

Recycling and Management of Electronic Waste in Korea: recent trends and suggestions for sustainable management

Yong-Chul Jang, Chungnam National University, Korea
Jintae Kim, Geonguk Kim, Chungnam National University, Korea

CONTACT

Yong-Chul Jang

Industrial Waste Management
College of Engineering
Chungnam National University
Gung-dong 220, Yuseong-gu, Daejeon. S. Korea
Tel: 82-42-821-6674
Fax: 82-42-822-5610
E-mail: gogator@cnu.ac.kr

EXECUITVE SUMMARY

Managing electronic waste (e-waste) or waste electrical and electronic equipment (WEEE) has become a subject of major concern for solid waste community because of the magnitude of the waste stream and many toxic chemicals (e.g., barium, cadmium, chromium, lead, mercury, nickel, and bromated flame retardants) in the devices. Many countries are seeking environmentally sound management and treatment of WEEE. Recycling of the WEEE is an important area not only from the point of waste treatment but also from the recovery aspect of valuable materials such as aluminum, copper, iron, plastics, silver, and gold. Large amounts of discarded electronic home appliances such as refrigerators, televisions, washing machines, and air conditioners have been collected by electronic product producers for either recycling or disposal. Although the recycling of WEEE has been increasing for limited e-waste items in Korea, the infrastructure for collection and recycling processing technologies for diverse e-waste devices have yet to be established. This study discusses current management system, recycling rates and practices of WEEE in Korea. It also reviews recent national management efforts and

long-term recycling target rates of WEEE. Finally, several suggestions are made to improve the WEEE recycling and management.

INTRODUCTION

Waste electrical and electronic streams encompass a wide range of electrical and electronic waste products, including home appliances (e.g., refrigerators, washing machines, air conditioners); information technology and telecommunication equipment (e.g., personal computers, laptop computers, printers, copying equipment, calculators, facsimiles, telephones, mobile phones); consumer electronic devices (e.g., televisions, radios, video cameras, audio equipment); and other household electrical and electronic equipment (e.g., vacuum cleaners, toasters, coffee machines, hair dryers, watches, or irons). The large consumer demand for newer electronic products and the advanced development of information and communication technology (ICT) have resulted in tremendous amounts of WEEE that are disposed of. The disposition and management of WEEE is an emerging environmental issue of concern for the solid waste communities in Korea and around the world. As the lifespan of electronic devices is becoming shorter, the quantity of WEEE is expected to increase.

In response to the growing concern, many parts of the world are trying to seek environmentally sound and economically feasible models for WEEE management system. Many countries showed a great interest in establishing recycling processes to reduce the quantity of WEEE to be disposed and to recover valuable resources. Unlike municipal solid waste, the WEEE management system has not been well established in most countries. A number of studies have been recently published to provide current knowledge and/or to address potential problems associated with WEEE management (Townsend et al., 2003; He et al, 2006; Liu et al., 2006; Babu et al., 2007; Wong et al., 2007; Yang et al., 2007; Kahhat et al., 2008; Spalvins et al., 2008; Robinson, 2009; Wath et al., 2010; Ongondo et al., 2011).

This study presents current recycling and management practices of WEEE and recent national efforts on recycling policy in Korea. The collection system and recycling rates of WEEE are presented and updated. It discusses the recent regulatory efforts regarding WEEE management with an emphasis on the extended producer responsibility (EPR) policy and WEEE Act in Korea. The long-term recycling target rates of WEEE in Korea have been estimated with several assumptions based on the recent efforts. Finally,

suggestions are made for environmentally sound and sustainable management of WEEE in Korea.

METHODOLOGY

The methodology of this study included gathering data associated with annual domestic demands of 10 different home appliances and electronic devices, site visits, questionnaire surveys, interviews and conversation, and a review of available literature. The annual domestic demands of the target WEEE in Korea were obtained from the Bureau of Statistics in Korea. The statistical data regarding the amount of WEEE recycled were obtained by site visits to Korea Ministry of Environment (Korea MOE) and the Korea Association of Electronics & Environment (Korea AEE). The Korea AEE, a producer responsibility organization (PRO), was established in 2000 as a cooperative effort to share the responsibility of environmentally sound WEEE recycling between the electronic industry and its members. Interviews and conversation with environmental regulatory agencies, recycling industry experts, and PRO committees were conducted to obtain the details of recent progress and development associated with WEEE management. The results of the Monte-Carlo simulation regarding the long-term recycling target rates of WEEE by producers and local governments were presented based on the assumptions of the recent policy and management efforts to be established.

RESULTS AND DISCUSSION

WEEE management history and system

In response to the increasing volumes of WEEE and their potential environmental impacts through various disposal pathways, the Korea MOE modified the Waste Recycling Act for effective collection and recycling of the waste materials and promulgated an extended producer responsibility (EPR) regulation for the limited WEEE in 2003 (Korea MOE, 2002). The EPR involves producers taking more responsibility for managing the environmental impacts of their products throughout their life cycle. Producers that manufacture the EPR products must collect and recycle an assigned quantity based on a certain percentage of their annual production volume. Otherwise, they must pay more than the cost for recycling their waste products. Mobile phones and audio equipment were included in the EPR list in 2005, while printers, facsimiles, and copying machines were included in 2006. In 2007, a new legislation,

‘the Act on the Resource Recycling of Waste Electrical Electronic Equipment (WEEE) and End-of-life Vehicles’ was enacted (Korea MOE, 2007). The Act is aimed at reducing the amount of WEEE going to landfills and incinerators, achieving a high recycling rate for all targeted products by adopting the EPR policy, and improving the overall environmental performance of electronic products during their life-cycle. This new legislation is the counterpart of the EU directives such as WEEE directive, restriction of the use of certain hazardous substances (RoHS) directive, and end-of-vehicle (ELV) directive (EU Directive 2000, EU Directive 2002a, EU Directive 2002b). This indicates the overall ambition of the Korea MOE to minimize all possible environmental impacts caused by WEEE disposal. It should be thought of as a major response to the growing concerns about the WEEE management issue in Korea. Producers, importers, distributors, consumers, and all parties should be involved in the collection, treatment, recovery, and environmentally sound disposal of WEEE. Producers are required to finance the collection, recycling and disposal system of WEEE. Figure 1 shows the current management system of WEEE in Korea.

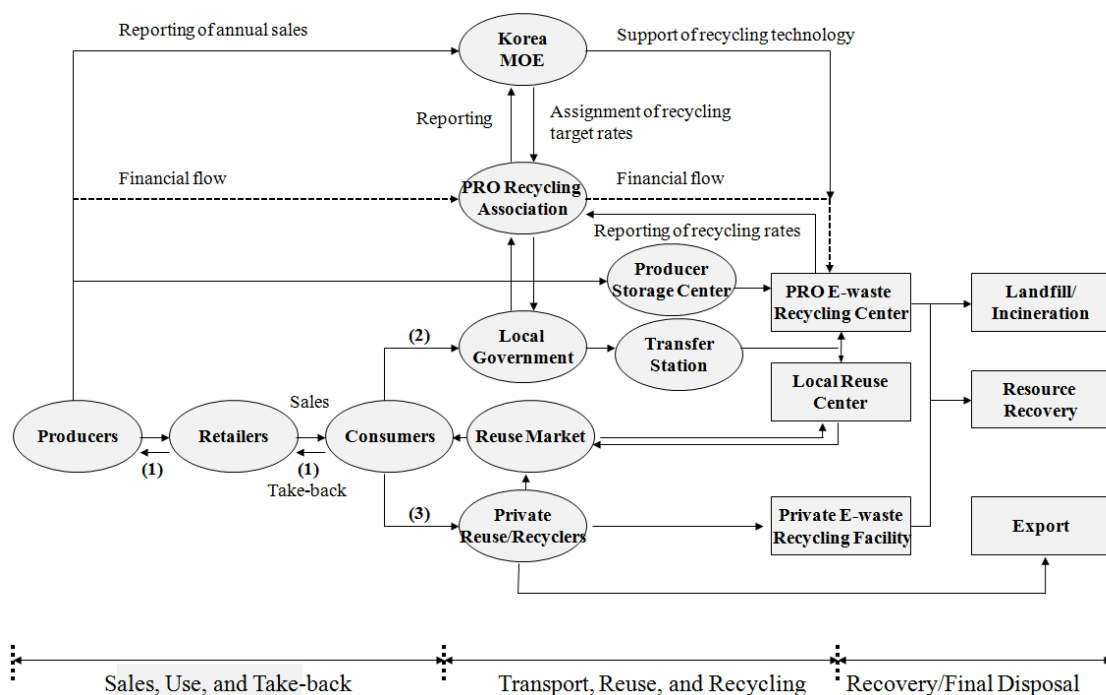


Figure 1. Collection and management system of WEEE in Korea

WEEE recycling rate

The annual mandatory recycling rate of each product is determined by the Korea MOE, based on the target recycling rates over the previous years, the amount of electrical and electronic products shipped from the warehouse, and the recycling market conditions. The total amount of the EPR mandatory recycling is determined by the annual amount of electrical and electronic products shipped from the warehouse shipment multiplied by the annual mandatory recycling rate. Table 1 presents the domestic demand, the EPR target rate, and the actual recycling rates of WEEE by the EPR policy in Korea between 2008 and 2010. For example, in the year 2010, the amounts of recycling EPR rates determined by the Korea MOE were 51,791 tons for refrigerators, 29,355 tons for washing machines, 16,397 tons for televisions, and 3,091 tons for air conditioners. The amounts of most WEEE products recycled by producers exceeded their mandatory target rates. Figure 2 shows the trends of recycling rates over time and per capita. As shown in Figure 2, the quantity of WEEE recycled continually increased over the years.

Table 2. Recycling rate of WEEE in Korea

(unit: ton)

WEEE	2008			2009			2010		
	Domestic demand	EPR Target Rate	Amounts of Recycling	Domestic demand	EPR Target Rate	Amounts of Recycling	Domestic demand	EPR Target Rate	Amounts of Recycling
Refrigerators	311,815	58,933	53,678	222,474	45,830	58,636	234,347	51,791	64,618
Washing machines	102,329	25,889	22,035	95,470	24,918	26,046	107,137	29,355	29,215
Televisions	73,480	10,655	18,664	74,214	11,874	18,544	86,300	16,397	21,491
Air Conditioners	124,120	2,855	2,438	126,979	2,921	2,887	128,790	3,091	3,064
Computers	51,028	5,256	9,992	47,605	5,284	8,383	54,304	6,679	9,790
Audio	3,908	582	1,170	4,901	760	685	4,632	787	711
Mobile phones	2,984	537	711	3,206	635	629	3,533	777	731
Copying machines	6,098	774	958	4,636	617	588	5,707	810	994
Facsimiles	837	95	111	468	57	117	525	70	129
Printers	22,829	2,557	2,002	11,929	1,420	1,938	15,056	1,957	2,462
Total	699,428	108,134	111,759	591,882	94,316	118,453	640,331	111,714	133,205

(Source: Korea MOE, 2011)

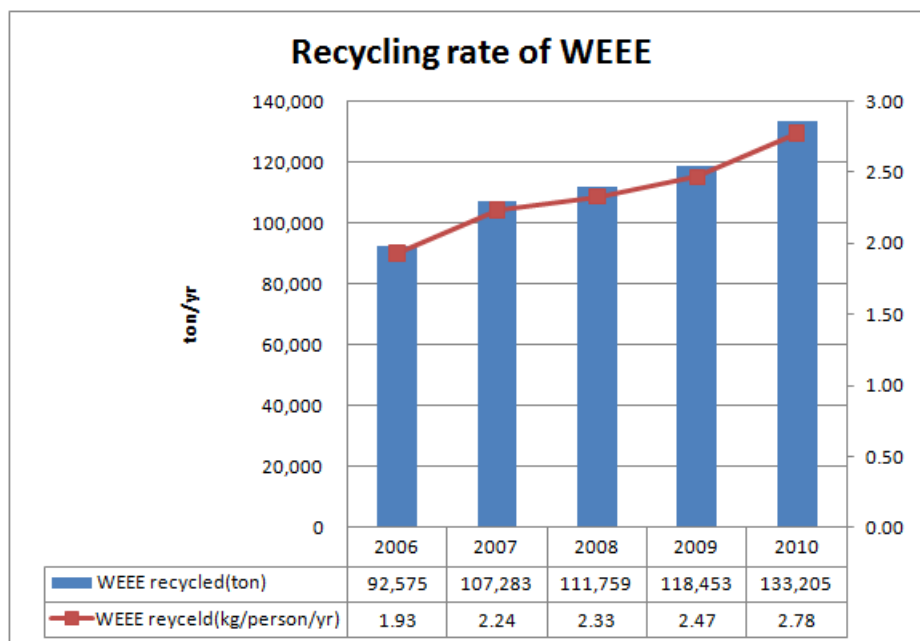


Figure 2. Recycling rate of WEEE in Korea

Current national efforts toward sustainable management

Recent WEEE recycling efforts by national government, local governments, and producers (i.e. electronic industry) are being made. This includes the establishment of the collection system for diverse e-waste devices, long-term recycling target rate of WEEE by national government, mandatory collection rates for retailers and distributors, the expansion of WEEE list, an increased role of local government for WEEE collection, and the development of recycling technology for WEEE. If the collection and recycling efforts on WEEE are continually improved, the amount of WEEE would largely increase over the time. Based on several assumptions reflecting the recent efforts above, a long-term national target rate of WEEE to be recycled (kg/person/year) is estimated by using Monte-Carlo simulation in this study. In 2017, the national recycling target rate of WEEE is predicted to be 4.74 kg/person/year on average (5% percentile 4.03 kg/person/year, 95% percentile 5.54 kg/person/year).

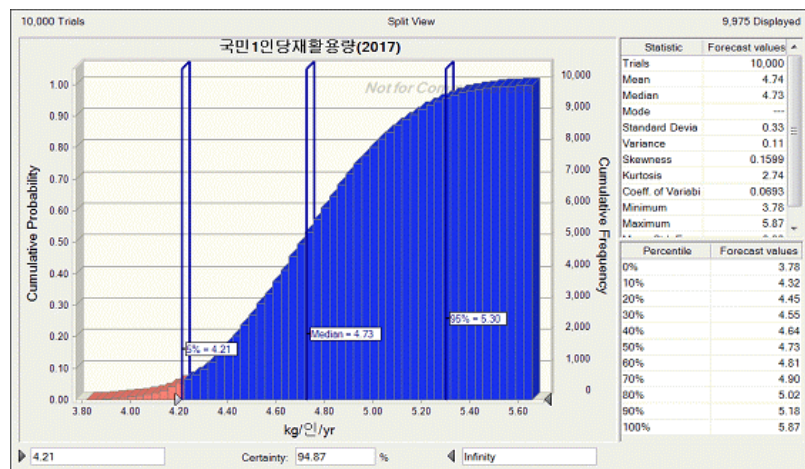


Figure 3. Results of predicted recycling target rates of WEEE in 2017 in Korea using Monte-Carlo simulation

SUGGETIONS AND SUMMARY

Electrical and electronic waste represents one of the fastest growing segments in solid waste streams in Korea. Still, public recognition of the need for WEEE collection and recycling should be largely promoted. A major challenge for WEEE collection is related to a lack of consumer awareness of potential hazards that result from improper disposal of WEEE. Another challenge for WEEE collection and recycling is the need for establishing a proper collection system for a stable supply of diverse WEEE to be recycled. Especially, WEEE collection programs by local governments have not been successful at promoting material recovery and recycling. They need to play a significant role of WEEE collection in municipalities by raising public awareness associated with its potential hazards and the importance of WEEE recycling. In perspective of recycling of WEEE in Korea, much work to date has mainly focused on the recycling and recovery of materials from limited WEEE categories, especially large home appliances and a few electronic devices. In addition, small proportions of electronic devices in the current system are currently recycled. Thus, the WEEE policy and regulations need to increase their target recycling rates and to provide various incentives to remove WEEE from household storage. Also, categories and items in the WEEE recycling list need to be expanded, including small home appliances (e.g., vacuum cleaners, rice cookers, coffee makers) and other IT products (e.g., MP3 players, game players). So far, limited

information and official data in regards to WEEE generation rates, WEEE material flow, and recycling of many other electrical and electronic devices are currently available. As some of the data and the issues associated with the WEEE management aforementioned are better understood, the findings could provide a basis for better environmentally sound WEEE management in Korea.

REFERENCES

Babu, B, Parande, A, Basha, C. (2007) *Electrical and electronic waste: a global environmental problem*. Waste Manage. 25. 307-318.

EU Directive (2000) 2000/53/EC of the European parliament and of the council of 18 September 2000 on end-of-life vehicles (ELV). Official Journal L269:0034-43

EU Directive (2002a) 2002/96/EC of the European parliament and of the council of 27 January 2003 on the restriction of the use of certain hazardous substances in waste electrical and electronic equipment (RoHS), Official Journal L037:0019-23; 2002a.

EU Directive (2002b) 2002/96/EC of the European parliament and of the council of 27 January 2003 on waste electrical and electronic equipment (WEEE)-joint declaration of the European parliament, the council and the commission relating to article 9. Official Journal L037:0024-39; 2002b.

He, W, Li, G, Ma, X, Wang, H, Huang, J, Xu, M, Huang, C. (2006) *WEEE recovery strategies and the WEEE treatment status in China*. J Haz Mat. B136. 501-512.

Kahhat, R, Kim, J, Xu, M, Allenby, B, Williams, E, Zhang, P. (2008). *Exploring e-waste management systems in the United States*. Resource, Conservation and Recycling 53. 955-64.

Korea Ministry of Environment (Korea MOE) (2002) The Act on the Promotion of Conservation and Recycling of Resources (Revised by Korea MOE)

Korea Ministry of Environment (Korea MOE) (2007) The Act on the Resource Recycling of Waste Electrical Electronic Equipment (WEEE) and End-of-life Vehicles (ELVs)

- Liu, X, Tanaka, M, Matsui, Y. (2006). *Electrical and electronic waste management in China: progress and the barriers to overcome*. Waste Manage Res. 24. 92-101.
- Musson, S, Vann, K, Jang, Y, Mutha, S, Jordan, A, Pearson, B, Townsend, T. (2006). *RCRA toxicity characterization of discarded electronic devices*, Environ Sci Technol. 40. 2721-26.
- Ongondo, F, Williams, I, Cherrett, T. (2011). *How are WEEE doing? A global review of the management of electrical and electronic wastes*, Waste Manage. 31. 714-730.
- Robinson, B. (2009). *E-waste: An assessment of global production and environmental impacts*, Sci Tot Envir . 408. 183-191.
- Spalvins, E., Dubey, B., Townsend, T. (2008) *Impact of electronic waste disposal on lead concentrations in landfill leachate*. Environ Sci Technol 42(19). 7452-7458.
- Townsend, T., Jang, Y., Ko, J., Pearson, B., Spalvins, E., Wadanambi, L. (2003). *Assessment of true impacts of e-waste disposal in Florida*. Prepared for the Florida Center for Solid and Hazardous Waste Management. Gainesville, FL.
- Wath, S, Vaidya, A, Dutt, P., Chakrabarti, T. (2010). *A roadmap for development of sustainable E-waste management system in India*, Sci Tot Envir. 409. 19-31.
- Wong, M., Wu, S., Deng, W., Yu, X., Luo, Q., Leung, A., Wong, C., Leung, A., Wong, C., Lukseburg, W., Wong, A. (2007). *Export of toxic chemicals-A review of the case of uncontrolled electronic-waste recycling*. Environmental Pollution. 149. 131-140.
- Yang, J, Lu, B, Xu, C. (2007). *WEEE flow and mitigating measures in China*. Waste Manage. B136. 501-512.