned earlier, recycling business is subsidized from RMF (see Table2), in accordance with the number of pieces of recycled items, to encourage recyclers to perform better collection result. It's noteworthy that the difference between collected fee from producers and the subsidy to recyclers is due to the fact that the total sold volume each year is much bigger than the scrap volume processed by the recyclers. Since the first announcement of recycling fee rate for IT products in 1998, the level of fee rate in general is keeping lowering (see appendix). In the year 2000, RMF has accumulated twenty million TWD surplus in IT products, therefore a big range of fee rate lowering was taken place (EPA, 2000). Notebook was adjusted from 112 TWD to 52 TWD, lowering the rate up to 50%. Monitor was from 147 TWD to 102 TWD, main frame was 67.5 to 40.5; also 11 TWD to 6.5 TWD for computer case and power supply (RMF, 2004).

Table3-4 subsidy for recycling of different items in 2004
(unit: TWD, Exchange rate: 1 TWD =0.0235130 Euro (XE.com, 2004))

Item	Notebook	Monitor	Pinter	Computer case
subsidy	303	215	192	182

Source: RMF (2004b)

3.3 Collecting and recycling mechanism

This section depicts the collecting and recycling mechanism of scrap IT products. Figure 3-7 provides the overview of actors involved and flow of discarded products. It must be mentioned in fact the scrap IT products from consumers to a large extent can be diverted to secondhand market instead of going directly to the recycling stage. In a waste management hierarchy, reuse is more preferable than recycling, but the current EPR program focuses on recycling work. Thus to understand the environment effectiveness of such waste management, the reuse flow must be taken into consideration. Fig 3-7 will be further explained in the following text.

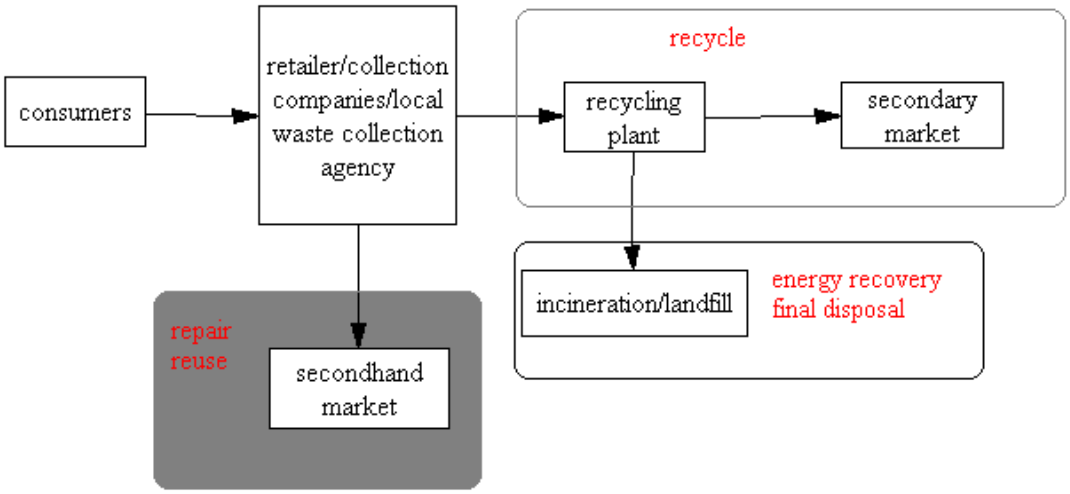


Fig.3-7 Material flow of discarded products

3.3.1 Collection and inventory

The primary actors involved in collection discarded products include retailers, collecting companies and local government (local waste collection agency), from where some of the products will be transported to recycling plants. To expand the collection network, some collecting program is initiated in public institutions, communities and schools. The collecting network at the beginning was built by government's providing economic incentive and now the market has developed. The take-back routes are various. Following table illustrates the ratio of different routs:

Table 3-5 ratios of take bake routes

collector	Source		Flow to	
Retailer	Consumer *	64%	Collecting company	82%
	public institution and school	36%	Secondhand market	10%
			Recycling plant	6%
			Export	2%
Collecting company	Source		Flow to	
	Consumer*	60%	Secondhand market	13%
	Public institution and school	29%	Recycling plant	79%
	Retailer	11%	Export	2%

* Consumer also includes the secondhand product dealer

Source: Chang (2001)

According to the original data, among the consumers who bring back products to retailers, 9% is "exchange old for new", since retailers sometimes give discount to consumer who buys new products when they bring back the old products. The author suspects that these take-back products are likely to be still useable; thus they possibly flow to secondhand market or are exported. In conclusion, it can be calculated that the discarded IT products flowing to recycling plants accounts 78%, to secondhand

market accounts 14%, and 8% are exported. Flow to secondhand market and export implies the products could be back to use phase again.

3.3.2 Issues concerning secondhand market

As IT products have the characteristic of rapid advancement of technology, consumers tend to upgrade to advanced one and discard the old, unwanted one before it run off. The lifetime of computer is about 7 years but the current consumption pattern reduces the length of use phase to about 3 years. As mentioned in last section, the old computers in the take-back flow, 14% go to secondhand market; 8% be sold to other countries. From an interview with Chang in RMF, repair and reuse is a better waste management, but RMF only focuses on the recycling part (Chang in RMF, personal communication). This flow diverted from recycling becomes a grey zone of the EPR program.

As value of used computer products is higher in selling it in the secondhand market than the reward money through the recycling program, naturally the products tend to flow out from the recycling system. According a secondhand survey (Chang, 2001), the profit margin for secondhand dealers is often more than two times of the purchasing price, though it varies in different equipment. For example, a 14 inch monitor can be bought for 200 TWD and sold for 900 TWD. The source is from consumer's take-back when they purchase new products, or from bidding and collecting from companies or communities. Secondhand dealers have two ways of processing the computer products: 1) dismantle and sell the pieces, or 2) repair and sell the original equipment again (Chang, 2001).

The emergence of computer exporting is because of the demand for computer products in less developed countries. It is estimated that export used computers amounts 10,000 pieces per month, and mostly flow to South Easet Asia and China (Chang, 2001). The brokers purchase used IT products from secondhand dealers, retailers, or companies. They are dismantled domestically or abroad. Exporting can be considered as flow to secondhand market also as they are back to the reuse stage again. But since they wouldn't be processed and recycled in Taiwan, these products cannot be covered under the domestic EPR program.

3.3.3 Processing and recycling

The producers of IT products in Taiwan don't involve in the collecting and recycling of their products in question. There is no PRO to assign the work; the EPR program in Taiwan is centralized in a way that it's government assigns the recycling work. There are eight registered recycling plants which are monitored and subsidized by RMF. Auditing and Verifying Organization is authorized to monitor and inspect the work performance of recyclers, and audit the collecting amount which flows to the recycling plant. The collecting amount of IT equipment grows continuously since the beginning of recycling scheme for IT products (see table 3-6)

Table3-6 collecting amount of discarded IT equipment (unit: in piece)

Year\ Item	Notebook	Main frame	Monitor	Printer	Total
1998	458	45,015	93,055	-	138,528
1999	1,090	207,885	277,000	-	385,975
2000	1,828	497,054	447,636	-	946,518
2001	1,662	579,065	582,683	84,536	1,247,946
2002	2,866	686,985	805,235	206,251	1,701,337
2003	2,507	680,568	646,771	490,037	1,819,883
2004 (Jan.)	n.a.	78,140	48,240	30,789	157,169
Total	10,411	2,696,572	2,852,380	780,824	6,340,187

Source: RMF (2004c)

EPA in Taiwan doesn't set collecting rate for IT products. However, the recyclers has to report their recycling performance according to how many units being collected and recycled, and if the volume exceeds or recedes 15% in comparison with the volume of former year, an explanation must be presented to the Auditing and Verifying Organization (Chang, personal communication). From a secondhand data from IER[18], it shows collecting rate of IT product in average is over 70%. According to Wu, the collecting rate is the ratio between the sold volume this year and the collecting amount that flows to recycling plants (Wu, personal communication). Based on the method for collecting amount calculation, the collecting rate could exceed 100% when the collecting amount is more than the sold amount.

Table3-7 collecting rate of discarded IT equipment (unit: in piece)

Year	1998		1999		2000	
	Collecting amount	Collecting rate	Collecting amount	Collecting rate	Collecting amount	Collecting rate
Notebook	458	3.98%	1,090	4.30%	1,828	4.51%
Main frame	45,015	24.73%	207,885	61.32%	497,054	123.03%
Monitor	93,055	51.13%	277,000	81.71%	447,636	110.80%
Printer	-	0.00%	-	0.00%	-	0.00%
In total	138,528	36.89%	485,975	69.09%	946,518	111.55%
Year	2001		2002		2003	
	Collecting amount	Collecting rate	Collecting amount	Collecting rate	Collecting amount	Collecting rate
Notebook	1,662	3.02%	2,866	4.48%	2,507	0.77%
Main frame	579,065	97.98%	686,985	89.80%	680,568	79.08%
Monitor	582,683	98.59%	805,235	105.26%	646,771	69.15%
Printer	84,536	19.66%	206,251	35.98%	490,037	100.19%
In total	1,247,946	74.87%	1,701,337	78.50%	1,819,883	69.66%

Original source: RMF

[18] From (Chang, Chi-Chen, personal communication). The author called to RMF for provision of recycling rate data but the attempt didn't succeed. With the help of a staff in Institute of Environment and Resource (IER), data in table 5 is acquired.

In a case study of recycling plant, it is indicated that averagely 337,000 kg per month of scrap IT products is dismantled by hand and processed; the material can be recovered and reused, including valuable metals, IC board, glass, plastic, copper, cord, iron and some substances, amounts to 99.1%. 0.2% of the material, such as batteries, fluorescent powder, liquid-crystal display, is put in storage since processing is constrained by the technical deficit, and 0.7% will go to waste disposal (Wu, 2003). Table 3-8 shows from processing 337,000 kg of IT products, the substances required storage and disposal, as well as some examples of material which can be recycled. A rich amount of materials can be extracted (see appendix). The waste from recycling plants is considered industrial waste, which will be incinerated or landfill.

Most of the recovered material will flow to the secondary market. However, research and development on recycling techniques still need be further improved to deal with the storage. But for recyclers, cost of processing and the demand for recovered materials are greater concerns than limits of processing technique (Change, personal communication).

Table 3-8 Treatment and amount of recycled substance

Material	**Amount (ton/month)**	**Treatment**
fluorescent powder	0.007	Storage
Batteries	0.021	Storage
Condenser	0.600	Storage
Liquid-crystal	0.050	Storage
Industrial waste	2.322	Waste disposal
IC board	17.000	Recycle*
Glass	75.000	Recycle*
Plastic	61.000	Recycle
Copper	9.000	Recycle
Cord	2.500	Recycle
Transformer	4.500	Recycle
Iron	157.000	Recycle

*IC board and glass are reprocessed in the recycling plant and make into artificial marble, brick, art craft; etc.

Original source: Wu (2003)

3.4 Social aspects

This section examines how actors perceive their roles in the EPR program and the relevant issues influencing the effectiveness of the program.

3.4.1 Consumers' action and awareness

According to Lindhqvist (2000), factors deciding the collection results in EPR program are regarded as 1) **financial incentive**, 2) **level of convenience or inconvenience**, in terms of how much effort must be taken to dispose the waste product, and 3) **level of information and awareness**. In the EPR program in Taiwan, there are approaches to deal with these factors in consumers' side to improve

consumers' willingness in bringing back the waste products.

For customers, as there is no specific hand-in mandatory by law, economic incentive was used as a strategy to stimulate consumers' willingness when RMF just came into force. Also to provide convenient access for consumers, wide-spread collection points were established, and local government authorities provides free service to collect waste IT products from households. EPA plays an essential role in information provision via multiple channels, like brochures, posters, commercials, website information and so on. Retailers or stores registered as collecting points will put a standard sign issued by the government on the entrance to help consumers to identify where to hand in the waste products.

RMF has cancelled the recycling bonus to consumers in 2002 as they consider the collection work is on the right track in consumers' side. But many collectors still keep giving reward and even provide free transport service and therefore the convenience and financial incentive are still driving force in influencing consumers' willingness. Hence, consumers' environmental awareness as a driving force in implementing recycling is difficult to measure.

The general public's awareness in reusing and recycling is more associated with the traditional values that one should treasure material and keep low material desire. Such values are relatively strong in the old generation who used to live in poverty before and during the economic take-off. Environmental awareness is much raised after 1980s, when environmental movements started to take place to mobilize the public to protect the environment. According to Hsiao (1999), three streams of environmental movements-- anti-pollution protest movement, nature conservation movement, and anti-nuclear movement--raised people's awareness of environmental problem caused by rapid industrialization.

A recent survey regarding the level of consumers' environment concern indicates that 25% of the consumers show strong interest and are active in environment issues, and 46% prefer simple and low consumption of resources but have little knowledge about environment protection. In total more than 70 % of the consumers can provide the potential market for green products, which emphasizes resources conservation. Acknowledgement of the potential of **green consumption** shall encourage producers' willingness in DfE (design for environment) (TEEMA, 2004).

In conclusion, an efficient EPR program relies on consumers' participation, and it's important to accompany with top-down strategies to mobilize the general public at an initial stage. On the other hand, consumers' environmental concern can be a bottom-up approach that impacts policy and social norms, and also demands producers' environmental and social responsibility

3.4.2 Producers' response

Extended producers responsibility was a fairly new concept for enterprises in Taiwan as incorporating social and environmental concerns was not emphasized in the local

business climate.

When RMF announced to start the recycling program in IT equipment and demand mandatory financial responsibility from the IT enterprises, the idea encountered strong resistance from the business side. Computer Association and many IT companies regard the enforcement of the fee-charging is too rush and they are not involved in the decision-making of such a policy. Some companies questioned the system under the control of RMF, considering it's not transparent and unable to provide clear information about the control of the money. Some had doubts in the paying mechanism to be fair and worried about losing competitiveness[19]. In conclusion, the biggest worry from business side is they don't have trust in RMF.

According the requirement, producers only need to pay a fee to RMF, and such a fee is very small[20]. Though the aim of EPR program is to make producer be responsible of their products at end-of-life stage and thus promote design for environment at design stage, however it is questionable the legal framework can promote producers' awareness if the producers are alienated from the recycling system. How producers perceive their role and influence can be a driving force in EPR program.

In spite of the fact that most of IT producers have ISO 14001 certification[21], are active in public affairs, and meet the general environment requirement, but they are quite reluctant in environmental and social reports. In general, producers are considerably poor in **information provision** to the public, and they have not recognized the importance of incorporating social and environmental responsibility (Chung, 2004). Several IT producers with large market share worldwide are now facing great challenge of growing environmental standards in the European market[22].

Due to the pressure from legislations in foreign market, most local producers are aware that incorporating environmental responsibility is significant in keeping the competitiveness and market share of their products. Furthermore, many foreign companies outsource IT products from Taiwan, local producers are requested to provide certification and information on products' environmental impact. In addition, therefore, there is a trend of **design for environment** (DfE), and **supply chain management** among producers (Huang, 2004). Some enterprises have started to devote in research in better design, product and material control, management of environmental system, and information sharing. At the same time, some enterprises are going ahead and push forward of their environmental awareness. For example, EPSON initiates voluntary recycling program of cartridges[23], and keep upgrading

[19] Chinatimes news, 1998.04.28, retrieved from http://www.gcaa.org.tw/env_news/199804/87042806.htm

[20] Take notebook for example, the market price ranges from 30,000 NT to 40,000 NT, and the fee rate is 39 NT in 2004, which means about 0.01% of the selling price goes to the end-of-life management.

[21] ISO 14000series cover several environmental standards

[22] Two major legislations will have great impact on IT producers: EU WEEE (waste electrical and electronic equipment) Directive (2003) demands producers to take care of waste management of their products. And the coming RoHS (restriction of hazardous substances) Directive will set sticker standard in the material using of the product.

[23] Available information on : www.epson.com.tw

their environmental management.

In conclusion, IT enterprises used to be passive in environmental issues, and such an attitude is at present being challenged by international environment demand. EU WEEE and RoHS Directives has become an effective driving force in producers' environment achievement.

4. Determinate factors for effective EPR scheme

An illustration of the EPR program of IT products from legal, economical, physical and social perspective is presented in Chapter 3, and these shall serve as a base for further identifying determinate factors for effective EPR scheme in Chapter 4.

A proper legal design is fundamental for an effective practice of EPR. Current EPR program managed by RMF has been in practice since 1998, which starts fairly early in comparison with other countries (for example, Sweden's "*Ordinance on Producer Responsibility for Electrical and Electronic Products*" in 2001, and Japan' "*Specified Home Appliance Recycling Law"* in 1998). In general, the legislation in Taiwan is rather complete in terms of the requirements for actors involved, and the scope of EPR scheme[24].

Several issues concerning the legal design as well as the work in practice come about during the research, which could influence the success or failure of the recycling scheme in Taiwan.

4.1 Target setting

To evaluate the performance of EPR program, environmental effectiveness is a major criteria often being applied. Defined by OECD (2000), environmental effectiveness refers to *"the extent to which the instrument could be used to reduce or change environmental impacts in relation to the policy targets set. In the context of EPR, upstream changes in products design and composition and waste diversion could be two factors."* The ultimate goal of the policy is to reduce the environmental impact, thus a target aiming to promote environmental effectiveness should be clearly set up.

Tojo et al (2001) argues that the establishment of mandatory targets from the government can effectively contribute to high collection, reuse, and recycling rates. In Taiwan, there is no mandatory collection and recycling rates for IT equipment. But recyclers are required to maintain their processed amounts of IT products within a specific range[25]; thus a required target still exists in a sense. Collecting rate could be used as a good indicator to measure the progress of recycling scheme. However, using collecting rate as an indicator to evaluate the environmental effectiveness may only tell parts of story. According to Chang in RMF, RMF only focuses on the waste products flow into the recycling plant where the collecting rate is calculated, but in fact the flow of some scrape IT products that goes into secondhand market and is repaired or reused, contributes more in terms of environmental effectiveness (Chang in RMF, personal communication). Thus it's obvious if a mandatory processed rate for recyclers is set too high and flow to secondhand market is diverted to recycling plants, it won't be an optimal waste management.

When setting up target for recycling scheme, it's important a credible **calculation**

[24] Articles announced for recycling cover vehicles/motorcycles, packaging/containers, batteries, EEE, and IT products.

[25] The amount should not exceed or recede over 15% in comparison with the amount of the former year

methodology is used, which makes actual measurement at optimal levels. Current calculation method for collecting rate is the ratio between sold pieces and collected pieces in the same year (Fig. 4-1).

Collecting Rate% = collected volume in pieces year t / sold volume in pieces year t

Source: Wu (personal communication)

Fig. 4-1 method for collecting rate calculation

Various calculation methodologies can be applied in measuring collecting rates, but as they involve lots statistical discussion, the author didn't go further into it. Nevertheless, the author identified two practical issues should be concerned in the setting of recycling rate as a target for IT products.

First, the **durability** of IT products is relatively long compared with products with shorter life span, such as packaging, non-rechargeable batteries; the total amount of certain IT products sold to the market in the same year could reach their post-consumer stage in different time. Thus it is difficult to estimate the waste volume from the each year's production volume. During the research, the author found out an equation for estimate waste amount, which takes into account of various lifespan of IT products. As shown in figure 4-2:

$$Bt = \sum_{i=1}^{7} Pi * Xt - i + 1$$

B_t is the estimate waste amount in the year t.
P_i is the expected probability of lifetime.
X_{t-i+1} is the sold volume in the time $(t-i+1)$.

Fig.4-2 equation of estimated amount

Source: Chang (2001)

The expected probability of lifetime is based on the table below:

Table4-1 expected probability of lifetime

Lifetime	expected probability of lifetime
1 year	P_1=3.96 %
2 years	P_2=13.69 %
3 years	P_3=20.75 %
4 years	P_4 =24.92%
5 years	P_5 =18.82%
6 years	P_6 =10.80%
7 years	P_7 =7.06%

Source: Chang (2001)

According to this equation, the waste amount of the year 2004, will be the total amount from the sold volume of 1998 times 7-year-lifetime probability, plus the amount that the sold volume of 1999 times 6-year-lifetime probability, plus the amount that the sold volume of 2000 times 5-year-lifetime probability, and add up to

the year 2004. The characteristic of long durability and different lifetime of an IT product is reflected in this equation. However, it bases on the assumption that the products will flow to recycling process at the end of the lifetime, and it doesn't include the dynamic that some scrap products may be diverted to secondhand market or other ways (for example, giving it for free to friends) which transfer them to reuse phase.

The other issue worth considering in target setting is the waste flow to domestic **secondhand market,** as well as to foreign countries. As mentioned earlier, the scrap IT products flow to secondhand market in Taiwan and to market abroad accounts 14% and 8% respectively. And this amount is excluded from the waste management accounting. IT products have the characteristic that the used ones still possess relatively high market value and can be easily reuse. Take personal computers for example, they are easy to dismantle and various units are likely to be sold back to the market again. The high reusability is more preferred than high recyclability from an environmental perspective; however the present target setting for waste management fails to reflect the environmental effectiveness from the reuse phase. The secondhand market system is sort of outside of the legal system; therefore it becomes quite tricky when it comes to evaluate the EPR program.

Thus it's worth considering to monitor material flow that is diverted from the regular recycling treatment, such as directly to the landfill, to the secondhand market, or to foreign countries. Further discussion will be in section 4.3.

4.2 Allocation of responsibility

Two major types of responsibility under EPR are physical responsibility and financial responsibilities, both of which are fundamental pillars for EPR system. They can be carried collectively or individually by actors involved. The nature of EPR allocates the responsibility to producers as "*producer is in the position to influence a number of stakeholders to accept responsibility for their behavior, including supplier, businesses, consumers, educator, media, government and retailers"* (OECD, 2001). The producer is regarded to have the greatest influence over the product design and materials selection; however there are different opinions about who is the producer. For products with long-life span, OECD (2001) considers the producer to be the importer or the firm whose brand name appears on the product in question. EPA in Taiwan has defined producers in EPR program as manufactures, importers, and sellers. But from the practice of EPR program, the financial responsibility is allocated on enterprises who sell the products in domestic market[26].

Examining the current practice of EPR program in Taiwan, allocation of responsibility is shown as Table 4-2.

[26] In the fee charge system, enterprises pay the recycling fee in accordance the sold volume. See Fig 3-5.

Table4-2 Allocation of responsibility for IT products in Taiwan

	Collection	**recycling**
Consumer	Physical res.(not mandatory)	
Producer		Financial res.(mandatory)
Local government	Physical res.(mandatory)	
Collectors	Physical res.(not mandatory)	
Recyclers		Physical res.*

*Recyclers' processing discarded items is a commercial behavior in nature; thus they fulfill physical responsibility which it is not demand by law. But they need to reach a mandatory target to keep the business running.

Producer responsibility is narrowed down to financial responsibility and physical responsibility is collectively carried by different actors. Such design bases on government requirement in combination with market mechanism. Producers don't need to involve in end-of-life management but are obliged to pay a fee to RMF. Meanwhile, other actors who carry physical responsibility in fact are following a market rule, i.e. it's more a business than responsibility to them. The author recognizes some concerns about such design.

First, though Resource Recycling Act decreed citizens' responsibility in recycling, however it is principle declaration[27]. As consumers' responsibility is not mandatory, the taking-back of scrap products relies on consumers' voluntary behavior, which could be driven by two reasons: awareness and economic incentive. Two types of behavior have been observed and it's hard to conclude which one is more dominate. A hand-in mandatory by law is possible; nevertheless it's difficult for authorities to enforce and validate it.

Second, the fact that producers distance from the physical responsibility could weaken the feedback from recycling process. Hence it's of less interest for producers to design products which are with longer durability or are easier disassembled, reused and recycled. According to Johansson et al (2000), cost benefits is an important internal driver for company to corporate environmental projects; company wants to profit from environmental projects in two ways: either they can sell more, or have the chance to lower the costs. Under the design of present EPR program, financial benefits of design change are not visible.

Last but not least, it's worth considering a fundamental change of the design of the program—to reduce the government involvement and let the producers manage the waste management of their products individually or collectively. According to a researcher, Taiwan is the only centralized EPR system in the world and there are many

[27] Resource Recycling Act, Article 10: Citizens shall have the duty and be responsible for abiding by the principles of reducing resource consumption, controlling waste production, and promoting resource recycling, and, to the greatest extent possible, extend the usable life of goods, use recycled products, and sort recyclable resources to prevent goods from becoming waste and appropriately recycle goods and renewable resources.

problems due to such a design (Shaw, personal communication). During the research, the author indeed acknowledged some drawbacks of the RMF-based waste management; the biggest one is the **lack of motivation for DfE** as illustrated above. Also the high administration costs associated with such design can result in inefficient management of the fund. The potential of **PRO-based EPR program** is worth looking into. But it's important to extract some lessons from the experience of PRO-based management before 1998. The author considered a clear definition and allocation of responsibility, as well as an effective monitoring mechanism must be stressed. As it requires more research on feasibility of PRO scheme, the author can't conclude an alternative design which is optimal in theory can work better in practice than the current centralized system.

4.3 Monitoring

Monitoring is essential to examine progress of a system. Local EPA and Auditing and Verifying Organization (refer to AVO) are responsible for monitoring the recycling program to ensure the recyclers reach the target. Following are two factors recognized by the author are important in affecting a successful monitoring.

- Choosing of Auditing and Verifying Organization: an **objective third-party group** as AVO can enhance the credibility of the performance, and present reliable report to recyclers and government. As an interviewer mentioned, third-party group is preferred since it is fair and reasonable in examining the performance. From the experience of some other group, requirements could be exaggerated and thus demands become unreasonable (Chang, personal communication). A creditable AVO can build up trust in actors involved and makes the network of the system go "smoothly".
- Developing **indicators**: indicators are important to evaluate the process and improvement of the program. Kim (2002) suggests developing indicators should take into consideration of the objectives in waste prevention, increased recycling and recovery, and improvement of recycling facilities. At present, indicators for recycling stage are developed, but for waste prevention and improvement of recycling facilities are difficult to set up.

However, current monitoring system is focus on the performance of the recycling treatment. But as mentioned earlier, there are some scrap products back to the use phase again, and in fact the waste reuse contributes more to the environmental effectiveness. It will help to evaluate the environmental performance by monitoring the material flow which is diverted from recycling process. Thus, the author considers it important to build up a **reporting system** that provides data regarding the waste in the secondhand market, and the waste flows abroad. These data, including the amount, the flow, the market value, and so on, can serve for two purposes. First, it helps to evaluate the waste management system. Secondly, it could help in designing effective targets for EPR program. With regard to how the reporting system should be design to meet the objective, it's is beyond the thesis ambition to go into detail of it.

4.4 Financial management

From the experience in the development of recycling programs, financing of the system is of significant importance in the success of the program. A sustainable financial mechanism requires take into consideration of proper **fee rate setting**, and well **management of the fund**. OECD regards economic efficiency as a criteria for comparing different EPR programs; economic efficiency is deeply rely on an efficient management of finance as economic efficiency *"would involve analysis of the costs of implementing the policy and ways to economize on or reduce the capital, labor and administrative costs if need be"* (OECD, 2001).

During the research, the author found out some noteworthy issues regarding the financial management of EPR program:

- Although the data about the total revenue and expenses of RMF is not available, it is known that 40% of the money in the fund is for work related to take-back, recycling, and 60% goes for monitoring and administration costs. It implies the administration cost of EPR program is higher than expenses on the practical work.
- The subsides' granting system has become easier to manage. RMF used to give reward money to consumers, subsidy to the retailers, and also subsidize the transportation for taking-back, and processing of scrap products. Now it only subsidizes the recycling plants. This structural change of financial management should save lots of costs and work in monitoring and administration.
- Also, the RMF's expenses on subsidy have decreased in general. In Table 4-3, comparison of subsidies for taking-back and recycling in 2001 and 2004 shows the total expense on subsidy for main frame drops from 352 TWD to 182 TWD, for monitor is from 383.5 TWD to 215 TWD, for printer keeps the same; only for Notebook rises, from 223 TWD to 303 TWD. This change implies the take-back market has been established; therefore government saves the expenses on subsidies. The take-back system is supported by market mechanism, and government focuses on the subsidizing and monitoring of recycling-stage.

Table 4-3 comparison of subsidy expenses from RMF in 2001 and 2004

	Subsidies for different actors (2001)				Total in 2001	Total in 2004 (to recycling plants)
	customer	retailers	Transport ation	recycling plants		
Main frame	60	100	50	142	352	182
Monitor	70	100	50	163.5	383.5	215
Notebook	50	100	50	84	223	303
Printer	90	no	25	77	192	192

- The recycling fee rate charged from IT products producers is fairly low. As explained in section 3.2, the big difference between production volume and recycling volume leads to surplus in the fund. The inconsistent input (production)

and output (recycled) volume, is suspected that it is result from two characteristics of IT products recycling: long durability of IT products and the secondhand market outside of the legal recycling system.

In an EPR program, it's difficult to adjust the fee rate to a proper level which is expected to stimulate producers' design for environment. Current financial mechanism in EPR program in Taiwan is advance disposal fee system; in Tojo et al (2002), it is considered a challenge for advance disposal fee system for durable products is the management of the fund, including the reasonable size of the fee. But if the question about "how much to charge" is hard to answer, maybe the other way to approach is to ask "how to charge". Different economic instruments to set up financial mechanism in EPR program have been widely discussed and they could bring different outcomes as the design of financial mechanisms will affect behaviors of actors. Other economic alternatives are discussed below.

Visible advance disposal fee

For some EPR program on EEE or cars, visible advance disposal fee system is applied (EEE in Netherlands, Switzerland; cars in Switzerland). The advantage of charging a visible fee is the educational effect, by making consumers aware that specific fee in the price goes to end-of-life management (Kim, 2002). However, in practice none of the advance disposal fees are differentiated within the same types of products; thus consumers cannot tell from the flat fee if certain product is easier to recycle or less environmental harmful (Tojo et al, 2001).

Deposit-refund system

Beverage container is a typical example of a deposit-refund system and this instrument has been proved quite successful in many countries. Advantage of the system is the high collection rate as the economic incentive encourages consumers' taking-bake. Panayotou (1998) regards deposit-refund can be applicable to a wide of products, such as container, packaging, plastic, and hazardous materials, but the author didn't find any program where it is applied on IT products. According to Shaw et al (2003), the refund mechanism can help to solve the illegal dumping as it combine the effects of economic incentive and self-monitoring. However, the author suspected that the potential of deposit-refund system on IT products may be constrained by the long durability of the products.

Last-owner-pays system

It is applied on EEE in Japan and some EEE in Switzerland. Last-owner-pays system can solve the problem about who is responsible for paying recycling fee for orphan, and privately important products, and also it could eliminate extra administration costs (Kim, 2002). However, as last owners have to bear the take-back cost, and recycling cost, such a design can lead to illegal dumping and mixed with mainstream waste (Tojo et al, 2001).

There are advantages and drawbacks for different financial mechanism. The author didn't intend to conclude the best economic instrument out of them. In practice, the

failure and success of an EPR program not only depends on the financial instrument but also depends on characteristics of the products and the surrounding systems.

In conclusion, it's important a financial management be economically efficient. According to Chang, RMF's subsidy is meant to stimulate recyclers reach better performance, especially in some items that have strong potential to achieve higher recyclability by improving recycling technology (Chang in RMF, personal communication). While the take-back and reuse system function on market mechanism, the government can divert the expenses to research and development on recycling technology at recycling stage, and innovation and technology of design for environment at design stage. So instead of expecting the fee rate sends strong signals to producers to initiate some design change, in fact government can lead research and development projects for cleaner production, which could help waste prevention and waste reduction,

4.5 Social acceptability

In the report which Tojo, Lindhqvist, and Davis prepared for OECD, it is stated that awareness and perception of affected actors in society is one factor affecting the results of the EPR program (Tojo et al, 2001). The author considered the awareness and perception of relevant actors could be seen as social acceptability. To examine EPR program in the context of sustainable development, the social impacts from such a program must be taken into consideration. Therefore the author regards social acceptability as a important criteria to evaluate EPR program, and also it is a determinate factors influencing the practice of EPR policy. Social acceptability can be differentiated as acceptability from consumers' side and from producers'.

Consumers' acceptability

Under an EPR program, consumers' acceptability can be seen from two aspects: the acceptability in physical cooperation in recycling work, as well as the acceptability toward green products. In Tojo et al (2001) it is argued that in spite of the growing awareness of environmental and health impacts of waste, consumers do not necessarily change their purchasing behavior. According to theory of reason action, one's behavior is affected by subjective norm and attitude toward behavior, but however under some conditions which can not be controlled by volition, the intended behavior may not be performed. The conditions such as inadequate information, skills, capability, limited time, and opportunities, are external factors that could hinder the happening of behavior. Thus while enhancing environmental awareness to make people perform certain desired behavior (like waste reduction, recycling, green consumption), it's important to make external factors help to reinforce it. The author suggested two approaches to stimulate consumers' behavior.

First approach is to **improve the convenience** for consumers to take back. As mentioned in section 3.4.1, three factors—convenience, financial incentives and information on the recycling scheme—could influence the consumers' willingness to bring back the discarded products. And according to a survey, 55.3 % regarded convenience as main consideration in cooperating IT products recycling (Chang,

2002). As IT products have the characteristics that they are usually heavy and take much space, it could be major concern for consumers to bring back in spite of economic incentive. Among people who have discarded computers, more people chose the take-back service from Local Waste Collection Agency who doesn't grant any reward money to consumers; as for people unwilling to bring back, the lack of information about access and inconvenience are big reasons(Chang, 2002).

Secondly, it's important for government and producers to **provide adequate information** to consumers. Information can not only influence consumers' disposal decision but also their purchasing decision. As government is responsible to provide information regarding the items should be recycled and the take-back access, it should ensure the information can be properly received by public. Information about the products is the information could particularly influence consumers' purchasing choice, thus in this sense, producers have more influence than government. Producers have more potential in providing clear and detailed products information such as the material used, treatment, recyclability, hazardous warning, and impacts on environment and human health.

Producers' acceptability

In Taiwan, EPR program is set up by government who imposes the duty on producers instead of producers' voluntarily initiation. Under such circumstance, producers are likely to be skeptical about such policy as the nature of EPR principle demanding producers to take more responsibility toward their products. Producers could regard it as a command and control policy and merely fulfill the financial responsibility. Nevertheless, producers' acceptability is important as they are in a crucial position to design green products to achieve waste prevention and waste reduction. From the evolution of EPR program, the author considered information provision from the government could help to increase producers' acceptability to policy.

When at the beginning IT products were decreed as recycling items, the policy encountered producers' opposition. It was because producers were not well-informed about the upcoming charge on their products and they had doubts if the fee rate is fair, and how the fund will be managed by the government. Thus government should make producers understand the objective and scope of requirements, and also provide clear information about responsibility allocation, fee rate setting, and financial management. Government should keep communication channel with producers in order to receive the feedback from them. **Transparency** of the decision-making and effective management is important in building credibility of government's policy.

5. Conclusions

IT industry is one of the dominating industries in Taiwan, and the fact that generation of IT waste is growing at a significant pace triggers the author to explore the end-of-life management of IT products. Extended Producer Responsibility has been applied in various products group in many countries as an environmental policy to combat the increasing generation of waste and pollution. EPR is in line with Polluter Pays Principle by imposing responsibility (in most cases, physical and/or financial responsibility)of waste management of the product to producers; what differentiates EPR program as merely waste management is it connects a feedback loop from end-of-life management to the production phase. The thesis aims to investigate the EPR-based recycling scheme of IT products, and thus extracts lessons that could help in designing a sustainable end-of-life management.

The IT products recycling system is examined from economic, physical, and social aspects. What the author identified as important economic issues in EPR program is the cost of end-of-life management and financial mechanism. The RMF's subsidies to recyclers are adjusted on the base of cost of end-of-life management; meanwhile such a cost comprises of costs in take-back, recycling treatment, and final disposal stage. As scrap IT products have fairly good market value due to its containing precious metal, and also economic incentives is provided to encourage the collecting and processing, transaction costs are eased while the material flows among take-back market, recycling processing market, and secondary market. Regarding to how to financially support the recycling scheme, one must look into the financial mechanism of EPR program. The producers in Taiwan are obliged to fulfill the financial responsibility by paying an advance disposal fee to RMF; such a fee rate is set to be able to allow the practice of recycling work to run smoothly.

The physical aspect of the recycling scheme deals with the material flow in the collecting and recycling mechanism. The products in post-consumer stage could be dumped in mainstream wastes or be taken back and processed. Because IT products contain hazardous substances, it is necessary to divert them from direct incineration or land filling to reduce the harmful environmental impacts; EPR program should establish take-back channels, processing and recycling treatment. However, the author identified that some scrape products flow to an invisible market outside of EPR program, where the products are dismantled or repaired, and be used again. Two findings can be concluded. First, the take-back mechanism was build up by government's provision of economic incentive, but now it works on a commercial base. And the current recycling scheme is rather complete to support the EPR program; average recycling rate of IT products is over 70%. Second, secondhand market is not included in EPR program although reuse is considered a more favorable waste management. Existence of a secondhand market is due to the characteristic of scrap IT products possessing high market value, and also, in fact, the fact that physical system can be built on market mechanism relies on such a characteristic to a great extent.

Regarding the social acceptability of EPR program, focus is placed on consumers and producers. Consumers are not required to take bake scrap products by law due to the

limited feasibility of such legislation. Therefore economic instrument were implied to mobilize the public to take bake. There is mandatory financial responsibility for producers and in general producers are able to fulfill the minimum environmental requirements. But as producers are not directly managing the recycling scheme, it's difficult to get a strong feedback from the recycling stage that have an influence on design stage of the products. Two drivers for producers to improve their environmental performance observed during the research are international legislation and top management commitment.

Some crucial factors, which can improve the environmental effectiveness, economic efficiency, social acceptability of the EPR program, are identified during the research.

- Target setting: there is no mandatory target for recyclers on IT products but current target for recycling scheme are set as that the processed amount should be within a certain range in comparison with former year. A reasonable target should bring out the optimal outcome in environmental effectiveness. Thus it is important to set target with a credible calculation methodology.
- Allocation of responsibility: physical responsibility is carried collectively by consumer, collector, local government, and recycler, and the take-back and recycling are supported by market mechanism. Producers' mandatory responsibility only falls in financing. Such design is in line with polluter pays principle, but is very weak in fulfilling design change as EPR program aims for. Decentralizing the current program is worth considering.
- Monitoring: monitoring is an important approach to ensure the responsibility is carried out to a required level. A reliable third-party group as AVO helps to gain trust from recyclers and credibility of the EPR program. Meanwhile it's important to have indicators for auditing and verifying the recycling results; thus government can evaluate the progress and improvement. In addition, a reporting system which provides information concerning the material flow in post-consumer stage, could help to monitor and evaluate the EPR program.
- Financial management: two issues must be stressed to achieve an economically efficient EPR program: efficient management of the fund and reasonable fee rate setting. Under current design, administration costs take a great part of the fund and an invisible advance disposal fee system is implied. Alternative approach should be considered to reach a cost effective financial management.
- Social acceptability: social acceptability can affects the success or failure of EPR program. To enhance consumers' cooperation in take-back, the author suggested two approaches: improve the convenience for take-back, and adequate information provision. Regarding to improve producers' acceptability toward the policy, stakeholder approach is suggested, which can build up producers' trust with information-sharing and communication.

During the research, many interesting issues come out but in order to keep the balance of research, the author didn't go into detail of these issues. Also due to the limitations the author faced, there is room for improvement to provide more in-depth analysis and more practical comments. Following research could be suggested:

- The material flow of scrap IT products could be more thoroughly examined. It's worth looking into the amount of products directly discarded in landfill and incinerated which cause serious environmental damage, as well as the amount being exported that the author concerned they could violate the Basel Convention.
- Investigating how business could confront and benefit from the growing trend of international environmental legislation, such as WEEE, and RoHs Directives in European market.
- Most EPR programs in Europe and in Japan, producers have to contract recyclers individually or collectively. The current design of EPR program in Taiwan is centralized and under control of government; the biggest problem is EPR is unable to become a strong drive for DfE but merely like tax system. The author considers it necessary to conduct more research regarding the potential for PRO-based recycling scheme.

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Abbreviations

AVO: Auditing and Verifying Organization
EEE: Electrical and Electronic Equipment
EPA: Environmental Protection Administration
EPR: Extended Producer Responsibility
DfE: Design for Environment
IT: Information Technology
OECD: Organization for Economic Co-operation and Development
PRO: Private Producer Organization
RMF: Recycling Management Foundation
RoHS: Restriction of Hazardous Substances
SVTC: Silicon Valley Toxics Coalition
TWD: Taiwan New Dollars
WDA: Waste Disposal Act
WEEE: Waste Electrical and Electronic Equipment

Appendix Ⅰ. Ranking of IT Hardware Industries GDP

Table Ⅰ Ranking of IT Hardware Industries GDP (unit: million USD)

Country\Year	1999	2000	2001	2002	'01/'02Growth rate
USA	89,055	85,523	70,995	70,296	-1.0%
CHINA	18,455	25,535	28,174	35,225	25.0%
JAPAN	48,279	52,153	39,204	31,488	-19.7%
TAIWAN	21,023	23,018	20,124	17,348	-13.8%
SINGAPORE	16,765	16,395	13,898	14,414	3.7%
UK	13,710	12,121	12,045	12,316	2.2%
SOUTH KOREA	7,427	11,856	9,837	12,180	23.8%
GERMANY	7,512	8,815	8,149	8,270	1.5%
MEXICO	7,500	9,400	8,211	8,246	0.4%
MALAYSIA	6,105	7,395	6,619	6,856	3.6%
IRLAND	6,757	6,470	6,654	6,777	1.8%
FRANCE	5,763	5,618	5,624	5,733	1.9%

Note: data based on sectors of computer and peripherals

source: ITRI (2004)

Appendix Ⅱ. Annual Fee Rate Charged from Producers for IT equipments

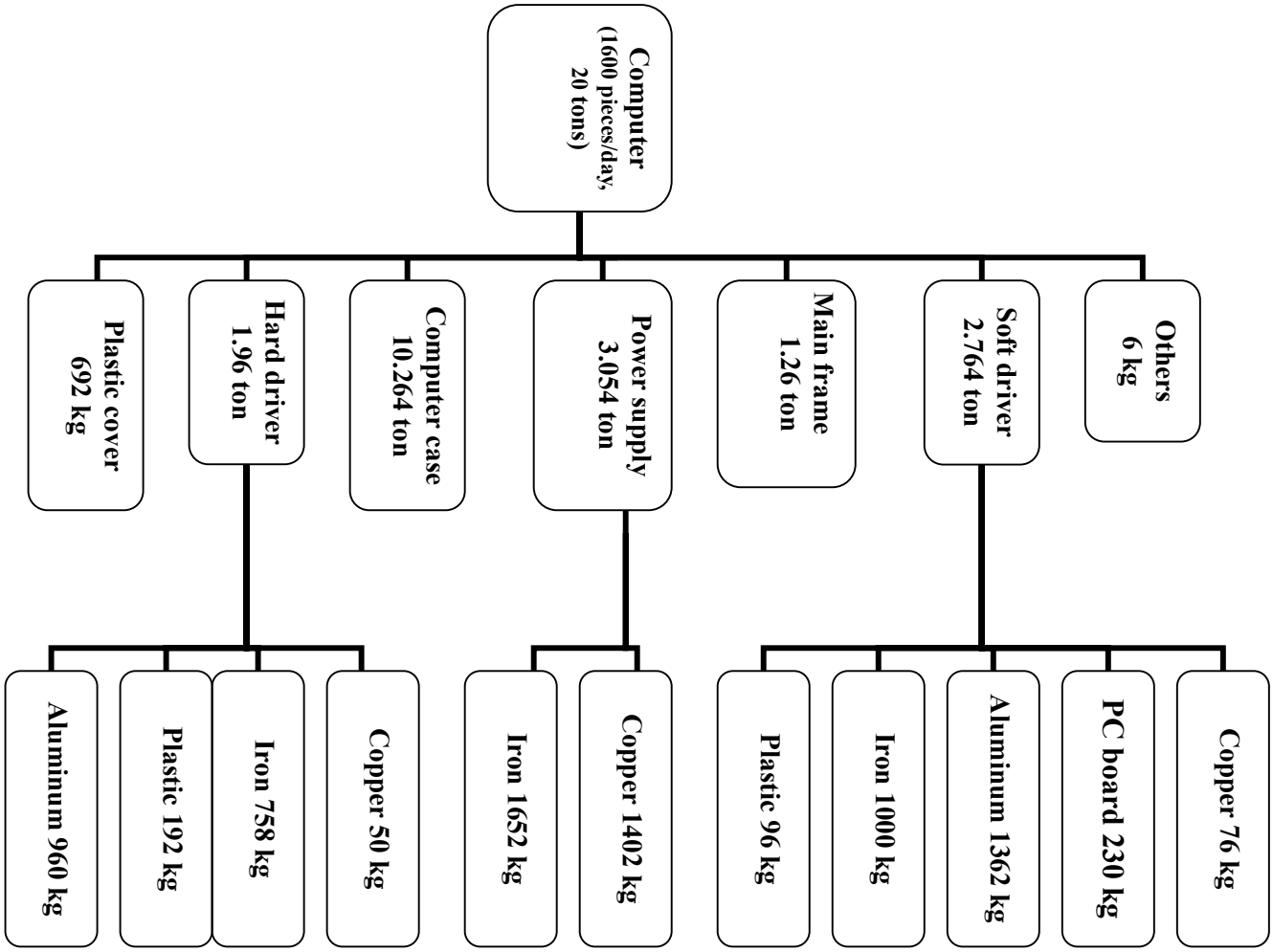
Table Ⅱ Recycling Fee Rate for IT products 1998-2004 (unit: TWD)

		1998.06-1999.06	1999.07-2000.12	2001	2002-2003.02	2003.03-2003.12	2004
Notebook		200	112*	52	52	39	39
Main frame		75	67.5	40.5	40.5	49.2	49.2
Disk driver		75	67.5	40.5	40.5	49.2	49.2
Power supply		12.5	11	6.5	6.5	8.2	8.2
Computer case		12.5	11	6.5	6.5	8.2	8.2
Monitor		125	147	102	147	127	127
Printer	**Inkjet**			84	58	81	81
	Laser			142	98	137	137
	Matrix			156	108	151	151

Source: RMF (2004d)

*Fee Rate for Notebook was adjusted to 90 TWD in 2000 November and Decembe

Appendix Ⅲ. Substances extracted from the recycling of computer



Source: Wu (2003)

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