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Exploring a Third-Party e-Waste Recycling System under the Extended Producer Responsibility Framework in China

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Introduction

The rapid advance of information technologies has produced a large amount of waste of electronic and electrical equipment (WEEE). WEEE or e- waste, refers to old, end-of-life (EoL) or discarded electronic appliances. The world produces 20 to 50 million metric tons of e-waste annually (Electronics Take-back Coalition 2009), of which China alone contributes 2 million tons. Each year at least 6 million washing machines, 7 million TV sets, 10 million PCs and 70 million mobile phones are discarded and the number increases at the rate of more than 10 per cent each year (Hung 2007), according to the report from the resource and environment comprehensive utilization department of the State Development and Reform Commission (SDRC 2006). Discarded electronic products contain a stew of toxic metals and chemicals such as lead, mercury, cadmium, chromium and polychlorinated biphenyls (Scott 2007) and cause great harm to the environment. Recycling and reusing e-waste are thus becoming an increasingly important global issue.

Extended producer responsibility (EPR) is defined as "a policy principle to promote total life-cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life-cycle of the product, and especially to the take-back, recycling and final disposal of the product" (Lindhqvist 1992). The ultimate goal of controlling e-waste is minimizing

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the impact on the environment of EoL products. E-waste recycling involves product and systems design that take EoL products into account. In order to fully integrate product retirement concerns into design considerations, it is necessary to gather feedback and internalize costs and data. Although EPR determines that producers have leading responsibility in this, other parties, including consumers, retailers, recyclers and governments need to contribute to this process.

Extended producer responsibility practices

Definition and legislation in different countries

The extended producer responsibility (EPR) concept was first formally used in Sweden by Thomas Lindhqvist in 1992 in a report to the Swedish Ministry of the Environment. The Swedish reports further specified how manufacturers should take responsibility for their products, including their liability, and their responsibilities in terms of the economic, physical and information aspects of doing so. In 2000 the European Parliament passed a directive requiring its member countries to institute EPR programmes for EoL vehicles (Forslind 2005) and an additional directive for waste electronics and electrical equipment (WEEE) was approved in early 2003. This is not only a European phenomenon; as, for example, Japan has also enacted an EPR law covering four large electrical home appliances (TV sets, refrigerators, air conditioners and washing machines) (Spicer and Johnson 2004). The USA established a similar system with variations focusing more on product responsibility, instead of products themselves. Table 9.1 shows the definitions and explanations of EPR in respective legislations.

In addition, scholars have explored relevant practices in different regions (such as Sweden, Germany, the USA, Japan and Taiwan) and across different products (printers, PCs, motor cars and batteries) (Forslind 2005; Hanisch 2000; Lee 2008; Mayers 2005). They reached a consensus recognizing that EPR policies can actually stimulate product innovation and environmentally friendly design in reducing the use of materials, resources and energy by eliminating the use of toxins, extending the useful life cycle, increasing opportunities for the recovery and reuse of products at their Eo and creating new forms of product delivery, such as a leasing product service system (McKerlie 2006; Nicol and Thompson 2007; Tojo 2001).

Table 9.1 Definition and EPR legislation in Europe

	Europe	Japan	USA
Legislation	WEEE Restriction of Hazardous Substances Package and EOL Vehicles	Home Appliance Recycling Law	Extended product responsibility The state of California imposed an electronic waste recycling fee on new purchases of electronic products with viewable screens.
Responsibilities			
Producers	Collection, recycling, disposal and charging the fee	Complete recycling rate index	
Consumers	Pay the recycling fee and insure the integrity of e-waste	Should inform the retailer when home appliances retire	
Government	Pay a part of fee of collection, disposable or make policy of fiscal subsidies of EPR organization	Enforce legislation	In EPR system, producer, supplier and customer take on responsibility for the environmentally appropriate disposal of e-waste

Extended producer responsibility modes of implementation and capital operation

Depending on how thoroughly it is implemented and how much the government is involved, there are three models of EPR implementation. The first is the voluntary model, that is, producers take measures to decrease the impact of their products on pollution. For example, enterprises devise a take-back plan and recycle their products at their EoL. The second is the enforcement model, as obligated by the government, in the government forces manufactures to recycle their products. The third is the economic model, realized by incentives such as an ecology tax, pre-fee for recycling, and deposit return (Wanggan 2006).

In terms of capital operations, in Europe, Korea and Taiwan the cost comes from the producer, while in Japan it comes from the consumer. The USA is an exception. With no legislation on the EPR principle, it refuses to impose a burden on the original manufacturer [Wu et al. 2008)] arguing that this model is not appropriate to keeping the lowest social cost.

The take-back model

There are three EPR take-back models: original equipment manufacturer (OEM), pool and third-party take-back. The OEM take-back model is an EPR system in which the OEM themselves take physical and economic responsibility for the products they have manufactured. In the pooled take-back model the physical and economic responsibilities for products are assumed by consortia of manufacturers, usually grouped by product category. The third-party take-back model is an alternative approach where private companies assume EoL responsibilities for products on behalf of the OEM. In such cases the OEM pays a fee to a product responsibility provider, who then undertakes to ensure that the manufacturer's products are retired in a way that is environmentally responsible and compliant with EPR legislation. The basis and standards underlying these models and their effects have been compared. The OEM take-back model has an advantage in feedback, since the manufacturers are simply directly responsible for their own products at EoL. Therefore, this is more feasible for big companies than small ones, but it raises a barrier of scale for small companies and cannot resolve the problem of orphaned products, while the pooled take-back system can address the issues on orphaned products. However, it is impossible for pooled systems to gather feedback from economic indicators and achieve the goal of sharing information and closed-loop recycling. In contrast, the third-party take-back model has advantages for both manufacturers and the general public and appears to be a promising approach in optimizing product design, specialization, immediate economic feedback and demanufacturing market development (Spicer and Johnson 2004; Zhong and Schiller 2009).

China's implementation of extended producer responsibility

China takes the long view in the exploration and practice of e-waste recycling. Government agencies deployed four national pilot projects for WEEE recycling and management between 2003 and 2005, in Beijing, Tianjin, Qingdao and Hangzhou. The typical process of Chinese legislation is to first formulate lower level ordinances and regulations, then to gather detailed information in pilot studies, and finally, to draft a national

law on a particular issue (Yang 2007). Legislation relating to e-waste recycling includes "The People's Republic of China Solid Waste Pollution Prevention and Control Law", "The People's Republic of China Cleaner Production Promotion Law", "Discarded Household Appliances and Electronic Products Pollution Control Technology Policy", "Electronic Information Products Pollution Control Regulations", the recent "Subsidy Program for the Replacement of Household Appliances" and the forthcoming "Waste Electrical and Electronic Product Recycling Regulations".

Although we may glimpse EPR concepts in these regulations, as at the time of writing there has still been no clear definition of EPR practice in China. As a result, as far as collection and recycling networks are concerned, very slow progress has been made, and this has become a bottleneck to recycling. The key obstacle is that the costs are higher than they are when EEE is collected informally. In other words, it lacks a coordinating mechanism to stimulate and engage all parties involved in the recycling process.

In current conditions it is not realistic for China to aim at the voluntary implementation of EPR. In addition to a legal obligation, the country needs the help of third-party take-back economic methods to push for the adoption of EPR, especially if this is an efficient profit model involving integrative, systematic optimum mechanism design to realize efficiency in recycling e-waste.

Building an extended producer responsibility third-party e-waste recycling system

Overall framework

In response to the existing problem and in accordance with the principles of standard recycling, scientific classification, specialized disposal and the harmless reuse of products, this chapter develops a model of a scientific e-waste recycling system (EWRS), addressing both the collection and disposal of e-waste. This system, as a third-party recycling organization, aims to engage the interests of all stakeholder: producers, consumers, government, retailers and disposal sites; and achieve the dynamic control and management of all the relevant processes by applying an e-commerce platform (see Figure 9.1.).

Analysis of the stakeholders in the recycling platform

All recycling systems comprise a reverse supply chain. A system mechanism design should coordinate all stakeholders, whose responsibilities and obligations in the platform are discussed later in this chapter.

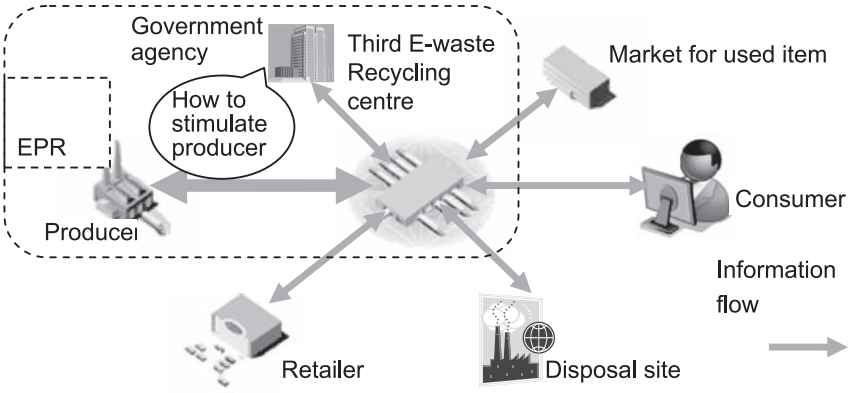

Figure 9.1 EPR Third-party e-commerce recycling system framework

The consumer, a supplier of e-waste, plays an important role in the reverse supply chain. Therefore, motivating the consumer is the key to the recycling platform operations. The system should take into account the consumer's bargaining power in order to avoid the deal failure. In particular, the recycling price should be based on analysis of the demand by interviewing consumers.

The recycling centre, as the provider of product and the reverse supply chain plan, has a close relationship with the original manufacturers through a contract with the principle agent. It receives e-waste collection and recycling fees from these producers together with government subsidies, and gathers revenues from the second-hand market by selling refurbished products. The core tasks of the recycling centre are to take a reasonable inventory, realize management scalability and maintain sustainable business.

The producer, as the EPR performer, is the real heart of the recycling system. On the one hand, from the viewpoint of a restraint mechanism-based contract of commission, the producer must pay a disposal fee in accordance with the complexity of disassembly of a particular product. As a result, producers will naturally be motivated to improve their product design. At the same time, from the standpoint of motivation, the government should offer subsidies and a refund mechanism or encourage compliance via a carbon tax, in order to encourage producers to fulfil their social responsibility.

The government, as the agent of enforcement, must focus on making efficient policies that provide incentives to producers, consumers and recyclers simultaneously in all the recycling systems in the large-scale control process. For instance, central government can focus on making

policies for allocating funds for subsidies and creating standards and objectives, together with supervising the EPR system.

Recycling system process design

Using an online system, consumers will submit the e-waste information, including the product category, brand, model, purchase date and its current condition via the internet or over the phone. The system will then automatically generate a list of the items to be recycled, which will be picked up by professionals from a third-party recycler. The recycling price will be decided by the special assessing system. After the transaction, the third-party recycler will pay the consumer over the internet or in cash. The e-waste will then be transferred to an e-waste recycling centre, a third firm dedicated to recovering reusable materials from EoL products and selling them in second-hand markets. Once it has been delivered to the recycling centre, the e-waste will first be inspected to determine whether it can be repaired or should be disassembled. Repaired products could be sold in second-hand markets, while disassembled EoL products will be separated into reusable, recyclable and disposable materials, sending each to its appropriate inventory. The reusable and recycling components will be tested for their usability potential before they are sent to a producer or retailer, and the disposable components will be sent to the disposal site (see Figure 9.2). At the same time, the government will provide

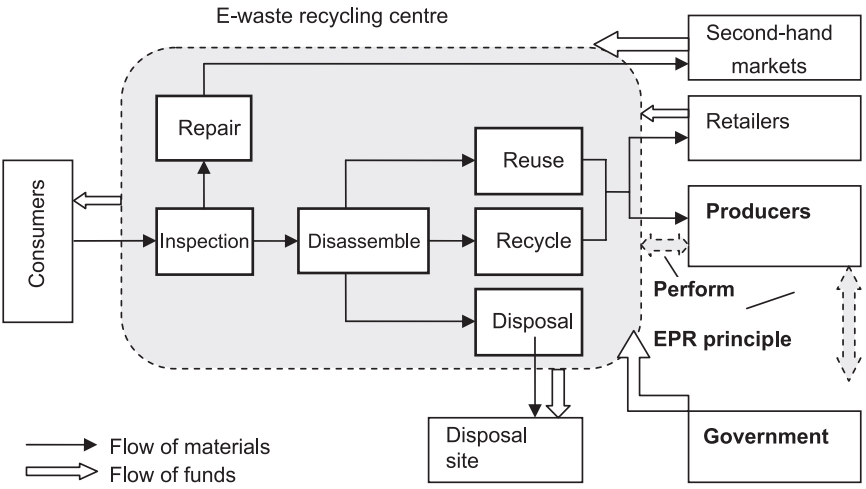

Figure 9.2 E-waste recycling process

the subsidy to the recycling centre or to the producers to realize the EPR principle.

The way in which the EWRS fulfils the EPR responsibility is the key to this system. The following two points need to be addressed: how to define the contract between the producer and the recycling agency and how the government should help to provide incentives to the producer. In light of economic realities, the government should assess the producer's contributions when establishing subsidies for recycling and disposal. Forthcoming legislation on "Waste Electrical and Electronic Product Recycling Regulations" clearly proposes that the government establish the foundation for the subsidy of recycling WEEE, and that both the collection and subsidy guidelines incorporate input from manufacturers, recycling firms and relevant experts. Therefore, the EPR principle is already involved in the proposed regulation and needs to be reflected through a reasonable contract and pricing mechanism.

E-waste recycling information system design

The e-waste recycling information system is composed of five modules to support the functionalities and business operations of the third-party recycler (Table 9.2). The client management module provides for real-time, online inquiries for recycling orders and processing information. The recycling processing module manages the recycling centre and documents information about the repair, disassembling, refurbishment, recycling and disposal of electronics. The inventory is maintained in the inventory management module. The information system also includes accounting functionalities to process, analyse, and report and manage costs. The logistics module collects, processes and presents information to support the reverse supply chain through which producers become recipients of recycled items.

Table 9.2 E-waste recycling management information system

Recycling	Inventory management	Accounting	Logistics
Client order processing	Inventory monitoring	Cost analysis	Reverse logistics
Recycling centre management	Stocking and processing	Analysis and reports	Information collection
Disposed products management			

Conclusion

In summary, this proposed e-commerce third-party e-waste recycling system has three benefits for efficient recycling and pollution reduction within the EPR framework:

- It will strengthen the theoretical system of EPR and explore a performance path for developing economies, offering increased economic incentives to stimulate all parties to become involved in the recycling process.
- It will increase recycling efficiency with the help of advanced information technology from the e-commerce information system.
- Using the third-party recycling platform as link, it will balance the interests of all parties and achieve a win–win situation all around. Consumer will be able to have their e-waste conveniently recycled and then receive economic compensation in return. Third-party recyclers can use the e-commerce platform to collect recycling items on a large scale and generate profits by disassembling and refurbishing them. Manufacturers can fulfil their social responsibilities and improve their corporate image by taking partial financial responsibility for the recycling process according to contracts between them and the third-party recyclers. The government will regulate the behaviour of all parties through policies and regulations and thus promote societal sustainable development, as well as peaceful coexistence between human beings and the environment.

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