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## **A Comparative Study of E-waste Recycling Systems in Japan, South Korea and Taiwan from the EPR Perspective: Implications for Developing Countries**

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A plant dismantling discarded home appliances in Japan.  
Photo by Sung-Woo Chung in 2002.



The number of discarded TVs received by recycling plant was counted by third party inspectors. The paints indicate these TVs were counted.  
Photo by Michikazu Kojima in 2005, in Taiwan.

## 6.1 Introduction

Since the Extended Producer Responsibility (EPR) entered the spotlight as a potential policy alternative for waste management around 2000, legislation on e-waste management has been promoted at an international level. The EU's Waste Electrical and Electronic Equipment (WEEE) Directive, which incorporated EPR as a basic principle, was announced in 2003. EU member states are accordingly required to ensure their own domestic regulations are compatible with it. Following the lead of California, the United States is also beginning to implement programs under its e-waste management policy.

Similar policy tendencies can be found in Asian countries. The countries leading the change—Japan, South Korea and Taiwan—have been tackling e-waste management since around 2000. Moreover, in recent years several developing Asian countries including China and Thailand have been readying themselves for implementing new regulations on e-waste management. However, it is hard to deny that these countries are being strong-armed to keep up with the policy implementation, as exemplified by the WEEE Directive, of the developed countries and may have failed to properly examine their own domestic situations. This failure could lead to problems in attaining policy objectives in the future. The present research topic emerged from the question, “What can be learned from the experiences of the forerunning Asian countries?”

In this context, this study aims to present practical policy implications to the developing countries willing to introduce new regulations or revise existing regulations for more effective e-waste management. For this purpose, e-waste recycling systems in Japan, South Korea and Taiwan are compared and analyzed mainly from the EPR perspective. These three countries have been selected for the following reasons: Firstly, they have implemented e-waste management regulations in the past five to 10 years and have undergone a process of trial and error to construct effective management of e-waste. Furthermore, because the policy development and legislative backgrounds of three countries vary, this comparative study can be considered to cover almost all types of e-waste management systems found in Asian countries.

Data and information about respective e-waste management situations were collected through personal interviews with high-ranking government officials responsible for e-waste management policy, as well as leading experts and senior managers within the e-waste recycling industry. Before we turn to general descriptions of e-waste management in the three countries, it is worth taking a brief look at the e-waste management situations in developing Asian countries for a comprehensive understanding of the underlying implications of this study.

## 6.2 E-waste Management Situations in Developing Asian Countries<sup>1</sup>

As a general proposition, it is reasonably uncertain if regulations adopted by developed countries will bring about similar outcomes in developing countries. This can be understood intuitively considering the different legislative backgrounds of different countries and is also applicable to e-waste management. If so, what are the characteristic common features of the current situations regarding e-waste management within the developing Asian countries? The first consideration is the low cost of labor. This is one of the substantial reasons why e-waste

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<sup>1</sup> Kojima et al. (2007) was referenced for a great deal of this chapter.

is continuously exported to developing countries by developed countries pursuing low treatment costs. Secondly, because the diffusion rate of home appliances is comparatively low, demand for secondhand goods is fairly high. Lastly, commercial recycling companies play a more significant role in e-waste recycling than in the developed countries. However, in regards to e-waste treatment, environmental impacts caused by improper practices are questionable.

Among Asian developing countries, China and Thailand are ready to implement new regulations that include EPR perspectives<sup>2</sup>. In respective drafts of these two countries' e-waste management policies, two common characteristic aspects are confirmed. One is that economic responsibility<sup>3</sup> for e-waste management is imposed on manufacturers, reflecting the principle that manufacturers should pay for the costs of recycling e-waste. However, physical responsibility<sup>4</sup> for e-waste recycling is not clearly stipulated in either draft. The other is that manufacturers pay third-parties to undertake the e-waste recycling. Monetary compensation is expected to function as an incentive for commercial recycling companies to carry out e-waste recycling.

However, at the same time these features potentially have negative influence on e-waste management. If the compensation (subsidy) for e-waste recycling is set lower than the actual cost of recycling, it is likely that it will not function as an economic incentive for commercially recycling companies. Raising the compensation above the actual recycling cost creates a huge financial burden for manufacturers. Furthermore, huge monitoring costs burdened by government are additionally required to ensure proper treatment practices. In addition, under the situation described above, if the physical responsibility does come to be imposed on manufacturers as a means for reducing improper treatment, they will be forced to compete with commercial recycling companies over the collection of e-waste. If manufacturers are legally required to collect e-waste beyond what is economically viable, they may have to purchase electronic wastage from consumers or secondhand markets as valuables. Conclusively, this becomes a distinct factor limiting the expansion of the range of the manufacturers' (economic and physical) responsibility for securing proper e-waste handling.

A full consideration of the e-waste management situation in the Asian developed countries would fortify the importance of making a discussion of policy implications possible. From the next chapter, a general description of the e-waste management system in the three developed countries will be presented before comparative analysis is carried out to clarify the policy implications for the developing countries.

## **6.3 General Description of E-waste Management Systems in Japan, South Korea and Taiwan**

### **6.3.1 E-waste Recycling in Japan**

#### *(1) Background to the legislation*

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<sup>2</sup> At present (Nov. 2007) draft regulations are under discussion in the two countries.

<sup>3</sup> Economic responsibility refers to the concept of the manufacturer ("producer" in original context) covering all of part of the costs of collection, recycling or final disposal of goods producer manufactures (Lindhqvist 2000).

<sup>4</sup> Physical responsibility is used to characterize a system in which the manufacturer ("producer" in original context) is involved in the physical management of the products and/or their effects (Lindhqvist 2000).

Japan deals with e-waste in two ways. One is the Law for the Promotion of Effective Utilization of Resources (LPUR), which focuses on enhancing measures for recycling goods and reducing waste generation. The other is the Law for the Recycling of Specified Kinds of Home Appliances (LRHA), which imposes certain responsibilities related to the recycling of used home appliances on manufacturers and consumers. LPUR covers personal computers and small-sized secondary batteries designated as recyclable products, while LRHA deals with four classes of items: television sets, refrigerators, washing machines and air conditioners. The common background to the enactment of both laws in Japan was an increasing scarcity of waste disposal sites and increased costs for waste disposal. The significant difference between LPUR and LRHA is that the former encourages manufacturers' voluntary efforts while the latter imposes compulsory obligations on manufacturers.

Municipalities have been demanding that used home appliances should be designated as troublesome wastes by the Ministry of Welfare (MOW) since around the 1970s (AEHA, 1998). Treatment at municipal facilities necessitated semi-skilled workers, which lead to an increase in treatment costs. To reduce these labor costs, municipalities began to resort to landfill sites as an alternative. However, this action only caused the landfill situation to worsen.

## *(2) Structure of collection and cost allocation*

### *Used computers*

Recycling of used computers does not fall under the LRHA and is therefore not regulated as a compulsory legal requirement under that law. However, since April 2001, computers discarded by businesses must be collected and recycled pursuant to the LPUR.

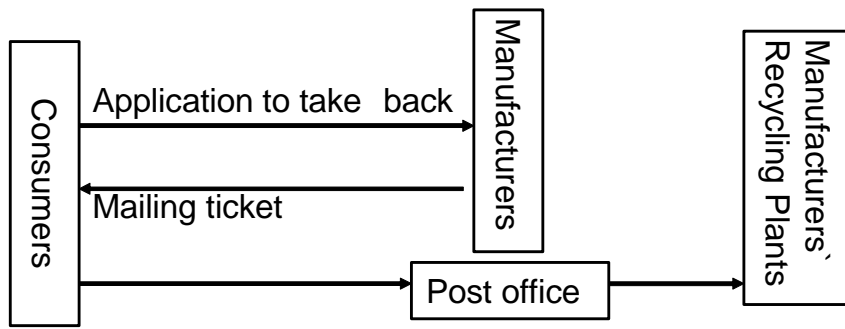
Regarding household used computers, manufacturers have been voluntarily taking part in collection and recycling since October 2003. The allocation of costs of these activities depends on the time of purchase. For used computers purchased after October 2003 consumers need not pay an extra recycling cost (visible fee) because the cost is already included in the purchase price (internalization). For computers purchased before October 2003, consumers must pay for the recycling cost upon disposal, just as for used home appliances (Figure 1). Consumers can dispose of computers either via the manufacturer or a post office. From the efficient utilization of resources, the following recycling rates<sup>5</sup> per item are recommended: 50% for desktop computers, 20% for notebook computers, 55% for CRT monitors and 55% for liquid crystal displays.

Moreover, LPUR, unlike LRHA, does not stipulate any compulsory responsibility for retailers, who are regarded as one of the main actors in used computer recycling under LRHA. This difference is a reflection of the difference in purchasing patterns between computers and home appliances. Firstly, consumers generally take newly purchased computers home themselves so it is quite rare for retailers to deliver computers to the purchasers' home. Secondly, there is time latency between purchasing a new computer and disposing of the old one due to the need of data migration and other factors. It is considered that even though certain type of physical responsibility is imposed on manufacturers, namely the obligation to accept old computers from consumers, consumers are not likely to present their used computers at the time of purchasing a new one.

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<sup>5</sup> Recycling rate of used computers = (recycled amounts as parts or recyclable resources)/(total recycled amounts)×100.

**Fig. 1** General Flow of Used Computers from Households in Japan



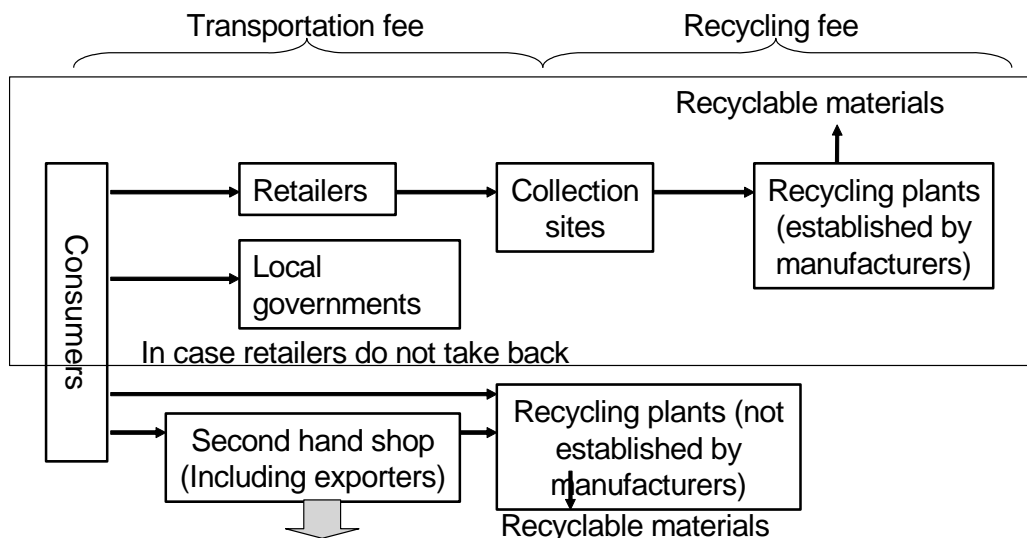
Take back or bring by consumers themselves  
(purchased before October 2003, with recycling fee)

Source: Compiled by the authors by reference to the PC3R Promotion Center Web site ([http://www.pc3r.jp/home/recycle\\_flow.html](http://www.pc3r.jp/home/recycle_flow.html)).

*Used home appliances*

LRHA adopts the principle of EPR, which extends the manufacturers’ responsibility from the production stage to the whole life cycle of the product, including the post-use and disposal stages. Specifically, LRHA clarifies the “take-back” and “take-in” flow of used home appliances originating from consumers and the responsibilities of the respective actors within that flow. Flows of used home appliances and the roles of associated actors under the LRHA are shown below (Figure 2).

**Fig. 2** Flow of Used Home Appliances and the Role of Associated Actors under Japan’s LRHA



Used products? Recyclable materials?  
Used products? Recyclable materials?

Source: Compiled by the authors.

When discarding used home appliances, consumers are responsible for the cost of transportation as well as e-waste recycling. Recycling fees range from 2,400 yen (washing machines) to 4,600 yen (refrigerators). Transportation costs are paid separately to retailers who convey the used home appliances to the collection sites,<sup>6</sup> which are designated by the manufacturers. Upon the request of consumers, retailers are obliged to take back used home appliances. Retailers then must transport the used home appliances from the consumer to the collection site.

Manufacturers are required to either establish their own recycling facilities or commission commercial recycling companies to fulfill their recycling obligations. They are additionally required to achieve compulsory recycling rates to ensure effective utilization of resources. These rates are: 55% for television sets, 50% for refrigerators and washing machines and 60% for air conditioners.

Regarding the role of municipal authorities in collection, they are no longer obliged by the LRHA to collect used home appliances. However, they still collect and treat used home appliances in their area of jurisdiction, which includes appliances that have been illegally dumped. In this case, municipalities, like retailers, do receive fees for transportation and recycling from consumers and deliver the used home appliances to designated collection sites.

From the above, it is evident that LRHA provides a legal framework for assigning responsibilities to manufacturers, retailers and consumers, with manufacturers having the responsibility of physically collecting and recycling used home appliances disposed of by consumers. However, the LRHA regulates only a part of the total process, indicated by the box shown in Figure 2. The processes described outside the box are not managed under the current law. At present, the latter part constitutes a “hidden flow,” the actual conditions of which require urgent clarification from the perspective of material control.

### (3) *Treatment and policy challenges*

As mentioned in 6.3.1.2, under the LRHA manufacturers are required to construct a recycling infrastructure for used home appliances. However, the specific method of doing so is not regulated. How then did the manufacturers address the new situation created by the legislation? Their responses can be broadly divided into two types: Group A and Group B.<sup>7</sup> It has been pointed out that the reason Japan came to have two types of recycling infrastructure is because of the promotion of competition between manufacturers and the need to avoid violating antitrust legislation. Additionally, Group A and Group B had dissimilar viewpoints on how to reduce general costs including collection and recycling of used home appliances (Hada 2003).

Specifically, Group A and Group B each provide 190 national collection sites. Group A attempted to keep recycling costs down through maximum utilization of existing waste management companies, which can be classed into three main types: industrial waste treatment companies, existing local scrappers and companies belonging to a *marisoru* network.<sup>8</sup> Facilities of existing recyclers are usually used as collection sites. Because Group A fulfills its legal obligations by contracting with 32 existing recycling plants, a flexible response to fluctuations

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<sup>6</sup> In many cases, transport company offices or existing disposal company yards are used.

<sup>7</sup> In case of manufacturers and importers not joining in Group A or Group B, they commission their legal obligation to the Association for Electric Home Appliance (AEHA).

<sup>8</sup> A *marisoru* network is a national organization of industrial waste treatment companies.

in volume is possible, which is important when collection of used home appliances fall short of expectations.

In contrast, Group B built 16 recycling plants and attempted to reduce total costs by adopting efficient logistics systems. Although the initial investments were burdensome, Group B is able to make adjustments to match operating conditions at recycling plants. Unlike Group A, Group B generally uses transport company warehouses as collection sites.

Because Group A and Group B's collection sites are managed separately, retailers may not choose their nearest collection site if costs are lower elsewhere. This creates a heavy financial burden on retailers as in reality they may not ask the consumers to pay transportation costs. Competition between retailers over sales of new products forces them to lower prices as much as possible, which may preclude the costs of transportation to collection sites.

A five-year post-implementation review of LRHA is currently underway, with several policy challenges presented. Related to the broader issue of hidden flow, illegal dumping and the export of e-waste under the pretext of it being secondhand goods are the main points at question. A joint working group of the Ministry of Environment (MOE) and the Ministry of Economy, Trade and Industry (METI) organized under the Waste and Recycling Subcommittee is currently reviewing matters that require comprehensive measures. The issues being discussed are: strengthening the measures for illegal dumping, promoting Design for Environment (DfE), driving 3R (Reduce, Reuse, Recycle) activities, setting the proper recycling fee and recycling rates, covering more items, cutting down the costs for collection in isolated island communities, raising consumer awareness and the approach taken with commercial recycling companies.

### **6.3.2 E-waste recycling in South Korea**

#### *(1) Producer deposit-refund system (1992 to 2002)*

##### *Background to the legislation*

Recycling management in South Korea began with the enactment of the Law for Promotion of Resources Saving and Reutilization (LRSR) in 1992. To address the rapid increase of waste for which there was insufficient landfill available, the act aimed to conserve resources and preserve the environment by promoting recycling. However, another significant driving force was the desire to counteract the presumed effects of a new system that was at that time about to be introduced that was to provide local authorities with greater autonomy. The proposed implementation of such a system gave rise to concerns that environmental damage caused by municipal development policies would expand across the nation, that the central government's coordinating role in waste management would diminish and that interregional disputes over waste disposal would intensify. An expansion and improvement of waste disposal facilities carried out to mitigate discord among localities brought about substantial increases in the waste management budget (Rhee and Jeong 2003). Because LRSR was regulated comprehensively, e-waste was managed as one category containing four items out of seven categories with 18 items (including packaging and products) under the Producer Deposit-Refund (PDR) system. Television sets and washing machines were included in 1992, followed by air conditioners in 1993 and refrigerators in 1997.

### *Structure of collection and cost allocation*

The PDR system depends upon three main actors: the Ministry of Environment (MOE), the Korea Recycling Corporation (KORECO) and the manufacturers. For each product item, the MOE requires manufacturers to pay advance deposits to cover recycling costs. These deposits are calculated from the number of products shipped during the previous year. KORECO manages the administration regarding recycling accomplishment and unreturned deposits. Deposits are returned to the extent that e-waste is properly collected and recycled. The defining characteristic of the PDR system is that it emphasizes the manufacturers' economic responsibility for promoting e-waste recycling, institutionalizing it in the form of deposits. The deposit rate rose from 30 won/kg in 1992 to 38 won/kg in 1996 for more recycling by manufacturers.

### *Treatment and policy challenges*

Manufacturers' reactions to the PDR system is divided chronologically into two periods: before and after 1996, the year in which the deposit rate was increased. In the first period (1992 to 1996), manufacturers contracted out their e-waste recycling to commercial recycling companies to secure the return of their deposits. In the latter period (1997 to 2002), manufacturers chose to construct several recycling plants on a regional basis for e-waste recycling.

Total deposits and refund rates are shown in Table 1. The increase in deposits since 1997 was caused by the addition of refrigerators and the increase of deposit rate in the previous year. Free take-back by Samsung started in 1995 and the build-up of recycling plants including that of Asan<sup>9</sup> both had an effect on the steady rise of the refund rate. However, from the policy perspective, a refund rate less than 10% is considered to be quite a low level of accomplishment.

**Table 1** Changes in Deposits and Refund Rates under the PDR System

	1993	1994	1995	1996	1997	1998	1999
Deposits (million won)	3,491	5,015	4,977	6,356	14,476	14,097	8,356
Refund rate (%)	0.03	0.6	3.04	5.56	8.3	7.3	8.7

Source: Environment White Paper (1993–2000).

Note: 100 won = 10.01 yen = 0.10 U.S. dollars (May 13, 2008).

There are two main policy challenges understood to exist within the PDR system. The first is the lack of economic incentives for manufacturers. The deposit rate is far lower than the actual costs of recycling. As such, it made more economic sense for manufacturers to pay the deposit rather than to recycle e-waste. The actual cost was 169.1 and 160.1 won/kg for television sets and refrigerators, respectively, which is approximately more than four times higher than the deposit rate (KORECO 1990). The second point relates to the improper recycling of e-waste via the municipality route. There was a strong possibility that e-waste discharged to the municipalities would be improperly treated, thus causing environment impacts

<sup>9</sup> Three main manufacturers (Samsung, Hyundai, Daewoo) agreed to build recycling plants on a regional basis to cover the whole country. Due to different understandings of e-waste recycling, construction of e-waste recycling plants was carried out separately under the PDR system.



(Kim 1998). When consumers discharge the e-waste to the municipality route under the PDR system, they commonly pay a certain fee (3,000 to 10,000 won) according to the type of item.

## *(2) Producer recycling system (2003 to present)*

### *Background to the legislation*

Since joining of the OECD in 1996, South Korea's environmental policy has been directly affected by the direction of policy in Western countries. In the field of recycling, the publication of the *OECD Government Manual* for the implementation of EPR in 2001 was essential for the development of South Korea's environmental policy. In January 2003, the Producer Recycling (PR) system, which emphasizes the role of manufacturers in e-waste recycling as a substantial one, was launched under an amendment to the recycling act. In addition to the four established items, computers (2003), audio equipment and mobile phones (2005) and OA equipment (printers/copy machines/faxes) (2006) were included, making the total 10 items by 2006.

### *Structure of collection and cost allocation*

The PR system was instituted for the purpose of extending the formerly limited responsibility of manufacturers and even suggesting specifically how to induce manufacturers to participate more directly in e-waste recycling.

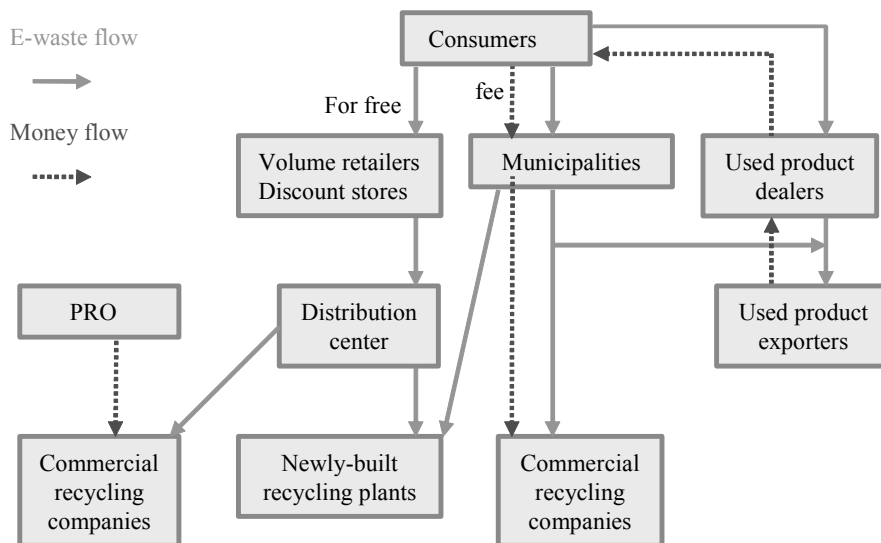
The PR system works in the following way: Firstly, while considering the recent recycling performances and recycling quantities undergone by manufacturers, the MOE annually announces the item-specific (i.e., refrigerators, washing machines, etc) rates. Thus, in the case where a new appliance is purchased, manufacturers are obliged to collect the used home appliance per consumer's request. Each item has a certain recycling target within the range of 55 to 70% based on weight. Each manufacturer can fulfill their legal obligation in one of three ways. One way is to construct their own recycling plant and do their own recycling. Another is to outsource the job to commercial recycling companies. The third is to join the Producer Responsibility Organization (PRO), pay the required fees, and have them do the recycling. Manufacturers can choose whichever option suits them best. Both individual responsibility<sup>10</sup> and collective responsibility<sup>11</sup> are possible under the PR system. In the event that the manufacturers do not fulfill the mandatory recycling rates, they are obliged to pay a fee, the amount of which is inversely proportional to mandatory recycling rates. Furthermore, they must take on an additional financial burden by paying a recycling charge. The Korea Environment and Resource Corporation (ENVICO) is responsible for the overall duties associated with the running system, such as keeping records on product shipments for each manufacturer, investigating the state of recycling performance and levying a recycling charge.

Regarding the actual responsibilities and roles of consumers and municipalities, no significant change is seen from those under the PDR system. It is still highly probable that consumers will discharge e-waste to commercial recycling companies or exporters on the basis of economic sense in accordance with the economic aspects of e-waste.

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<sup>10</sup> A manufacturer ("producer" in original context) takes individual responsibility if he takes responsibility for the end-of-life management of his own product (Tojo 2004).

<sup>11</sup> Manufacturers ("producer" in original context) take collective responsibility if those in the same product group jointly fulfill their responsibilities for the end-of-life management of their products regardless of the brand (Tojo 2004).

**Fig. 3** General E-waste Flows in South Korea

Source: Compiled by the authors

### *Treatment and policy challenges*

The PR system was launched in 2003, but a two-year pilot program which laid the foundations for the PR system was carried out prior to that, following a voluntary agreement entered into in June 2000 by three major manufacturers (Samsung, LG and Daewoo) and MOE. During this period, manufacturers were required to construct nationwide recycling infrastructure rather than depositing.

In reality, the actual recycling was carried out by the Association of Electronics Environment (AEE) by proxy. Specifically, with a few years' gap between each, the manufacturers constructed three recycling plants, starting with Samsung's Asan Recycling Plants (1988) and followed by LG's Chilseo Recycling Plants (2001) and finally the Metropolitan Recycling Plants (2003), by which they successfully increased their recycling capacity. These plants constructed by the manufacturers mainly recycle refrigerators and washing machines.

The commercial recycling companies that contract with AEE are paid by volume recycled. In 2006 there were 28 such companies (six for television sets and monitors, 10 for computers, seven for CRTs and five for mobile phones).

However, only about 40% (98 out of 232) of the municipalities actively cooperate with manufacturers. Cooperation between manufacturers and municipalities does not occur smoothly due to the poor financial situation of the municipalities. Instead, recycling costs are imposed on manufacturers and municipalities are required to pay the costs of transportation to the manufacturers' recycling facilities.

When high quality used home appliances are discharged to the second hand market, they are usually traded at positive rates. It is generally understood that considerable amounts of used home appliances are reacquired via this route. The collection and recycling process under the PR system are summarized as follows.

Irrespective of a sharp increase in collection by manufacturers, several policy challenges can be pointed out. Firstly, regarding the management of hazardous wastes, manufacturers are

required to collect CFCs, but environment-friendly treatment after collection is not mandated. At present, the Asan recycling plant is the only one that destroys CFCs contained in refrigerator insulation. Most CFCs collected are reused without their harmful characteristics being nullified. Secondly, the PR system primarily focuses on increasing the amount of recycling and guaranteeing proper treatment, rather than on promoting Design for Environment (DfE). In the manufacturer-built plants, fulfilling of mandatory recycling targets takes a higher priority than DfE. Know-how obtained in the recycling process is hard to incorporate in new product design if it is not economically profitable. Finally, from the perspective of e-waste flow control, it is worth paying attention to the export of e-waste. E-waste including mobile phones and CRTs is reported to be actively exported to East Asian countries. According to the Korea Custom and Trade Institute (KCTI), 305,460 television sets, 184,906 monitors, and 951,077 CRTs were exported in 2005 alone. The absence of a monitoring system to secure that these items are properly treated or not in the importing countries is an urgent problem.

### 6.3.3 E-waste Recycling in Taiwan

#### (1) *Background to the legislation*

In Taiwan, mixed metal scrappers, known as *fei-wuchin*, have traditionally treated e-waste. However, their methods of extracting metals, such as burning nonmetal parts or refining metal with chemicals, had high environmental impacts, including air pollution caused by burning in fields, polluting water and soil with heavy metals and illegal dumping of unwanted parts (EPA 1985). As a countermeasure, the Environment Protection Administration (EPA) in 1984 organized mixed metal scrappers together in two districts in an attempt to effectively monitor their recycling practices. This measure, however, only to be unsuccessful. In 1986, polluted water containing heavy metals that had originated in the monitored districts ended up in neighboring sea areas, affecting nearby oyster farms.

In this context, the EPA sought to reduce environmental pollution by introducing a government-led recycling scheme. In 1998, for the purposes of reducing waste, promoting resource collection and ensuring efficient use of resources, the Recycling Fund Management Committee (RFMC) system was introduced. Similar to that of South Korea, it was comprehensively regulated to include 10 categories, including home appliances and IT equipment, which contain eight and 11 items, respectively.

#### (2) *Structure of collection and cost allocation*

Taiwan introduced the RFMC system in 1998 to promote recycling of “(1) difficult-to-process products, (2) hazardous materials, and (3) valuable items for recovery and reuse.” The RFMC was established as a bureau of the EPA (Nihon Keizai Chosa Kyogikai 2000).

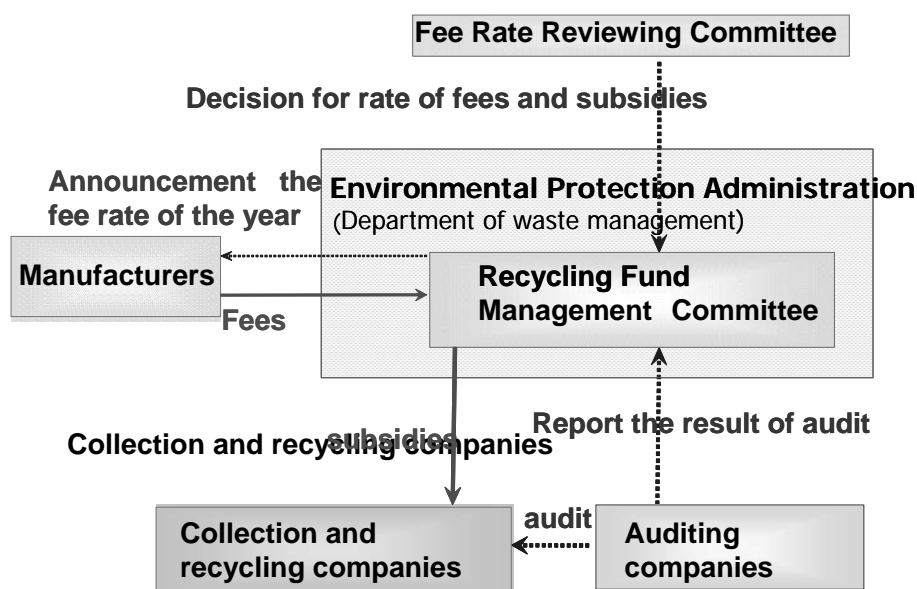
Under the RFMC system, manufacturers (including importers) pay fees for the collection and recycling of e-waste. The amount of sales of the previous year is multiplied by collection and recycling cost per item to arrive at the total fee manufacturers are required to pay. Collection and recycling costs are determined by the Fee Rate Reviewing Committee (FRRC), which is composed of representatives of government, academia, consumer groups, manufacturers and other sectors. The fees are revised on an annual basis in consideration of the funds

required for recycling (collection costs and costs of recycling at recycling plants), current prices for recyclable materials and other factors.

The fund is used as a source of revenue for subsidies paid by the RFMC to organizations participating in the collection and recycling of e-waste. However, only entities which are monitored by public auditing institutes are able to claim a return for collection and recycling. Recyclers who do not participate in the scheme are not penalized (Figure 4) but are rather not able to claim subsidies.

In other words, under the RFMC system, only manufacturers bear economic responsibility for e-waste recycling. This responsibility comes only in the form of the fees paid to the RFMC, and not for the collecting or recycling of e-waste. Meanwhile, through the incentive of subsidies, consumers, retailers, collection firms and commercial recycling companies performing the actual tasks of collecting and recycling are inclined to operate within the RFMC system.

**Fig. 4** Flow of Funds and Subsidies in Taiwan

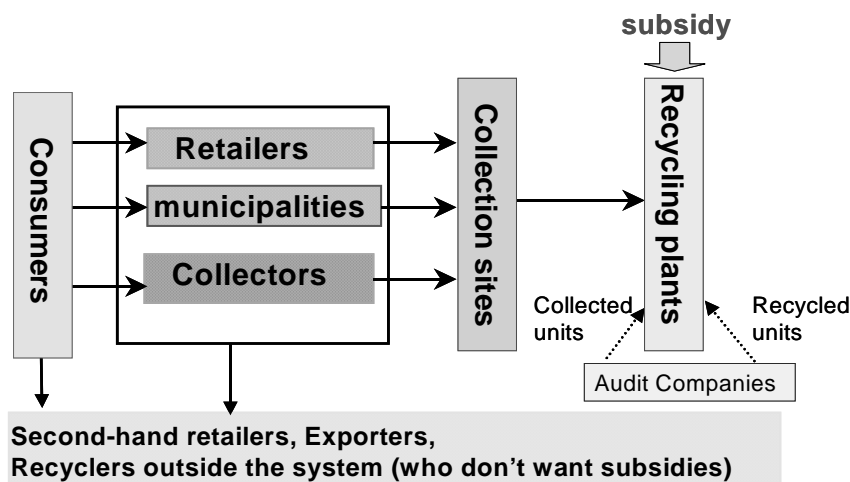


Source: Compiled by the authors.

Taiwan’s e-waste recycling scheme can be summarized as having three main features. First, the RFMC system emphasizes the economic responsibility of manufacturers. The second feature is the economic incentive (subsidies) used to induce commercial recycling companies to participate in the scheme. The third is that the proper treatment of e-waste is thoroughly guaranteed, which creates a huge monitoring cost.

*(3) Treatment and policy challenges*

Under the RFMC system, four types of used home appliances (television sets, refrigerators, washing machines and air conditioners) and used personal computers have been selected respectively as one category in the system (Chang and Shaw 2000).

**Fig. 5** General Flow of E-waste under the RFMC System in Taiwan

Source: Compiled by the authors.

E-waste flow in Taiwan is shown in Figure 5. Recycling plants buy e-waste from collection sites<sup>12</sup> and recycle them to obtain subsidies from the RFMC. At the recycling plants, the number of units to be processed is checked prior to acceptance. Again after recycling, subsidies are paid by the RFMC when the unit counts are confirmed to be in agreement.

Collection firms obtain revenue (sales and subsidies) by selling e-waste, which is generally collected from various routes such as retailers, local governments and collectors. Consumers can freely choose their preferred route for disposal of e-waste.

Regardless of the environmental burdens from the processing and recycling processes that are acknowledged to be a problem, one reason manufacturers are thought not to be assigned responsibility during collection and recycling stages is that the home appliance manufacturing sector in Taiwan is made up of numerous small and medium-sized manufacturers. There are no leading companies, thus, no single manufacturer is able to act as a driving force. However, since the system is set up such that the recyclers actually carrying out the processing and recycling are not compelled to perform all recycling within the RFMC scheme, but are free to choose whether or not to participate, it must be said that this system is inadequate as a system for managing improper processing and encouraging proper processing methods throughout the country (Murakami 2005).

Around 2007, nine recycling plants (eight companies) were recycling e-waste inside the RFMC system. Two of them (one company) were jointly built with investment from relatively major companies, and the rest are the existing recyclers and recyclers organized by retailers. These recyclers purchase used home appliances from 116 collection firms at a national level. In the case of IT equipment, 17 recyclers collect from 118 collection firms. Out of those 17, 12 collect home appliances as well as IT equipment. In the case of used home appliances, it seems that an agreement was made among recycling plants to avoid over-concentration.

<sup>12</sup> Unlike in Japan, the collection sites are managed by the specific collection firms rather than the manufacturers. Manufacturers are not required to organize collection sites in Taiwan.

**Table 2** Number of Recycling Plants and Collection Firms for Used Home Appliances and IT Equipment

		2005	2006	2007
Used home appliances	Collection firms	N/A	87	116
	Recycling plants	7	9	14
IT equipment	Collection firms	N/A	89	118
	Recycling plants	N/A	11	17

Source: EPA Web site

There are currently two challenges for policymakers. The first is that the economic incentive for recyclers to join the RFMC system is insufficient. Because the decision of whether or not to join the system can be made entirely at the discretion of the commercial recycling companies, such decisions are typically based only on economic concerns. This has resulted in a considerable number of the commercial recycling companies not joining the RFMC system, which is problematic as there is no monitoring of recycling undertaken outside of the RFMC system despite the fact that the RFMC system targeted the promotion of the proper treatment. The second is that the RFMC has only a weak influence on DfE. Under the current system, manufacturers are fulfilling their responsibilities by offering a recycling fund configured by Taiwan EPA. Fluctuations in the fees do not provide sufficient incentives for manufacturers to actively take part in DfE activities (Murakami-Suzuki 2007).

#### 6.4. Comparison and Analysis

We have confirmed the e-waste situation in developing countries and provided a general overview of the e-waste management systems in Japan, South Korea and Taiwan. In this section, we ask three significant questions regarding e-waste management. By answering these questions we will attempt to ascertain the policy implications for developing countries.

##### 6.4.1 Why Did the Three Countries Initiate E-waste Recycling?

This question is directed at discovering how specific background conditions influenced the enactment of the legislations managing e-waste in the three countries. We will attempt to identify the respective characteristics of the regulations that relate to the different backgrounds and priorities of each country.

In Japan, computers are managed under the LPUR because of their rapid turnover, which makes them worth recycling for the effective use of resources (Murakami 2005). Even though recycling rates per item and manufacturers' responsibilities for collection and recycling are stipulated in this law, a good deal of weight is given to the voluntary efforts of the manufacturers. Meanwhile, used home appliances had been regarded as troublesome for municipalities to recycling, due to technical difficulties and high recycling costs. Under the LRHA, the burden on municipalities to recycle e-waste was sharply reduced. In addition, the main reason for adopting the system of payment on disposal is considered to be the concern regarding additional fees for recycling adding to the cost of home appliances (Yoshida 2005). Instead, the physical responsibility for used home appliances came to be imposed on manufacturers. For the useful utilization of resources, recycling rates per item are stipulated at from 50 to 60% based on weight. Furthermore, to prevent illegal dumping during transportation, a manifest

system was introduced. Through the Internet<sup>13</sup>, consumers can check whether their used home appliances are actually transferred to the manufacturers' recycling facilities. Used computers and used home appliances came to be managed by separate regulations due to the different conditions previously existing and features of the pattern of purchase, as described in 6.3.1.1.

In South Korea, unlike Japan, there was not such a large distinction of e-waste as being troublesome because it was usually treated by the commercial recycling companies through contracts with municipalities. This difference accounts for significant contrasts between the Japanese and South Korean systems. Accordingly, municipalities are still collecting e-waste under the current South Korean legislation. As mentioned earlier, the implementation of local autonomy was one of the substantial reasons for enacting the URSR in 1992. Because the LRSR was designed to expansively cope with the waste problem that was expected to be an effect of the local autonomy system, it was stipulated to include comprehensive items. E-waste, along with packaging waste, was positioned as one of the recyclable resources. Where a consumer deposit-refund system is usually adopted to oblige consumers to make the deposit, South Korea accepted a producer deposit-refund system to impose the collection and recycling responsibility on manufacturers. Mainly due to the fact that the deposit is far lower than landfill and incineration costs, as well as the actual costs of recycling, the PDR system had a limited effect on increasing the amount of material recycled.

The details of the present PR system are strongly shaped by South Korea's understanding of EPR and the experiences under its PDR system. As a result, the PR system gave priority to manufacturer's physical responsibility rather than economic responsibility. Recently, stipulations on mandatory recycling targets (mandatory recycling rates since 2005) have been in-stated. EPR in South Korea is made concrete in the form of obligations on manufacturers to take back e-waste from consumers for free at their request. Contrary to Japan, consumers do not have any economic responsibility for e-waste recycling.

At time its legislation was drafted, Taiwan's policymakers were greatly concerned about managing the pollution caused by improper treatment rather than the heavy burden on municipalities or EPR. This led to Taiwan's unique e-waste recycling system. Manufacturers are not considered to be the sole actors in the recycling process, which meant they were obliged to take physical responsibility for e-waste. Under the RFMC system, the manufacturers are only required to pay fees for sales of the previous year. To promote proper treatment by the commercial recycling companies, the fees paid by manufacturers are converted into subsidies. Even though monitoring costs are strictly imposed, unit-based verification takes place to ensure proper treatment.

It becomes clear that details of the regulations reflect the respective countries' responses to the challenges they considered imminent. This indicates that it is necessary to develop an accurate understanding of the different conditions that exist in developing countries so that the experiences of the developed countries can be applied to them.

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<sup>13</sup> The Web site of the manifest ticket center (<http://www.rkc.aeha.or.jp>)

**Table 3** Backgrounds to the enactment of legislation in Japan, South Korea and Taiwan

	Background	Related Item Specified in Regulation	No. of Items
<b>Japan:</b>			
LPUR	1. Increasing scarcity of waste disposal sites and increased cost for waste disposal	1. Voluntary efforts by manufacturers 2. Differences in cost allocation according to the time of purchase	1
LRHA (Home appliances)	1. Increasing scarcity of waste disposal sites and increased cost for waste disposal 2. Heavy economic burden on municipalities	1. No explicit responsibility on municipalities 2. Adopting payment by consumers on disposal 3. Physical responsibility on manufacturers 4. Setting individual recycling rates for each item 5. Manifest system	4
<b>South Korea:</b>			
LRSR (1992–2002)	1. Implementation of a local autonomy system (1992)	1. Managed under different categories of recyclable resources under the LRSR (1992) 2. Economic responsibility on manufacturers	4
Revised LRSR (2003–present)	1. Amendments to PDR system 2. Publication of EPR government manual by OECD (2001)	1. Physical and economic responsibility on manufacturers 2. Announcement of recycling targets by MOE 3. Free take-back and mandatory recycling rates/targets per item	10
<b>Taiwan:</b>			
Waste Disposal Act (1998–present)	1. Improper recycling practices (environmental impacts)	1. Managed under two categories of recyclable resources under the RFMC system 2. Subsidies as incentives for recyclers to join the system 3. Economic responsibility on manufacturers	19 <sup>14</sup>

Source: Compiled by the authors.

### 6.4.2 What Responsibility Is Imposed on Manufacturers?

In order to answer this question we must understand the relationship between the regulations regarding manufacturers' responsibilities and the policy outcomes. First of all, a comparison is made of the type and range of responsibilities as set out in the relevant legislation (Table 4). From this, we can confirm that every regulation evidently stipulates economic responsibility in terms of collection and recycling. Japan is the only country to impose economic responsibility on consumers. However, contrary to this, regulations on physical responsibility show different patterns. South Korea (PDR) and Taiwan do not specifically stipulate who should physically treat e-waste. As we confirmed, both systems stressed economic responsibilities as a way to increase collection and recycling rates: By raising deposit rates in South Korea and providing subsidies in Taiwan to attain the respective policy targets. Japan (Group B) and South Korea (PR) have the common feature that physical responsibilities are fulfilled by manufacturers, (although, the range of responsibilities differs). This resulted in a similar

<sup>14</sup> This classification is not the same as that of Japan or South Korea. 19 items in Taiwan mean that manufacturers have 19 categories of e-waste, which have different recycling fees. However, 19 items becomes eight or nine items using the criteria of Japan or South Korea.



phenomenon, in which manufacturers set up new recycling plants to fulfill their legal obligations. This is not common in Taiwan. This should be considered in connection with the manufacturers' economic responsibilities. In the case of South Korea, because economic as well as physical responsibilities are imposed on manufacturers, the range of responsibility seems to be comparatively limited.

Secondly, the policy outcomes in the three countries are categorized (Table 5) and contrasted to give a clear picture of the respective situations. Policy outcomes must be considered in connection with regulations on manufacturers' responsibilities. Judgments are made on a subjective basis.

**Table 4** Regulation on Manufacturers' Responsibilities in Japan, South Korea, and Taiwan

		Collection		Recycling		Range of Responsibility
		Economic	Physical	Economic	Physical	
Japan	LRHA	C	M	C	M	HA consumers pay a recycling fee
South Korea	PDR	M	N	M	N	HA for 100% of shipment of the previous year
	PR	M	M	M	M	HA for the mandatory recycling rates
Taiwan		M	N	M	N	HA for sales the previous year

Source: Compiled by the authors.

Note: HA: home appliances; M: manufacturers; C: consumers; and N: no clear stipulation.

**Table 5** Strengths and Weaknesses in Current E-waste Recycling Systems of Japan, South Korea and Taiwan

	Strengths	Weaknesses	Note
Japan (LRHA)	1. Monitoring process ensures proper treatment 2. High quality of recycling by high technology	1. Increase in hidden flow (illegal dumping etc) 2. Heavy burden on consumers 3. Narrow categories of items	Manifest system
South Korea (PR)	1. Harmony between manufacturers and existing recyclers 2. Broad categories of items (10)	1. Limitations in raising the mandatory recycling rates 2. Role of municipalities is unclear	Conglomerate-centered manufacturers
Taiwan	1. Unit-based verification for collection and recycling 2. Broad categories of items	1. Negative competition between recyclers inside and outside of the scheme 2. High monitoring costs	Fluctuating fees

Source: Compiled by the authors.

#### 6.4.3 How Has the Implementation of EPR-based Regulations Affected the General Flow of E-waste?

This question focuses on the general flow of e-waste before and after the implementation of regulations that incorporate the principle of EPR in each of the three countries. A standardized comparison of general e-waste flow is difficult to make, due to the different indexes used for

measuring the policy outcomes. However, we will attempt to identify the general trend of e-waste flow in recent years.

**Table 6** General Flow of Used Home Appliances in Japan (2005)

	Estimated generation	Recycling by manufacturers	Export		Remainder
			JTS	MOE	
Data 1 (MOE/METI)	2,287 (100%)	1,162 (51%)	337 (18%)	594 (26%)	788-531 (31-23%)
Data 2 (NIES)	2,129 (100%)	1,069 (50%)	449 (21%)		611 (29%)

(Unit: 10,000)

Source: Document of a Working Group of the Ministry of Environment and the Ministry of Economy, Trade and Industry on Used Home Appliances and NIES (2007).

Note: JTS is Trade Statistics of Japan.

A review of the LRHA is currently under discussion in Japan, with the hidden flow considered to be a significant challenge for policymakers. For this purpose, data on the general e-waste flow has been announced (Table 6). According to MOE and METI data, as is shown in Table 6, about 22 to 23 million used home appliances are generated in Japan every year. Regarding e-waste exports, MOE (METI) and NIES provided two figures useful here.<sup>15</sup> The remainder includes reuse and resource acquisition, and treatment by municipalities in Japan. It must be noted that about 49% used home appliances which were ultimately handled by non-manufacturers. At the time of enactment, Japanese legislators did not expect such a high rate of collection by non-manufacturers. The NIES study filled in some of the data.<sup>16</sup> However, even if there is small change in the respective figures, significant differences are not found when compared with Data 1 regarding the general material flow perspective.

In the case of South Korea, reliable data on the generation of e-waste are not available. However, South Korea has comparatively accurate data on the export of e-waste as second-hand goods. Rather than calculating the ratio of e-waste exported to that generated, we have calculated the ratio of e-waste exported as secondhand goods to that collected by manufacturers from 2003 to 2005. For values greater than one, export exceeds collection by manufacturers.

As a result, the ratio ranges from 0.75 to 0.9. No distinct change is found over the three years. If we consider that collection by manufacturers has increased steadily since 2003, we can say that export has increased considerably. Interestingly, there are significant differences in ratio values of different items. For example, television sets and computers are actively exported, while refrigerators, washing machines and air conditioners are not.

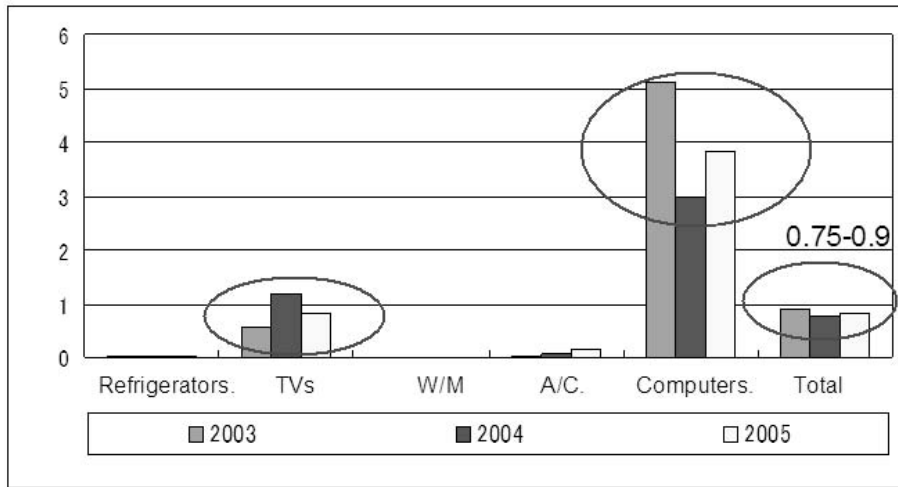
Since implementation of the RFMC system in Taiwan, the ratio of units collected within the system is calculated to obtain an estimate of generation. Overall, we can see that there are two types of items from the collection rate.<sup>17</sup> Washing machines and refrigerators account for around 50% of the collection rates. Meanwhile, air conditioners and television sets account for less than 20%.

<sup>15</sup> In the JTS data, export as a new product is calculated.

<sup>16</sup> Main amendments by NIES are as follows: 1. Hoarding is considered. 2. Discrepancies between trade statistics and estimated export are settled.

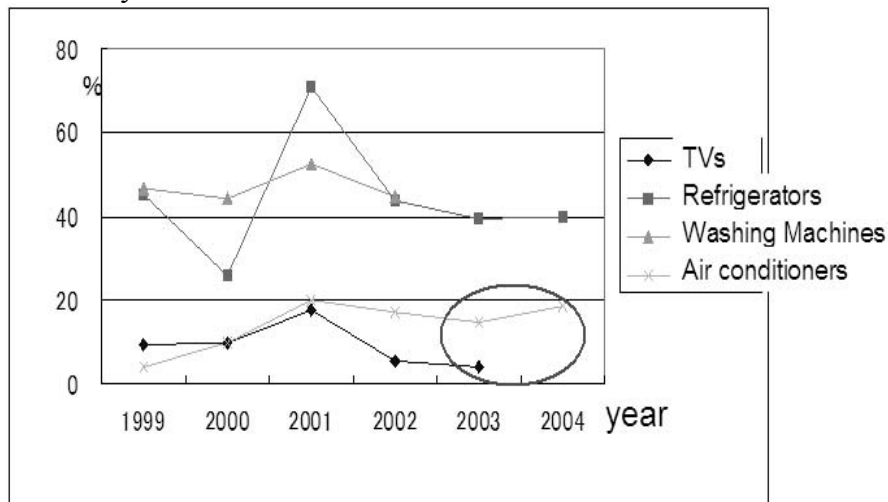
<sup>17</sup> Collection rate in Taiwan's case signifies the ratio of treatment inside RFMC system to the estimated generation.

**Figure 6** General Flow of E-waste after the Implementation of PR System in South Korea



Sources: KECTI (2006) and AEE (2006).

**Figure 7** General Flows of E-Waste after Implementation of RFMC System in Taiwan



Source: Environmental Protect Agency (data on collection).

Note: Estimated generation of HA is calculated by authors, using Taiwan's data and sales.

### 6.5 Conclusions

The authors have conducted a comparative analysis of e-waste recycling systems in Japan, South Korea, and Taiwan to identify practical policy implications for developing countries from an EPR perspective. By comparing the three systems, it became evident that positive aspects of one system can be adopted to improve another. However, it is also difficult to determine an optimal sustainable e-waste recycling system as the economic and cultural contexts of Japan, South Korea and Taiwan are different. Nevertheless, the authors can identify several implications for developing countries. First, we have confirmed that the three countries have constructed their respective e-waste recycling systems on the basis of EPR, but the

details of each system differ significantly. This implies that it is essential that relevant existing conditions are to be understood and challenges are clarified in order to effectively implement e-waste recycling in developing countries.

Second, before an e-waste system is implemented, several questions should be answered. For example, developing countries should clarify who will play the leading role within the electronic wastage system. In other words, these governments are left with a choice between a manufacturer-centered recycling system and a commercial recycling company-centered recycling system should be made. Naturally this decision should be approached from both physical as well as economic angles. Accordingly, the relationship and roles of the actors involved, such as consumers, municipalities and retailers, should be clearly defined within their respective areas.

Finally, regarding the general flow of e-waste, a similar pattern is confirmed in the aforementioned three countries. This indicates that despite the adoption of a system based on either economic or physical EPR, significant hidden flow of e-waste still exists. To reduce the existence of e-waste hidden flow in developing countries, attention should be paid to the relations between commercial recycling companies and manufacturers, particularly in terms consistent of the e-waste collection stage.

Further, this relationship should be transformed from one that promotes negative competition to one that stimulates a collaborative effort between commercial recycling companies and manufacturers for a sustainable environment. In this respect, the cases of Japan (Group A) and South Korea (PR) deserve focused attention.

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