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Comprehensive Study of Waste Management Policies & Practices in Korea and Recommendations for LDCs and MICs

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UNDP

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Abbreviations and Acronyms

BTO	Build-Transfer-Operate
BTL	Build-Transfer-Lease
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
EU	European Union
EPR	Extended Producer Responsibility
ERP	Enterprise Resource Programme
ECOAS	Eco-Assurance System
FS	Feasibility Study
FIT	Feed-In-Tariff
IPP	Integrated Product Policy
GoK	Government of Korea
GHG	Greenhouse Gas
K-eco	Korea Environment Corporation
KMOE	Korean Ministry of Environment
KRW	Korean Won
KIPA	Korea Institute of Public Administration
KIPO	Korea Intellectual Property Office
LDCs	Least Developed Countries
LFG	Landfill Gas
MICs	Middle Income Countries
MOE	Ministry of Environment
MBT	Mechanical and Biological Treatment
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MERS	Middle East Respiratory Syndrome
MRG	Minimum Revenue Guarantee
NWMP	National Waste Management Plan
O&M	Operation & Maintenance
PPP	Public-Private Partnership
ROHS	Restrictions on Hazardous Substances
RoK	Republic of Korea
RFID	Radio Frequency Identification
RDF	Refuse Derived Fuel
STPs	Sewage Treatment Plants
VBWF	Volume-Based Waste Fee
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization
WtE	Waste to Energy

I. Introduction

The objective of this report is to study the policies and practices on the management of Municipal Solid Waste (MSW), e-waste and industrial waste in the Republic of Korea (RoK), covering the aspects of reducing waste generation, increasing recycling and resource recirculation. It further investigates the status of food and medical waste management and waste-to-energy practices in Korea and provides recommendations for Least Developed Countries (LDCs) and Middle Income Countries (MICs). The report concentrates on (i) the analysis of Korea's policies and practices in the waste management sector, especially how to reduce waste generation and increase the recycling rates, (ii) thorough research on current practices towards technical and financial sustainability in the waste management related programs as applied in developing countries. It is based on the desk review of relevant materials, information, and personal experience in Korea and a number of developing countries.

During the last 50 years, as a result of industrialization and urbanization, Korea has achieved rapid economic development. With economic growth, environmental pollution issues have escalated very quickly and environmental rehabilitation became an urgent task of the Government of Korea (GoK). To deal with emerging challenges, the GoK introduced several environmental management policies and instruments to cope with pressing environmental issues. Among them, those related to the waste management sector are analyzed for LDCs and MICs.

Due to excess waste generation and a shortage of landfill sites, Korea had also experienced difficult times. The GoK has introduced a number of policies to tackle these issues, trying to carry out sustainable resource management practices focusing on waste management and resource recirculation. As a result, Municipal Solid Waste (MSW) management has improved significantly with high waste recycling rates and low landfilling rates, leading many developing countries to visit Korea to learn and study experiences and successful cases in this particular sector.

Table.1 Waste management policies in Korea

Reduction	Reuse and recycling	Safe disposal
• Restriction for usage of disposal products • Suppression of packaging waste generation • Waste Charge System (applicable to products not easy to recycle or containing hazardous materials) • Volume-based waste fee system • Food waste reduction campaigns and food waste recycling	• Separate waste collection at the source and free collection for recyclable wastes • Extended Producer Responsibility (EPR) system • Separate disposed mark system • Support for recycling industry • Mandatory recycling and use of construction wastes (concrete and asphalt)	• Allbaro (E-manifest) system for hazardous, medical and construction wastes • Inspection system for landfills and incineration plants • Post-management system for waste treatment facilities • Management for neglected waste

Source: Compiled by the author with reference to the *Environment White Books* from 2008 to 2014, KMOE

To achieve waste management goals in Korea, the core measure is to promote "3R" (Reduce, Reuse, and Recycle). The 3R approach contains several successful policies and practices such as "Volume-Based Waste Fee (VBWF) system", "Extended Producer Responsibility (EPR)" and "Allbaro (e-manifest system)". In Korea, the waste recycling rate has increased substantially during the last 20 years following the introduction of VBWF system, free collection for recyclable waste, the EPR system, etc.

Efforts to resolve environmental problems associated with rapid economic development are recently gaining more attention in various countries. Within this area, the main goals of waste management are to provide a clean and safe environment to people and to conserve the environment by minimizing waste generation, increasing waste recycling and disposing of waste in an environmentally sound manner. The objective of this report is to help facilitate the introduction of advanced waste management policies, while minimizing expected trials and errors for other countries that wish to adopt the MSW management system based on the progress achieved and performance of waste management practices in Korea.

II. Korean experience in Municipal Solid Waste management

2.1. Volume-Based Waste Fee system

The waste disposal services in Korea until mid-1990's were performed using the traditional method of 'collection and landfilling', similar to other developing countries. This traditional waste management approach was no longer an efficient way to accommodate rapidly increasing MSW resulting from industrialization and urbanization. In order to tackle MSW problems and reduce waste generation, the GoK introduced several market-based policies and instruments. Among them, the VBWF system is well known as a basis and a fundamental policy on MSW management in Korea.

Background. Rapid industrialization and urbanization during the 1960's through 1990's in Korea had resulted in substantial increase of waste generation, causing environmental pressures on the relatively small land area of the Republic of Korea. Municipal Solid Waste (MSW) generation had increased significantly in early 1990s and most of the waste was disposed of at landfill sites. The total amount of municipal waste generation was 83,962 tons/day in 1990, 92,246 tons/day in 1991 and 75,096 tons/day in 1992. About 93 percent out of the total quantity of solid wastes was dumped into the landfills in 1990, and about 89 percent in 1991 and 1992*. Since the early 1990's, construction of new landfills had become more and more difficult because of the 'not-in-my-backyard' (NIMBY) phenomenon resulting in complicated procedures for securing landfill sites, rising public concern for better living and a cleaner environment, and owing to concerns regarding a drop in land price and civil complaints against construction of new landfills.

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* Source: *Korea Environmental Policy Bulletin*, Updated Version of Issue I, Volume I, Jan. 2006, KMOE

Until 1994, a waste tariff system in Korea was set up as a monthly lump-sum fee system. Under this fixed-tariff system, the cost per each household remained constant regardless of the amount of waste disposal. The analysis revealed that the fixed tariff system contributed to acceleration of waste generation as most of citizens did not care about the amount of waste generated or about disposal costs.

Introduction of VBWF system. To reduce waste generation at the source, and to maximize the waste recycling rate, the Korean Ministry of Environment (KMOE) introduced the VBWF system in 1995. The main objective of the VBWF system is to impose waste treatment costs on each polluter according to the amount of waste disposed of. Free collection services for recyclable waste were provided to prevent a sharp increase of tariffs and encourage the collection of recyclable wastes. By providing free collection for recyclable waste, the VBWF system induces the public to be more active in waste separation at the source. Under the VBWF system, households and small sized commercial enterprises purchase plastic bag in advance to dispose of their waste. Waste tariff, consequently, was charged in proportion to the amount of disposed waste.

The target waste under the VBWF system is waste generated by households and the small commercial sector.

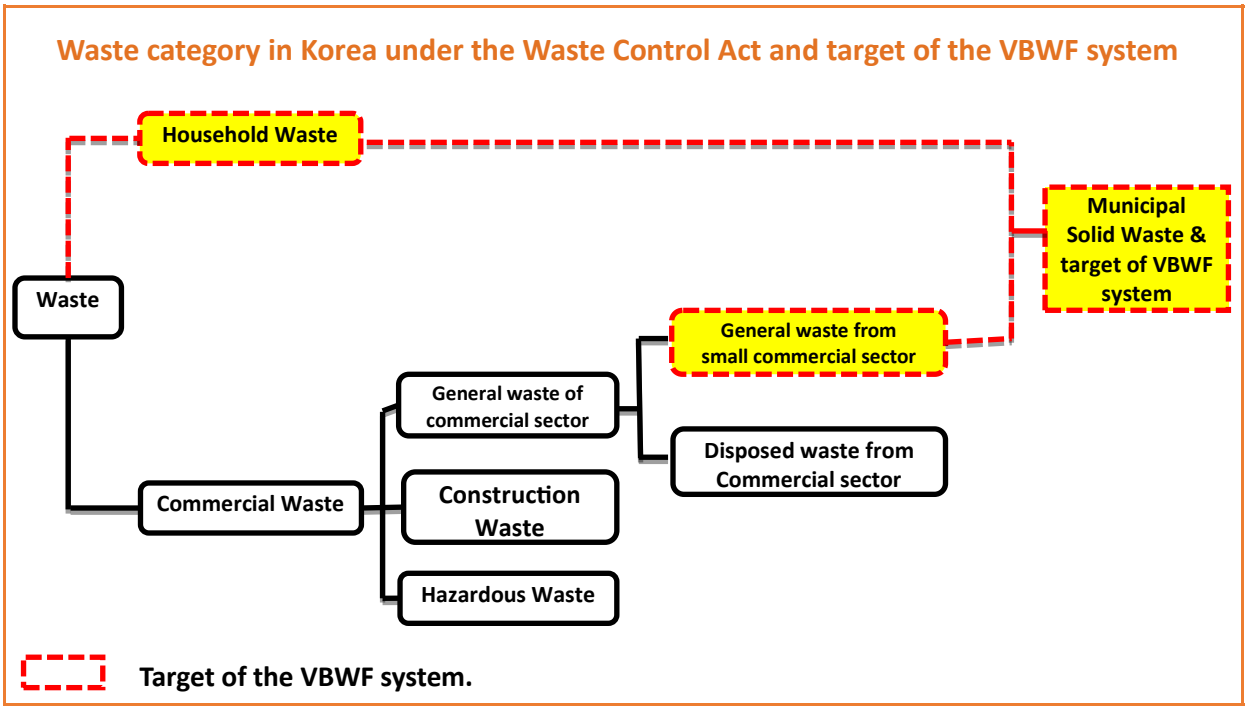

Figure.1 Waste category in Korea under the Waste Control Act and target of the VBWF system

Source: Compiled by author on *Korea Environmental Policy Bulletin* "Volume-based Waste Fee System in Korea", KMOE, 2003

Under the VBWF system, wastes generated by households and the small commercial sector are disposed of according to the following four methods:

a) Garbage (or mixed and dirty waste) is disposed of using standard plastic bag ("VBWF bag") of vari-

ous sizes purchased from supermarkets, grocery stores etc. The costs related to waste collection, transportation, and disposal is included in the price of a VBWF bag. The price of VBWF bag is determined by the local government based on disposal costs.

b) Food waste must be disposed of and collected separately from garbage in the VBWF bag as well as recyclable wastes. Since 2013, the VBWF system also covered food waste.

c) Recyclable materials are collected separately free of charge by local government or private haulers in single house area at a designated time and place. However, in apartment complexes or large public entities, recyclable wastes are sold directly to private recycling companies.

d) Bulky wastes such as home appliances and furniture are disposed of separately. Residents must purchase stickers according to the size and materials in advance from local government offices or private haulers and attach them to the wastes to be disposed of. Local government collects bulky wastes only when the stickers are attached.

Efforts to prevent illegal dumping. When the waste is disposed of without designated VBWF bags or there are cases of illegal incineration, a maximum fine of KRW 1million (around USD 900) can be imposed on the violator. Enforcement tools can be applied to the violator in the form of mandatory education on disposal practice and delayed waste collection services. To monitor any such illegal behavior, supervision-specialists are employed for periodic monitoring, while municipalities also operate special reporting centers. Monitoring and crackdown measures for illegal dumping are executed by civil servants and CCTV was installed at places most vulnerable to illegal waste disposal.

Checking the content of non-standard bags by public officials to find evidence of violator's identity

Illegal dumping monitoring by surveillance camera

Figure.2 Monitoring and crackdown for illegal dumping

Source: *KSP report of the VBWF system in Korea,* p77~78, KMOE and Korea Environment Institute, 2012

Effects of the VBWF system. After the implementation of VBWF system in 1995, the MSW generation declined dramatically. The quantity of MSW generated fell from 58,118 tons/day in 1994 to 47,774 tons/day in 1995 showing a 18% reduction and the recycling rate increased by 27% compared to the

previous year, 1994.

Table.2 Change in the Waste Generation Quantities, 1994-1995

Item	1994	1995
Total (tons/day)	58,118	47,774 (82.2%)
Recycled (tons/day)	8,927	11,306 (126.6%)
Per capita generation (kg/person/day)	1.3	1.05 (80.8%)

Source: *Korea Environmental Policy Bulletin,* Volume-based Waste Fee System, KMOE, 2003

After 10 years of VBWF system implementation, the system proved to be very effective and successful policy in limiting MSW generation and increasing the recycling rate. Between 1994 and 2004, MSW generation decreased by 14 %, while, at the same time, the recycling rate has increased from 15% in 1994 to 49% in 2004. Another important factor substantially reducing MSW generation in the beginning of 1990's was the heating fuel change from coal briquette to oil and natural gas*. Total amount of MSW generation in 1990 was 84 million tons, a third of which was coal briquette ash. Excluding briquette ash, the generated amount of MSW was 57 million tons in 1992 (total MSW generation - 75 million tons) and 53.6 million tons in 1994 (total MSW generation - 58 million tons).

Figure.3 Waste Generation Status Before & after Introducing VBWF system (Unit: thousand tons/day)
Source: *Environment Statistics Year Book*, KMOE

The amount of waste buried at landfills or incinerated decreased from 85% in 1994 to 41% (landfilling - 16% and incineration - 25%) in 2014, while the amount of recycled waste has increased significantly. During this period, the net recycling rate rose from 15% in 1994 to 59% in 2014 and the landfill rate drastically fell from 81% to 16%. Waste generation per capita also dropped from 1.33 kg/capita/day in 1994 to 0.95 kg/capita/day in 2011.

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* Source : Dr. Kwang-yim, Kim (KEI), Waste prevention indicators in Korea - Test results of proposed OECD indicators, KMOE, 2005

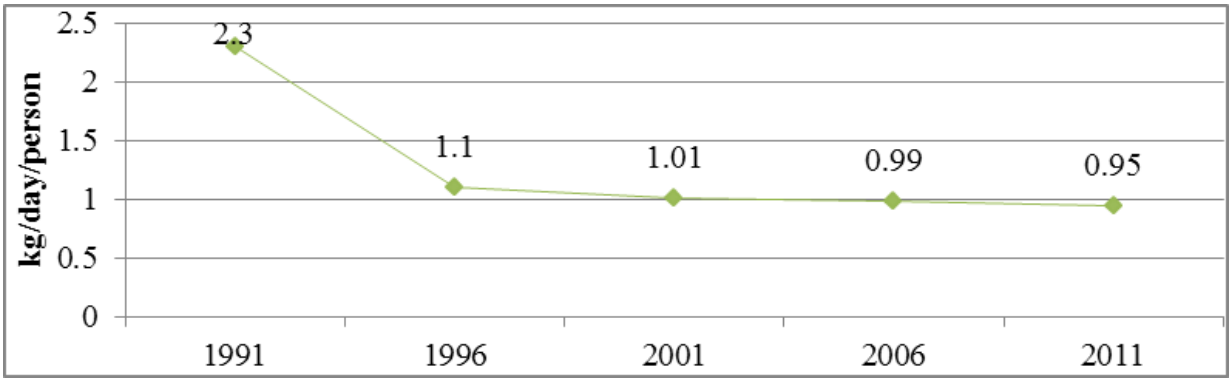

Figure.4 Changes of unit rate for domestic waste generation (kg/day/person)
Source: *Environment Statistics Year Book,* KMOE

The results of the VBWF system are summarized in Table 3 below.

Table.3 Comparison of waste management in Korea before & after the introduction of VBWF system

Item	Before (~ 1994)	After (1995 ~)	Remarks
Waste disposal stream (MSW)	Mixed waste	Garbage in VBWF bags, Food waste, Recyclable waste Bulky waste	
Tariff	Fixed tariff based on building area or property tax	Reflected in the VBWF bag based on "Polluter pay" principle	
Share of cost of cleaning covered by income	14.8% (1994)	26% (2014)	Seoul : 46% Jeju : 12%
Waste generation per person per day	1.33 kg (1994)	0.95 kg (2011)	MSW
Recycling rate	15.4% (1994)	59.0% (2014)	MSW
Landfilling rate	81.1%(1994)	15.7%(2014)	MSW
Economic benefits	-	KRW 19,560 billion (USD 17.8 billion) until 2012	USD 1 = KRW 1,100

Source: Compiled by the author with reference to the *Environment Statistics Year Book* on the VBWF system, KMOE (2012); VBWF system in Korea (2011), p.95; Modularization of Korea's Development Experience, KMOE and Korea Environment Institute (KEI) (2012); and Research on evaluation of VBWF for 20 years and improvements, KMOE and KEI (2014)

Successful factors for the VBWF system. The VBWF system could not succeed without implementation of relevant practices. Free collection of recyclable wastes, development of recycling industry can be considered as successful auxiliary factors including efforts of KMOE and municipalities to familiarize themselves with the new system.

a) **Free collection for recyclable waste.** Separate collection of recyclable waste is mandatory in Korea. Recyclable wastes are collected free of charge with services provided by the municipalities in parallel with the VBWF system implementation. According to the Waste Control Act in 1995 and the Guidelines for the VBWF system, MSW should be disposed of separately at the source from general garbage using a VBWF bag for recyclable waste, food waste and bulky waste. Free collection service was an incentive for households to separate recyclable items, encouraging the public to be more active in waste separation and promoting waste recycling.

Table.4 Waste collection under the VBWF system

Source: *The 1st Stage Master Plan of Resource Recirculation*, KMOE (2011)

Source	Type of wastes	Use of VBWF bag	Charge of collection
Households & Small commercial sector	Garbage (Mixed waste)	Yes	Yes
	Food waste	Yes	Yes
	Recyclable waste	No	No (Free of charge)
	Bulky waste	No	Yes

Table.5 Sorting facilities for recyclable wastes in Korea (2010)

※ *Note: According to the Environment Statistics Year book in 2014 of KMOE, total number of waste recycling companies in private sector was 1,234 with capacity of 74,468 tons/day and the total amount of recycled waste was 3,502,817 tons/year (≒9,596 tons/day).*

Public sector			Private sector		
Number of facilities	Capacity (ton/day)	Sorted amount (ton/day)	Number of facilities	Capacity (ton/day)	Sorted amount (ton/day)
217	4,723	2,676	524	60,291	8,486

Source: *The 1st Stage Master Plan of Resource Recirculation* (2011~2015), p21, KMOE (2011)

b) **Assistance for developing a recycling industry.** The recycling industry is the foundation for a sustainable society that uses resource circulation. Due to the introduction of the VBWF and the EPR system, the resource-recycling businesses in South Korea have been growing rapidly. The number of recycling companies increased significantly from 2,941 in 2001 to 5,372 in 2014, employing a total of 136,666 people*. Financial support from the government is provided to the private sector in assisting the growth of waste recycling industry. The KMOE provides long-term loans with a low interest rate to small and medium-sized recycling companies for the development of recycling

* Source: *Environment Statistics Year Book* about Waste Recycling, KMOE

technologies and facilities. As part of its green growth initiatives, the South Korean Government had allocated a total of 930 billion Korean won (KRW) (around USD 808 million) for investment in projects related to the recycling of waste resources from 2009 to 2012, which, as estimated, enabled the creation of about 16,196 new industry jobs.

In support of developing the recycling industry, KMOE has allocated a total of 103.6 billion KRW (around USD 94.18 million) in 2016 with an interest rate of 1.51% for a maximum period of 10 years for the waste recycling investment activities. It is expected that this initiative will help to create new jobs and promote the use of recycled products. In order to increase the use of recycled products, the national and local governments and government-related public institutes must purchase some portion of environmentally-friendly products (including recycled products) in accordance with the *Act on the Encouragement of Purchase of Environment-Friendly Products.*

Table.6 Conditions of the fund for recycling industry development in 2016

Total fund amount	Supporting area	Number of beneficiaries	Average supporting amount	Loan period	Interest rate
KRW 103.6 Billion	Facility	81 (81 applied)	KRW 537 mln (total 43.5 Billion)	10 years including 3 years of grace period	1.51% (Variable)
	R&D	1 (1 applied)	KRW 895 mln (total 0.9 Billion)		

Source: 2nd *Quarter Notice for Environment Policy Fund*, Korea Environmental Industry & Technology Institute, 2016

c) **Promoting public awareness and change of behavior.** The changes introduced to the waste collection services and tariff system for MSW management resulted in complaints from residents. This in turn resulted in the need to hold well-planned public promotion campaigns to raise awareness and implement the VBWF system. Korean Ministry of Environment (KMOE) carried out a number of public promotion campaigns using TV advertisements, newspapers, TV discussions and distribution of promotional materials such as VCR tapes, brochures, and posters. Additionally, public hearings, workshops with the relevant civil servants, seminars, and symposiums* are organized on a continuous basis. Through upstream activities, KMOE and municipalities tried to improve the VBWF system, focusing on the quality and standard of waste disposal bags and the establishment of the detailed guidelines of the system. They also tried to introduce measures to collect recyclable materials at the right time and prevent mixing with general waste, as well as guidelines related to charging penalties and imposing fines. As a result of public campaigns and continuous efforts of KMOE and municipalities, residents were familiarized with and encouraged to use VBWF bags for waste disposal.

d) **Challenges of VBWF system.** Waste tariff rate is still insufficient to cover costs of waste management despite VBWF system implementation. According to the KMOE, tariff realization rate** was

* Refer to *Volume Based Waste Fee System* in Korea, p 60. 2012, KOME and KEI

** Tariff realization rate : current tariff / actual waste treatment costs.

24.9% in 2013. The low tariff acted as a financial burden on each municipality. Consequently, KMOE and municipalities have been trying to increase the price of VBWF bags.

Table.7 Tariff realization rate (2012-2014) and tariff variation in Seoul (2015-2017)

Tariff realization rate	2012	2013	2014
Average in Korea	25.2%	24.9%	26.3%
Seoul	39.9%	39.0%	46.4%
Tariff variation in Seoul	**2015**	**2016**	**2017(announced)**
Tariff (KRW, for 20 L VBWF bag)	350 (100%)	440 (↑25%)	490 (↑40%)

Source: Compiled by the author with the reference to the *Environment Statistics Year Book on VBWF System,* KMOE and at http://mulga.seoul.go.kr/info/charge01.jsp

2.2. Food waste recycling

Food waste for a long time has been a significant problem in South Korea, especially given the need for large number of small dishes for its traditional food. Food waste does not only include throwing away cooked food, but also all food wastes across production and distribution channels. Koreans are known for their dining traditions, and changing this dining culture is difficult. These cultural peculiarities were contributing to the gradual increase of food waste generation.

Efforts to reduce food waste generation. Over the years, the Government of Korea has launched various programmes aimed to raise public awareness on food waste disposal practices and reduction of food waste generation. A nation-wide campaign called 'Food Table with Less Waste' was introduced in 1992. Restaurants were encouraged to use less and smaller size side-dish plates and adopt eco-friendly menu; cafeterias in public institutions were encouraged to hold a "no-leftover day" once a week. School canteens were guided with the expected food demand while service bars in rest areas along highways offered different menus for standard and small food meals. The Korean Ministry Of Environment also cooperated with the Korea Hotel Association and the Korea Restaurant Association to promote waste reduction at the 'before and after' consumption stages. The ministry additionally carried out various activities, including TV and radio campaigns to encourage food waste reduction and everyday action plans. In collaboration with other relevant ministries, it executed a food waste reduction project by signing agreements with various stakeholders for voluntary cooperation. The sectors included restaurants, hotels, schools, rest areas along highways, etc. However, food waste, which is primarily generated by households and small restaurants, has continued to increase annually as a consequence of increased income and persistent consumption patterns, by 3% from 11.4 thousand tons/day in 2000 to 15.1 thousand tons/day in 2008.

Table.8 Food waste share in MSW (1998-2008)

Item	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
MSW(tons/day)	44,583	45,614	46,438	48,499	49,902	50,737	50,007	48,398	48,844	50,346	52,072
Food waste (t/d)	11,798	11,577	11,434	11,237	11,397	11,398	11,464	12,977	13,372	14,452	15,142
Portion of food waste in MSW (%)	26.5	25.4	24.6	23.2	22.8	22.5	22.9	26.8	27.4	28.7	29.1

Source: *Environment White Book of 2010, p550*, KMOE, 2011

Ban on direct landfilling of food waste and separate collection. At the time of the VBWF system introduction in 1995, food waste was disposed of with other solid wastes using VBWF bags. However, since most of food waste is soggy, it creates a foul odor, generates of a large amount of leachate at landfills and decreases incineration efficiency. One of the best solutions for food waste, which contains a high level of organic matters and nutrients, is to process it, deriving value from these organic resources. As food waste is a major source of greenhouse gas (GHG) emissions and environmental pollution during the decomposition stage, since 2005, KMOE banned direct landfilling of food waste to overcome the landfilling problems and to improve the recycling rate. Following the regulation, food waste has been collected separately using food waste-only collection bins or food waste-only bags. At its initial stage since 1997, separate collection and recycling requirements for food waste were enforced mainly for large-scale food waste generators such as restaurants and group-meal facilities, and since 2005 this system has been expanded to small-scale generator and households.

Table.9 Current food waste management status in Korea

Item	Households and small-scale restaurants	Large-scale restaurants and group-meal facilities
Waste Disposal Responsibility	Municipality	Owner of facility
Collection and transportation	Municipality	Private company under the contract with owner of the facility
Treatment Capacity (Num. of facility)	Total 308 facilities with 19,425 t/d in 2015 [Public - 99 facilities with 7,585 t/d, Private - 209 facilities with 11,840 t/d]	
Criterion for large scale food waste generator : over 300 kg/day		

Source: *Food Waste Treatment Facility Status of 2015*, KMOE, 2016

Recycling: Following the continuous public awareness campaigns related to the separate disposal and collection of food waste and promotion of food waste recycling, the rate of separate collection of food waste at the source increased from 81% in 2004 to 97% in 2005. The recycling rate increased from 81% in 2004 to 94% in 2005. To further promote recycling, the government provided financial support for the expansion of public and private recycling facilities that process food waste into animal feed and compost for fertilizer and bio-mass.

Table.10 Food waste recycling status in Korea, 2011

Disposal Method	Recycling				Landfilling	Incineration
	Total	Animal feed	Composting	other		
Amount (t/d)	12,905	6,291	5,237	1,377	167	465
Share (%)	95.3	46.4	38.7	10.2	1.2	3.4

Source: Korea Food Recycling Association, www.kofra.org, last accessed 12 May, 2017

The number and capacity of food waste treatment facilities increased drastically in late 1990s, especially in the private sector.

Table.11 Food waste recycling facilities in Korea (1997-2010)

Facility		1997	1998	1999	2000	2003	2005	2007	2010	2015
Total	Number	46	167	231	233	262	256	255	259	308
	Capacity (t/d)	1,076	3,178	4,228	5,195	9,815	13,364	15,569	17,502	19,425
Public	Number	32	50	73	80	80	90	95	98	99
	Capacity (t/d)	547	1,007	1,223	1,905	2,945	4,198	5,340	6,554	7,585
Private	Number	14	117	158	153	182	166	160	161	209
	Capacity (t/d)	529	2,171	3,005	3,290	6,870	9,166	10,229	10,948	11,840

Source: compiled by the author with the reference to the *Report of Food Waste Disposal, Management and Treatment Status*, p. II -25, KMOE & K-eco, 2010 ; and the *Food waste treatment facility status* of 2015, KMOE, 2016

Volume-Based Food Waste Fee System. Nationwide, around KRW 800 billion (approx. USD 727.2 million) is spent annually on food waste disposal. In 2010, KMOE and 7 municipalities launched pilot projects for "Volume-Based Food Waste Fee System". As a result of the pilot project, food waste generation in Gimcheon city decreased by 54% from 26.5 tons in 2010 to 12.3 tons in 2012. Based on the results of the pilot project, KMOE launched a "volume-based food waste fee system" nation-wide to limit food waste generation at the source since 2013. With consideration of local conditions, local governments can choose how to measure the weight of disposed food waste and how to impose tariff based on following three options: (i) Pre-paid Garbage Bags, (ii) Pre-paid Chips or Stickers, and (iii) Radio Frequency Identification (RFID) Tags.

Standard plastic bag	Payment chip	RFID tag
		
Specially designed and distinctively colored pre-paid garbage bags	Standardized disposal containers with a pre-paid chip or sticker.	Disposal booths that are equipped with magnetic card reader and weight measuring device

Figure.5 Implementation options for volume-based food waste fee system

Source: Compiled by author using internal Report on *Volume-Based Food Waste Fee System*, K-eco, 2015

Radio Frequency Identification (RFID) Tag: Food waste weight can be measured at specifically designed food waste disposal bins that are equipped with a magnetic card reader and weight measuring device. Each household is given a magnetic card that contains information about them. When the households dispose of their food wastes, they touch the card reader with their card and the household information is read. The waste weight is then measured and the information is transmitted to a centralized online management system. The monthly disposal data serves as the basis for charging fees to each household.

Challenges of food waste recycling: Food waste recycling rate is over 95% and is considered as the maximum attainable rate for food waste recycling. However, the quality of food waste recycling cannot be considered as optimal. Among 124 available animal feed facilities to treat food wastes, only 9 facilities were selling products and receiving money, while among 86 existing composting facilities, only 24 were selling their products to farmers. Most public facilities are providing the products for free and this causes operational deficit for the facilities. Since 2012, to enhance the final product quality of food waste recycling facilities, KMOE has tried not to use plastic bags for food waste disposal. The use of plastic bags is temporarily allowed for a limited period of time, e.g. when large amount of food waste is generated during holiday periods.

2.3. E-waste recycling

In the last several decades, Korean industries were developing very quickly, especially in the field of high technologies to produce electrical and electronic equipment and products, including televisions, computers, refrigerators, air conditioners and mobile phones. These are all categorized as *E-waste* with its components and parts having a high value compared to traditional MSW. At the same time, Korean industries always have been suffered from high dependency on imported energy and resources. As a result, to address some of those issues, recycling of e-waste was put on the agenda to recover energy and resources. Korea Ministry of Environment (KMOE) has tried to improve recycling activities including, collection system and recovery center with the facilities through introduction of the Extended Producer Responsibility (EPR) system in 2003 and Eco-Assurance System in 2008 for the regulation of e-waste.

Table. 12 Generation and recycling amounts of e-waste, unit: 1,000 ton

Year	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Generation amount	504	596	596	659	662	713	592	641	634	623	595
Recycled amount	58	66	80	93	107	113	118	133	126	-	158
Recycling Rate (%)	12	11	13	14	16	16	20	21	20	-	27

Source: Seung-Whee Rhee, "Beneficial use practice of e-wastes in Republic of Korea" *at the 10th International Conference on Waste Management and Technology* (ICWMT), 2014

2.3.1 Extended Producer Responsibility system

Background. To use limited resources efficiently, it is essential to save the resources and then to recycle as much of the recyclable materials as possible. In recognition of these needs, the KMOE has been making efforts to utilize the recyclable waste and establish a resource circulation society. *The Act on the Promotion of Saving and Recycling of Resources (the Act)* came into force in 1992, aiming to reduce waste at the source and improve resource circulation by clearly defining the responsibilities and obligations of the stakeholders (government and producers) throughout the entire product cycle.
Under the Act, a "deposit-refund" system was introduced in 1992 to increase the recycling rate of certain products and further to promote a "recycling society". The "deposit-refund" system was designed to involve producers to play a role in end-product recycling. Producers had to pay a certain deposit fee per product in advance as determined by the government, which could then be paid back to them upon proof that the end-product has been recycled. Since the amount of the fee determined by the government was much lower than the actual recycling cost, the "deposit-refund" system in Korea failed to motivate producers to improve end-product recycling rates. The KMOE, therefore, introduced an alternative "Extended Producer Responsibility" (EPR) system in January 2003.

Rationale and key drivers. EPR system in Korea was introduced to address the following issues:

a) *Limited space for landfill sites*: a driver for recycling initiatives;
b) *International regulations and agreements*: compliance with EU ROHS (Restrictions on Hazardous Substances) and WEEE (Waste Electrical and Electronic Equipment) regulations;
c) *Resource scarcity*: both resource depletion and the increasing price of resources have played a role to recycle valuable materials in wastes.

Korean EPR system. When the EPR system came into force, there was strong opposition from producers due to the financial and physical burden related to end-product recycling. The government attempted to convince producers that the EPR system would not only increase recycling rates, but also they would benefit from the improvement of product design, enhancing the concept of "Design for the Environment".
The EPR system in Korea was focused on packaging materials such as metal cans, glass bottles, PET bottles, plastics, and household appliance products such as TVs, refrigerators, washing machines, air conditioners, personal computers, hi-fi systems, fax machine and mobile phones. Under the Act, the mandatory rate of waste recycling under the EPR system has been levied for the producers and importers of those products. Following the EPR system, the producer or the importer should meet the mandatory waste recycling rate, which was agreed between the government and the producer and importer. If producers or importers do not fulfil the mandatory recycling rates, a fine shall be imposed. The fine is calculated based on the recycling shortfall multiplied by 115 to 130 percent of the standard recycling cost calculated by the KMOE.

Since 2008, wastes of electric and electronic products among the EPR items have become subject to *Eco-Assurance System* under the *Act on the Recycling of Electrical and Electronic Equipment* to enhance

the E-wastes recycling rate and to control the restrictions on the use of hazardous substances. As of 2012, the targeted items under the EPR system included four types of packaging materials (paper packs, metal cans, glass bottles and plastics) and five types of products (lubricants, batteries, tires, fluorescent lamps and Styrofoam float for aquaculture). Products and packaging materials, classified as the EPR target items, are defined by the Article 18 of *the Enforcement Ordinance of the Act on the Promotion of Saving and Recycling of Resources*. Table 13 shows each entity's role under the EPR system.

Table.13 Roles of each entity under the EPR system in Korea

Entity	Roles
Consumer	- Thoroughly separate and properly dispose of recyclable goods
Producer	- Fulfill the responsibility of recycling individually or by joining a Producer Responsibility Organization (PRO)
Local Government	- Separate collection of target items of EPR
Korea Environment Corporation (K-eco)	- Collect and approve the sales & import records and the responsibility fulfillment plan of producers - Accept the fulfillment report and verify/inspect performance - Manage administration and oversight related to EPR operation, including recycling charges
KMOE	- Operate the overall EPR Program, and support the enactment and revision of laws, regulations and guidelines - Calculate and announce the recycling target rates for each item

Source: Leaflet of EPR system in 2012, p.5 "Role of each Entity", KMOE

The EPR scheme and its coverage in Korea are presented in Figure 6 and Table 15.

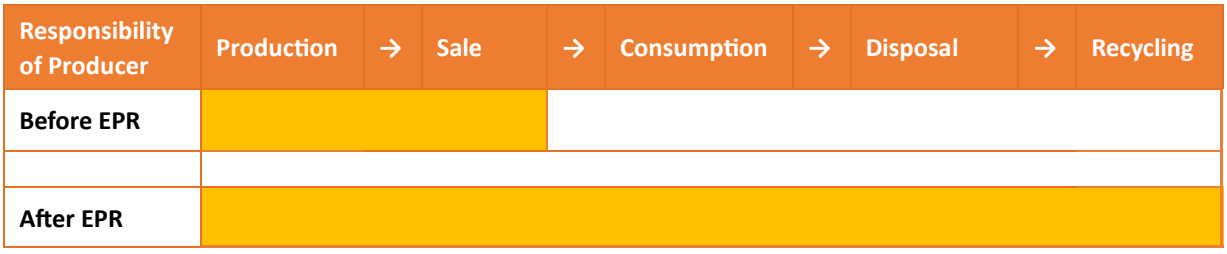

Figure.6 Producer responsibility before & after the EPR system implementation

Source: Leaflet of EPR system in 2012, p.5"Role of each entity", KMOE

Table.14 Target items of the EPR system in Korea

EPR	Target items	
Recycling targets	Packaging materials (4 types)	Iron cans, aluminum cans, glass bottles, paper packs, PET bottles, synthetic resin foam, polystyrene paper, PVC, plastic container, trays, plastic film and sheet type materials
	Products (5 types)	Lubricants, tires, mercury batteries, silver oxide batteries, lithium batteries, nickel-cadmium batteries, manganese batteries, alkali manganese batteries, nickel-hydrogen batteries and fluorescent lamps, Styrofoam float

Source: Leaflet of EPR system in 2012, p.7, KMOE

Comparison with EPR system elsewhere: The EPR system varies in Korea, Japan, Taiwan and China. There are also a range of different approaches, requirements and mechanisms that have been put in place under different national schemes. Schemes in Taiwan, South Korea and China have placed a financial responsibility upon producers, while the Japanese scheme places financial responsibility on consumers, and imposes the responsibility for specified end-of-life consumer goods on producers on registered recyclers for a fee.

Table.15 Comparison of product stewardship and the EPR schemes in selected Asian countries

Country	Japan	Taiwan	China	South Korea
Scheme	Product Stewardship	EPR	EPR	EPR
Year of introduction	1998-2000: Origins of legislation introduction.	1988: EPR incorporated into the Waste Disposal Act	2011 : Regulations on the Management of the Recovery and Treatment of Waste Electronic and Electrical Products*	2003 Product Recycling System
Product and material coverage	Packaging, electrical and electronic appliances	Electrical and electronic equipment	Electrical and electronic equipment	Electronic equipment, tires, lubricant, batteries, fluorescent lamps, packaging.
Requirements and mechanisms	Consumer responsibility to purchase recycling ticket that enables them to dispose of home appliances (consumers pay a higher price for the disposal of products that are more expensive to recycle). Producers are obliged to take back and recycle goods of particular types.	Producer has financial responsibility. Registered recyclers take physical responsibility for goods in return for a small subsidy. No contribution by producers is made on equipment that is exported.	Details to be determined. Manufacturers will pay fees to the central government fund.	Producer responsibility to meet recycling targets based on sales.

Source: Institute for Sustainable Futures, UTS, Briefing Paper, *Product Stewardship schemes in Asia: China, South Korea, Japan, and Taiwan*, July 2009.

* Refer to Jinhui Li, Jie Yang and Lili Liu, Development potential of e-waste recycling industry in China, *Waste Management & Research,* 2015, Vol. 33(6)

Achievements: Major achievements of the EPR system include increased recycling of waste and saved resources. The mandatory rate for the EPR products has been continuously increasing even though the actual recycling amount and rate did not meet expectation. Table 17 and table 18 show the recycling performance under the EPR system. According to the K-eco, comprehensive recycling performance has been meeting the target since introducing the EPR system. However, the performance rates for each item varied from 50% (silver oxide batteries) to 117% (plastic packaging materials) in 2014.

Table.16 Recycling performance under the EPR system

Year	Production (ton)	Mandatory (ton)	Recycling (ton)	Performance (%)
2011	1,991,803	1,295,031	1,400,842	108%
2012	2,007,286	1,346,073	1,377,269	102%
2013	2,048,910	1,363,637	1,419,118	104%
2014	2,231,774	1,497,243	1,562,586	104%

Source: *Handbook of the EPR system*, K-eco, Korea, July 2016.

Table.17 Various items' recycling performance under the EPR system (in percent of mandatory recycling rates)

Year	Paper packs	Glass bottles	Metal Cans	Plastic packing materials	Battery						Tires	Lubricants	Fluorescent lamps
					Mercury	silver oxide	nickel-cadmium	Lithium	nickel-hydro-gen	manganese and alkali manganese			
2013	98	99	111	113	-	50	89	78	45	40	96	99	87
2014	74	99	102	117		50	144	60	23	73	94	97	93

Source: *Handbook of the EPR system*, K-eco, Korea, July 2016.

2.3.2 ECOAS system

Background. Since early 2004, the KMOE carried out a feasibility study to introduce an "Eco-Assurance System (ECOAS)", which restricts the use of hazardous substances in electrical and electronic equipment. It also promotes recycling of E-wastes by applying a systemic management for life cycle analysis from cradle to grave similar in its effect to the Directives on waste electronic and electric equipment (WEEE) and Restriction of the use of Hazardous Substances (RoHS) in EEE in the EU.

This system encourages the minimization of environmental loads through systematic management of all processes from product design/manufacturing to disposal in order to manufacture electrical and electronic products that can be easily recycled. In case of vehicles, it restricts the use of toxic materials in such products, while promoting the recycling of the related waste materials.

Rationale and key drivers: The ECOAS system in Korea was introduced to address the following:

a) As the population grows and living standards improve, the electrical/electronic and automobile in-

dustries are growing rapidly, resulting in increases in the amount of waste generation by 6 to 7% per year.

b) To reduce environmental loads throughout the production processes. To promote the recycling of waste products, the EU and other international organizations are pursuing an IPP (Integrated Product Policy) based on the prevention rules and the "polluter pays" principle.

c) The EU enforces and follows strong environmental regulations such as a ban on imports if a company violates the standard related to the restricted use of toxic materials in electrical and electronics products and vehicles, and the standards related to recycling methods.

d) In order to comply with international regulations such as EU's RoHS Directive, it is required to restrict the use of toxic materials in the electrical and electronic products and vehicles, while promoting their recycling.

Korean ECOAS system: Since January 2008, the ECOAS system has been implemented under the *Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles,* for a joint legislation by the Ministry of Environment, the Ministry of Knowledge & Economy, and the Ministry of Land, Transport and Maritime Affairs. After introducing the ECOAS system, e-wastes had been separated from the EPR system to strengthen the promotion of recycling facilities within electronic industries. The ECOAS system in Korea was expanded to cover from 10 items of e-wastes in 2008 to 4 product groups and 27 items of e-waste including household small appliances such as electric fan, electric heater, iron, and air purifier, etc. in 2014.

Table.18 Target products of ECOAS system, 2016

Classification	Product Group	Target Products
Electrical· Electronic Products (27)	**1. Large Equipment(5)**	Televisions / refrigerators / washing machines (household) / AC /vending machines
	2. Communications Office Equipment (4)	Personal computers (including monitors and keyboards) / printers / copying machines / faxes
	3. Mid-sized Equipment(5)	Electrical water purifiers (including cooling/heating systems)/ electrical ovens / microwaves / food processors / dish dryers (including dishwashers)
	4. Small Equipment(12)	Electrical bidets / air purifiers / electrical heaters / audios (excluding portable) / electrical rice cookers / water softeners / humidifiers / electrical irons / fans (excluding ventilators) / blenders (including juicers) / vacuum cleaners / video players (limited to VCRs and DVD players)
	5. Mobile Phone Devices (1)	Mobile phone devices (including batteries and chargers)
Vehicles (3)		Passenger vehicles / van (9 persons or less) / freight trucks (light weight and small- less than 3.5t)

Source: *The Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles*, 2016

Challenges for e-waste recycling. The Korean ERR system has not promoted reuse market for old products, although these should be given higher priority than recycling in the waste management hierarchy.

In addition, there are no special measures to secure and enhance the reuse rate for reusable old products. As a result, it has been observed in producers' recycling facilities, that all collected old products are usually dismantled and further reprocessed or recycled without consideration of the possibility of reuse. Therefore, concerning the obligation to collect old products, the recycling target amount allocated to each producer should not be set too high. Otherwise, they may be tempted to collect and recycle old products that may otherwise still be functional.

2.4. E-Manifest system on Industrial and Medical waste

With industrial development and growth of population, industrial and medical waste generation, including hazardous waste, is also increasing. The issues of proper waste management needs have become a public concern due to growing waste generation, shrinking disposal capacity, rising disposal costs, and public opposition related to the land sites issues of new disposal facilities. Many communities are struggling to develop cost-effective, environmentally protective solutions.

Improperly managed hazardous waste poses a serious threat to human health and the environment. Hazardous waste is generated from many sources and may come in many forms, including liquids, solids gases, and sludge. Manifesting the industrial and medical wastes, including hazardous waste, is highly important. An effective waste disposal verification system establishes the basis of pursuing legal action against illegal waste management by tracking the whole process of waste generation, transportation, and disposal. This was done in Korea first by using paper vouchers, and subsequently using e-vouchers.

2.4.1 Korea Electronic-Manifest system—Allbaro

Background. The key component of the waste tracking system is the *Uniform Hazardous Waste Manifest*, which was developed by US Environmental Protection Agency in 1980. In the past in Korea, the manifest system was a paper document containing multiple copies of a single form. The users (generator, transporter, treatment facility) of paper document system had to make complex documents of waste handover, whenever the case happens, and the users had to report all of the procedures to each other and regulatory office the KMOE and local government. The conventional manifest system has revealed some difficulties and problems during its operation:

a) It was time consuming and also expensive because the vouchers were written by hand and then mailed. Every year 26 million vouchers (83 tons of mail) were used, with estimated cost of 1 billion USD. (refer to Dr. Hyun Soo, Joo, Korea Environmental Policy Bulletin, KMOE & KEI, 2008)*
b) It was inconvenient to fill out the handover statements at the site of waste transportation and treatment.
c) The handover statements were not the perfect solution to prevent illegal waste treatment, since

* Cost for manual manifest system, around USD 1 billion/year, was estimated based on the direct and indirect costs such as mailing costs, labor cost for inputting information on vouchers, etc.

the administrative body was unable to track the handover statements until the waste treatment process had completed, thereby only ex-post control was possible.

d) There was a lack of manpower to manage, check, and confirm the validity of the handover statements. It was impossible for one or two public officers at each environmental office to check and confirm all the handover statements. Also, there was no place to store the handover statements produced.

Given the above mentioned issues, the KMOE started to devise new techniques and systems to solve the limitations of the paper voucher system. The outcome was the development of an electronic waste manifest system, Allbaro. Allbaro is a combination of the words "all" and "barometer", meaning the barometer for all wastes. In Korean, it also means that all wastes are treated correctly.

Allbaro - online waste disposal verification system. Allbaro system was introduced by the KMOE in 2001 to replace the conventional system. In contrast to the paper voucher system, it allows for the entire waste disposal process to be accessed online and in real time. The system streamlined the treatment verification process and made it more efficient and less costly.

The system was designed taking into account the followings:

a) It can monitor waste management processes in real time and has a function to prevent illegal waste treatment and disposal.
b) It can reduce the burden of management and costs by digitization.
c) Public awareness, trust, and transparency regarding waste management should be improved.
d) Electronic waste handover statements should be able to check and confirm the process in real time.
e) It can read and store the information from generation to final disposal including detailed information of waste generators, transporters, and disposers.

Allbaro is composed of three parts: i) Handover system, ii) Approval and licensing, and iii) Analytical processing.

Allbaro System	
	**Handover system:** Waste generators, transporters, and disposers input information regarding the type of waste, amount, and date through the entire process, thereby ensuring that the entire process can be monitored online. When an error is made, it can be confirmed by the administrators. When waste is treated in an inappropriate way, administrators can monitor the situation in real time.
	Approval and licensing: Waste related approval and licensing can be applied for and provided online. The majority of users are industrial waste generating businesses such as general industrial waste businesses, infectious waste generating businesses (hospitals) and construction waste generating businesses, as well as waste transportation businesses.
	Analytical processing: The management of the electronic handover statements and approval and licensing systems can be analyzed using statistical analysis for the drafting of new policies and processes.

Figure.7 The Allbaro System
Source: Compiled by author based on Korean Environmental Policy Bulletin "Allbaro", p.5, KMOE, 2008

System development. The development of the Allbaro system has gone through six phases:

(a) Demonstrative operation → (b) Initial operation → (c) Establishment of the approval/licensing system and data analysis system → (d) Establishment of disaster recovery center and statistical analysis processing system → (e) Establishment of the digitized management system for construction and infectious waste → (f) Establishment of the Automated Response System (ARS) for compatibility between Allbaro and large waste generating companies, disability management, and Short Message Service (SMS) through mobile phones.

In details the phases include:

a) Phase One (2000-2001): Allbaro system, as a demonstrative operation, was used by a limited number of waste generators such as large generators and general hospitals.
b) Phase Two (2001-2002): As the system was implemented and enforced, roughly around 1,500 businesses handling waste, including hazardous waste, were encouraged to use the system.
c) Phase Three (2003): This system was expanded and used by 8,000 waste related entities. To provide better service for the increased number of users, an approval and licensing system was developed.
d) Phase Four (2004): Approximately 20,000 waste related businesses were encouraged to use the Allbaro system. During this period, special training courses were provided for new users and personnel in charge of waste management at the local government level. A disaster recovery system was established to ensure uninterrupted provision of services. In line with the approval/licensing system, a data analysis system was also developed.
e) Phase Five (2005): 45,000 businesses started to use the system. During this phase, the use of Radio Frequency Identification (RFID) technology was developed and operated for the treatment of hospital wastes, resulting in increased performance and reliability. The use of RFID tags and readers made the practice of illegal treatment almost impossible.
f) Phase Six (2006-2007): For the user's convenience, the ARS system was introduced so that people could use telephone and SMS instead of Internet. In addition, the connection system with big business places running their own system like Enterprise Resource Program (ERP) was introduced, and this resulted in the improvement of system efficiency and compatibility by eliminating the overlapping of two systems. When the *Waste Control Act* was amended, the use of electronic handover statements became mandatory for most businesses resulting in a total of 84,000 waste related entities registered as users.

Obstacles and Solutions. To familiarize with the new system and attain the objective of the Allbaro system, participation of stakeholders was crucial. However, during the early implementation stages, participation was not as high as expected. Early adoption of the system was low and slow due to reluctance to use the new system and its voluntary nature. In order to increase the number of users, MOE introduced a number of incentives and increased public relations, stressing that the Allbaro system would be cost effective and more efficient than the manual system.

The second problem was that it was incompatible with the existing systems - such as EPR - which were used by the large waste related businesses. As a result, personnel had to input the same data twice into two systems. Businesses began to complain of the added workload. To solve the emerging problem, a

conversion system was implemented so that data input was entered into one system and automatically loaded into the other systems. Once the different systems were capable of communicating with each other automatically, the use of Allbaro system increased significantly.

Korea MOE has been continuously promoting and improving the system, and as a result, the number of users has steadily grown. Modifications to the waste management system were developed using the following key strategies:

a) First, Allbaro users were composed of administrative bodies, waste generators, transporters, and disposers. Due to the different processes involved, education for those working in the various fields was different. Customized manuals for each group were prepared and distributed and training videos were made available on the Allbaro homepage for users who could not attend on-the-spot training courses. Furthermore, since waste related businesses are spread out all over Korea, instructors toured the country, making education available for users at all levels.
b) Second, a feedback system was established so that users could report problems, recommend improvements, and provide opinions. For the effective collection of opinions and recommendations, a number of features were built into the feedback system.
c) Third, a call center was established and was available 24 hours a day, and an online customer service center was built into the Allbaro homepage. Additionally, a customer consultant committee, consisting of personnel from administrative bodies, waste generators, transporters, disposers, academia, and NGOs, was launched to help frame and revise related laws and policies.
d) Fourth, Allbaro was expanded further by adding a feature to automatically produce annual accomplishment reports, which had to be submitted once a year. Mandatory waste management reports could also be completed by the system automatically.
e) Fifth, an online approval/licensing system was established. For companies that could not access the Internet, an ARS system was introduced to prepare electronic handover statements by phone.

Achievements. Allbaro has been recognized as an innovative Korean brand, and has been patented through the Korea Intellectual Property Office (KIPO). The brand has been growing in popularity and has become a global brand with national level support. The system has been used as a benchmark for improving service quality in the public sector and is being connected with other environment related systems.

Through the use of Allbaro, GoK could achieve (i) effective and transparent environment administration, (ii) improved work productivity through computerization, and (iii) enhanced accuracy on statistical data relating to industrial and medical waste treatment. Furthermore, industries can reduce costs related to the waste manifest. According to the analysis and research results of the Korea Institute of Public Administration (KIPA), it is estimated that KRW 134 billion (about USD 122 million) and 9.8 million hours of time can be saved annually by introducing Allbaro system. Public officials in charge of waste management are able to maximize their business efficiency and obtain waste statistics automatically. Above all, Allbaro system makes it possible to monitor the waste treatment status in real time and to prevent and reduce illegal waste disposal activities significantly.

2.4.2 RFID system for Medical Waste Management

Background. In 2004, 51,921 facilities in total generated 43,127 tons of medical waste in Korea. There were 127 collection and transportation companies and 14 incineration plants for final disposal. From the total amount of waste generated, 82% was treated by incineration, 17.6% by means of sterilization-shredding, 0.4% of waste was reused (Ministry of Environment, 2005). The users of Allbaro system, web reporting system, have to type the complex documents of waste handover whenever it happens, which renders the process of preparing or typing documents time-consuming. Above all, these two systems could not identify the violations of law made by the users.

The main violations include illegal waste transportation, illegal waste treatment including the change of wastes between the treatment facilities and illegal dumping. In April 2006, there was an accident in which the illegal truck transporting the medical waste turned over and the medical wastes spilled on the road. The accident was broadcast all over the country. Korea MOE decided to address the issue with violations fundamentally by introducing the RFID system for the medical waste management. The stakeholders protested against the RFID system pointing to its economic burden and technical immaturity.

New RFID system. New RFID system is mainly a substitution for the conventional manifest system, document or web system. Under this system, waste generator attaches a tag to the medical waste box according to the waste category. After its use, the generator delivers it to the storage building and puts it on the scale and stores it. The information is read by the RFID reader and sent to the central system, then the transporter comes to the storage building and loads the waste to the vehicle. Due to the RFID reader and the system, handover of the information and receipt is done automatically. There is no need to fill out a document manually or online, or to have signature confirmation. Final check is completed by the reader in front of incinerator input gate. At this stage, there is also no need for any document to be filled out manually or using a web system, and no need for a signature. The annual report is unnecessary, and all data can be processed statistically from the RFID system. The Radio Frequency Identification (RFID) system for medical waste is also operated and managed within the Allbaro system.

Overall, the objective of the RFID system is that it can register and monitor the whole process-from discarding to final disposal-in real time using the RFID technology. Major components include (i) Fixed reader (installed and operated by the discharging business and disposal facilities) to recognize a RFID tag, (ii) Antenna for sending information to control centre, (iii) Portable reader for transporters, and (iv) Electronic tag for dedicated containers.

Figure.8 Main components of the RFID system
Source: Internal Report about Medical Waste Safety Management using RFID Technology, p.2, K-eco, 2017

Medical waste is treated using the following steps:

a) Medical waste from hospitals is packed and sealed in dedicated containers and then the electronic tags are attached (including waste type information, tag serial numbers) to the containers;
b) Automatic registration will be completed using the RFID reader installed in the hospital - automatic registration of generator, date and amount of waste;
c) Handover of medical wastes between generator and transporter - automatic registration of disposal date, transporter and disposal site;
d) Registration of handover information between transporter and disposer - automatic registration of disposer, transition date, and transition amount;
e) Real-time registration and management of the whole process by recognizing the tag attached to the dedicated container after passing the RFID reader in front of incineration receiver.

Figure.9 Business procedures about medical waste management system using RFID Technology
Source: *Internal Report about Medical Waste Safety Management using RFID Technology*, p.3, K-eco, 2017

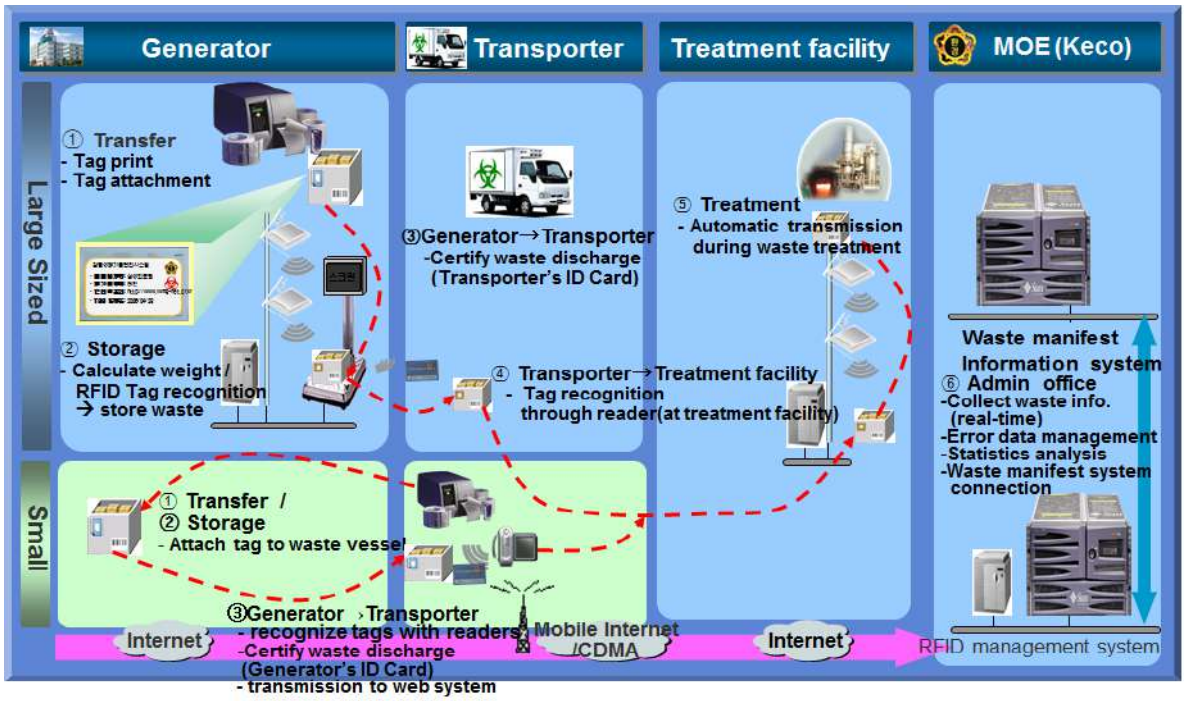

Figure.10 Information Flow about Medical Waste Management System using RFID technology
Source: Internal Report about medical waste management using RFID technology, p.4, K-eco, 2017

Achievements. According to Kang *et al* (2007), a cost/benefit analysis proved that the RFID system was very efficient. The results revealed the RFID system could reduce costs by about USD 200 million per year compared to the conventional waste manifest system. Information technology saved labor time by about 80%, although it added the new cost of the RFID equipment and maintenance. The cost-effectiveness can be proved by voluntary user's response. Voluntary users of the RFID system rapidly increased and were up to a number of 3,815 among 50,000 potential users in June 2007* and the number of RFID users in medical waste increased to 66,535 users (generators) in 2016.

This RFID system technology was recognized by the World Health Organization (WHO) in 2013, having received the highest score (5/5) for technology assessment under the WHO evaluation of medical waste management system among 24 Southeast Asian countries.**

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* Refer to Sung Goo, Kang, Jai-Young, Lee and Yong-Jin, Kim, *A Policy Making Procedure and Economic Feasibility Analysis of the RFID system in the Medical Waste Management*

** Status on healthcare waste management in selected countries of the Western Pacific Region, 2008–2013- Some countries (such as Japan) introduced the management system, but it is applied to users who want to use the e-manifest system (based on user need), and uses a web registration system.

Box 1: Case study: E-manifest system in Japan

Waste manifest system in Japan was implemented in April 1993 as a regulation for only hazardous industrial waste management, and was thereafter revised to expand to all kinds of industrial waste. In order to facilitate the proper disposal of industrial waste and the prevention of illegal dumping, the legal system for electronic manifests (E-manifest) was introduced when the Waste Management and Public Cleansing Law was amended in June 1997. Thereafter, waste generators could choose either the paper or E-manifest system. Upon implementation in December 1998, Japan Industrial Waste Information Center (JW) was designated as an Information Processing Center (IPC) to operate the information system in Japan. At present, the number of users (subscribers) and manifest registrations have increased to more than 70 thousand and about 10 million registrations per year, respectively, and the share of E-manifest of the total number of manifests created (46 million) reached 23% in 2010.

Source: Yoshihisa Hamada and other three researchers, *Present State of the Electronic Manifest System for Industrial Waste Management in Japan,* Japan Industrial Waste Information Centre, Japan, 2011

Countermeasure to Middle East Respiratory Syndrome (MERS) emergency. The RFID system for medical waste played a very important role in the national disaster emergencies. The MERS virus, which originated in the Middle East countries in 2015, hit Korea in May 2015 and spread rapidly across the country by of that year in June. At that time, 186 people were infected and 38 died. This disease spread between May 20, 2015 and December 23, 2015. During this period, the need to isolate MERS contaminated medical wastes was critical to prevent the spread of the virus nationwide. In June 2015, the spread of MERS virus became a national concern; the generation of medical wastes was increased by 246% compared to the previous month of 337 tons. The RFID system played a central role to confirm proper collection, transportation and final disposal at incineration plant. MERS isolated medical waste tags were separately issued and managed intensively. Korea MOE established special management system for hospitals which were disposing of MERS contaminated medical wastes - about 76 hospitals and clinics, where the wastes were transported and disposed of the same day.

Challenges in the Allbaro system. Allbaro system was developed to reduce the social cost related to manifest proper disposal of industrial waste, including hazardous waste and medical waste. However, the Allbaro system was provided to users without any collection of money in return. Thus, no revenue was generated by operating the Allbaro system. The development and O&M costs are covered by KMOE and the system is operated by K-eco. K-eco is carrying out a feasibility study for collecting fee from users.

Table.19 Operation status of Allbaro system by K-eco (2016)

	O&M Cost	Operator
Total: KRW 3,601 mil. (About USD 3.27 mil.)	- Personnel expenses: KRW 1,363 mln (USD 1.24 mil.) - O&M costs: KRW 2,238 million (USD 2.03 mil.)	26 staff

Source: Internal information of K-eco, 2016

2.5 Waste-to-Energy & Public-Private Partnership (PPP) project

Energy production from waste has emerged as an efficient and cost-effective method to realize the goal of "low carbon, green growth". As of 2012, the ratio of new and renewable energy to total domestic primary energy was a mere of 3.2%. Over 67% of new and renewable energy is produced from waste, especially through incineration plants and landfill gas (LFG) generation projects whose production cost can be cheaper than solar power and wind power. Thus, energy production using waste has emerged as the method that can generate new and renewable energy in the most effective way at an early stage. Since 2007, the Ministry of Environment has gradually increased government subsidies to expand power generation facilities from waste.

2.5.1 Waste-to-Energy Project

Heat recovery at incineration plant. Waste to energy (WtE) at an incineration plant is the recovery of the energy content, preferably from non-recyclable wastes. This is usually achieved by combustion of the waste to release its chemical energy and then transferring this energy to water/steam in a boiler to produce heat and/or power. Municipal Solid Waste (MSW) is an important energy resource for combined heat and power (CHP) generation. Incineration plants in metropolitan areas are usually located close to a residential area. Incineration plants can operate in a CHP mode - that is when the residual heat in the form of steam after power generation is exported to a district heating system or to nearby heat demanding industries as processed heat. According to the KMOE, only 35 large incineration plants, out of total 177 incineration plants, constructed in metropolitan areas, are currently using waste-based heat for energy recovery in the form of heat and/or electricity production as of 2010. The rest of the incineration plants have limited capacity and only dispose of MSW.

Table.20 Waste to Energy generation in Mapo incineration plant in Seoul (2012)

Outline of facility	Energy recovery
Capacity : 750 tons / day (250 t / d × 3 units) Process type : Stoker + Rotary Kiln Project cost : KRW 166,547 million (about USD 151 million) Beginning of operation : May 21, 2005 Waste received: 205,110 tons/year Treated waste : 136,542 tons/year Unit cost for treatment : KRW 36,286/ton (USD 32.9) Income : KRW 8,869 million Expenditure : KRW 22,950 million - Personnel expenses, tax and etc. : KRW13,378 million - O&M costs : KRW 9,572 million	Heat generated from Mapo incinerator goes to neighboring Korea District Heating Corporation and is supplied as district heating during winter season and cooling during summer season to 11,700 homes in Mapo area of Seoul. Total Energy production : 458,788 Gcal /year – Self-consumption: 41,289 Gcal/year – Heat Sale: 322,749Gcal/year KRW 6,601 million (USD 6 mil.) Turbine generator installed : 2011 for electricity generation – Electric generation: 94,750Gcal/year KRW 2,205 million (USD 2 mil.) • Electricity Generation: 36.9 million kW/year • Self-consumption of electricity: 22.8 million kW/year • Sales of electricity: 14.1 million kW/year

Source: http://attfile.konetic.or.kr/konetic/xml/oper/B1C2A1300034.PDF - *Operation Material of Mapo Incineration Plant in 2012,* last accessed 12 May, 2017

Prerequisite for incineration. Compared to landfills, incineration plants need several prerequisites for construction and operation:

a) Adequate calorific value (CV) of waste: it is desirable to have the average CV over 2,500 kcal/kg for incineration and average value of 3,000 to 4,500 kcal/kg for waste to save fuel cost. As the calorific value of MSW increases, MSW becomes a more efficient fuel to produce electricity and/or heat. According to the information by Seoul Metropolitan Government, average Calorific Value (CV) of VBWF bags in Seoul has increased gradually from 1,511 kcal/kg in 1999 to 2,794 kcal/kg in 2009 thanks to food waste separation in collection.

Table.21 Calorific value change of VBWF bags in Seoul (1999 ~ 2009)

Year	Calorific Value (kcal/kg)	Three Components (wt. %)			Number of Sampling
		Water Content	Combustible Content	Ash Content	
1999	1,511	53	36	11	15
2005	2,541	38	52	10	33
2006	2,596	37	53	10	33
2007	2,456	35	54	11	35
2008	2,632	34	55	11	35
2009	2,794	34	54	12	37

Source: Presentation material of Zero Waste Plan, Seoul Metropolitan, 2014

b) Development of technology for efficient incineration and stable O&M: compared to landfills, incineration plants needs not only high technology of incinerator but also development of electromechanical equipment for stable O&M. The first constructed incineration plant in Korea failed to meet the emission criteria of dioxin in 1984, and this plant had to be rehabilitated to meet the emission criteria. It is important to construct optimal capacity for continuous combustion as dioxin can be generated through incomplete combustion or around 250~400 degrees Celsius during stopping or re-burning process.

Electricity generation using Landfill Gas (LFG). Solid waste disposal sites are not always seen as opportunities for energy solutions. The waste that is disposed of in open dumps and landfills generate methane, contributing to global warming and greenhouse gases (GHG). However, LFG can be turned into energy. Landfill gas can be captured and utilized in a number of ways. This gas contains between 40-60% of methane, which can be used to drive a gas turbine to generate electricity or directly in boilers of nearby industry to provide heat or to power mechanical processes. It can also be purified and fed into the local natural gas distribution systems.

Many countries capture LFG to improve landfill safety, generate electricity, reduce GHG emissions and to earn carbon emission reduction credits. For instance, many projects in developing countries are taking advantage of the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) to earn carbon credits by capturing and combusting methane.

Table. 22 WtE case of LFG power generation in Daegu, Korea

Outline of the facility	Energy recovery
Landfill area: 860,000 thousand m2 Capacity: 23,154 thousand m3 Beginning of operation: May, 1990 Project Type: BTO (PPP) Project cost: KRW 26,869 million (about USD 24.4 million) Construction period: May,2005~Sep.,2006 Operation period: 2006~2006 for 20 years Facility: - LFG collection: 130㎥/min at 188 collection points - Gas engine: 1.5MW(750kW×2)	LFG from landfill used for power generation and supplied fuel to District Heating Co. Operation company gave KRW 500 million as a basic one time transfer and KRW 1.4/m3 for selling of purified gas. - Electricity generation: 1.5 MW for self-consumption - Fuel supply: 187,200 m3/day as gas status - Registration to UN for Clean Development Mechanism (CDM) in 2009 : Certified Emission Reductions (CERs) of 300 thousand tons of CO2/year  

Source: *WtE cases using LFG in Korea*, Sudokwon Landfill Corporation, 2005

There are 16 LFG power generation projects with a total capacity of 76.78 MW in Korea (2011) and all projects except in Nanjido proceeded as a Public-private Partnership (PPP) project.

Table. 23 Operational status of LFG projects in Korea, 2011

Number of sites	Capacity (MWh)	Operational status (unit : MWh, KRW thousand) – Power generation			
		Production	Self-consumption	Selling to Grid	Revenue
16	77	439,813	40,330	397,704	51,435,134
Number of sites	**Capacity (m3/min)**	**Operation status (unit : thousand m3, KRW thousand) – Supplying LFG as a fuel**			
		Production	**Self-consumption**	**Selling to Grid**	**Revenue**
3	632	61,841	0	61,841	8,397,572

Source: Construction and operation status of LFG facility, KMOE, 2012

2.5.2 PPP projects in the environment area

Public-private partnership (PPP) projects were introduced in 1994 to raise funds for covering insufficient government funding. Environmental facilities, which have been traditionally constructed and run using government resources, were also introduced to the PPP scheme not only to induce the private sector funds for construction and operation of environmental facility, but also to utilize the professional skills and efficiency of the private sector.

According to the PPP Act in Korea, the government may grant a construction subsidy to the concessionaire, since it is required to maintain the user fee at an affordable level. The timing of the subsidy is determined in the course of the concession agreement, and depends on the equity investment plan of the concessionaire. Compared to other developing countries, construction subsidy played as a very important role in expanding the PPP project implementation in the environmental area.

Table. 24 Average Level of Construction Subsidy by Sector in Korean PPPs. (Unit: % of total construction cost)

Facility Type	Road	Port	Environmental Facility
Level of subsidy	19.7%	22.2%	64.7%

Source: KSP report on Public–Private Partnerships: *Lessons from Korea on Institutional Arrangements and Performance*, p.40, Korea Development Institute, 2013

The first PPP project of waste treatment facility was an incineration plant in Sanju city, which was announced for bidding in 1998. Since 1998, 15 Sewage Treatment Plants (STPs) had been proceeding for construction using a Build-Transfer-Operate (BTO) approach. Build-Transfer-Lease (BTL) type plants have been introduced to expand sewer lines since 2005. The use of PPP use for environmental facilities has been expanded to include an incineration plant, Mechanical-Biological-Treatment facility, and a WtE unit using biomass.

Table. 25 WtE case of PPP project in Korea (2016)

Outline of Project	Facility
- Title: Environmental energy town in the northern Kyungbuk area - PPP Type: BTO - Total cost: KRW 161,056 mil. in 2011 Construction subsidy: KRW 68,803 mln (43%) Private fund: KRW 92,253 mln (57%) - Operation period: 20 years	- Mechanical Treatment : 450 tons/day - Incineration Plant : 190 tons/day - Biomass Plant : 120 tons/day - Current status : under construction Construction period : 30 months

Source: Internal information of K-eco, 2016

Success factors for PPP projects in the environment area are summarized below:

I. Environmental PPP projects in Korea were initiated by the government in the 1990s and the beginning of 2000. The feasibility study was carried out local municipality by hiring consultants. Thus, there was no need for the private sector to invest initial costs to develop a PPP project.

II. Government provides construction subsidy from 10% to a maximum of 70%, and this subsidy has encouraged the incentive for the private sector to participate.

III. In order to induce the participation of private companies, particularly, private financial investors such as banks or buyers of investment securities, the government provided an operational revenue subsidy through the Minimum Revenue Guarantee (MRG) provisions and redemption agreement (this MRG provision was terminated by the revision of the PPP Act in 2009).
KMOE designated K-eco, an expert institute on environmental facilities, to manage PPP projects to negotiate with the concessionaire on behalf of local governments. This was necessary because the officials of local governments do not have enough experience and know-how in the relevant technical and financial areas.

III. Gap analysis

3.1. MSW management

Dump site or unsanitary landfill. Waste collection and transportation in city areas of LDCs and MICs are carried out comparatively well to prevent occurrence of infectious disease, complaints of residents and to improve the reputation of a city. Importantly, waste collection and transportation can be profitable for the private sector in MICs given the fact that private companies usually make a contract with municipality under the condition of securing some level of profit. However, collected wastes are, predominantly disposed of at dump sites or unsanitary landfills without liners such as synthetic membranes or gas and leachate collection systems. As a result, dump sites cause health and environmental problems such as fire accidents, leachate, and contamination of surrounded areas.

Challenge. A sanitary landfill with a liner system is one of the essential components for proper waste disposal. Landfilling is the cheapest cost option for final disposal and, therefore, internationally is seen as the dominant practice. Thus, most of LDCs and even some MICs are adopting landfilling option for disposal of MSW given that correspondent construction and O&M costs of incineration are much higher. However, sanitary landfilling also requires higher initial investments and securing of finance source. In addition, cost recovery is a major challenge for LDCs and MICs.

The financial crisis in 2008 and low oil and raw materials prices have been acting as an obstacle to promoting and expanding environmental facilities in some countries, which are highly dependent on the oil industry or vulnerable to external shocks. These countries, such as Indonesia, Russia, and Kazakhstan, are under investing in the environment area because this field, and especially, MSW management, has a low priority compared to other infrastructure areas that are directly connected to economic development such as roads, power generation and water supply.

Low tariff and low collection rate. Construction and operation of sanitary landfills require comparatively large amounts of money. At the same time, most countries are adopting an autonomous (self-government) system, where political constraints preclude reflecting the full waste disposal costs (including collection and transportation costs) in the tariff. Thus, it is difficult to raise the waste tariff that actually reflects the real costs of services in LDCs and MICs. Additionally, tariff collection is not sufficiently implemented well because a municipality or waste management company does not have a strong enforcement tool applied to the homeowners or waste generators who are not paying the tariff in full.

Challenge. Largely, in LDCs and MICs, a flat or fixed tariff system is adopted for waste management services. Under the fixed tariff system, people do not care about the amount of waste generated and this undermines MSW management. With the “3R” (Reduce, Reuse, and Recycle) principle, waste reduction is the first pillar of the waste management. Often a low tariff that is not reflecting the real costs is a serious challenge to improving MSW management.

Box 2: Case study: Atyrau city in Kazakhstan

The Feasibility Study report for Atyrau estimated the capital investment needs for the improvement of waste collection at approximately EUR 68 million. This included the purchase of new trucks and containers, closing of old landfills, construction of a new landfill, and the implementation of a separation line for mixed waste with associated recycling facilities. The analysis of the study indicated that full recovery of the annual operational and amortization costs would require a substantial increase in the current tariffs. Households would have to pay more than 10 times for SWM as compared to the current tariff, KZT 120 (about USD 0.36).

Moreover, the tariff collection rate is low. While the waste management company has introduced an e-billing system, the tariff collection rate has not improved much compared to the previous manual system due to the lack of exact population information of each household. Tariff is charged according to the number of family members residing in an apartment/house.

Tariff collection rate in Atyrau (August 2016)

Estimated Population (A)	Charged population (B)	Tariff collection rate (C)
310,000	195,690	72.5% of B, and 45.7% of A

Mixed waste and low recycling rate. In most of LDCs and MICs, it is usual practice to dispose of MSW as mixed waste, including food waste. A top priority for the waste management company is to remove wastes from the streets or at the collection points as soon as possible without any concerns about the waste disposal status. Mixed waste is difficult to recycle and it needs additional sorting process, consequently requiring extra labor force or mechanical sorting line. Additionally, the quality of recyclable material cannot be considered good compared to that of separately collected materials at the source.

Challenge. Waste separation at the source, especially for dry recyclable materials, is essential to improve waste recycling. To raise the waste recycling rate, recyclable wastes are separately collected at the source or food wastes should be collected separately from recyclable materials. However, separate collection of food waste also requires the implementation of new infrastructure for collection, transportation and disposal; and as the Korean experience shows, the creation of appropriate incentives for households.

Box 3: Case study: Mechanical and Biological Treatment (MBT) facility for mixed waste - International experience and the technical and financial studies show that MBT would be expensive compared to landfills, and cannot yield revenues that can underpin sustained operations. Also, MBT facilities have not been built in developed countries in Europe in the past 15-20 years. However, some countries are trying to construct MBT facilities to treat mixed waste. For this to be successful, careful and detailed investigation on the technical and financial justification for a mechanical separation line and biological treatment of mixed waste is very important.

MBT facility was introduced to utilize the valuable materials in general waste. The concept of MBT facility in Korea is different compared to the EU practices or other countries because recyclable and food wastes are collected separately in Korea. Refuse Derived Fuel (RDF) is the product of MBT facilities in Korea, creating a type of pellet or fluff. RDF was planned to provide an auxiliary fuel for coal-generation plants or cement factories. However, O&M cost for a MBT facility is much higher than landfilling. The MBT facilities in Korea were introduced as an alternative method to decrease the direct landfilling of waste, and increase energy recovery from waste. Thus, LDCs and MICs need a prudent, multi-pronged approach for treating mixed waste, which relies on economies of scale.

Comparison of unit waste treatment cost of MBT facility vs landfilling in Korea

Capacity (t/d)	Under 100	100 ~ 400	Over 400	Landfilling
Unit cost (USD/ton)	83	67	59	17 (in 2015)

Source: *Evaluation of waste to energy projects*, National Assembly Budget Office of the RoK, 2010

3.2. Legal and institutional framework

Legal framework

The Volume-Based Waste Fee (VBWF) system has been seen as the basic and foundational policy in MSW management in Korea. This system has been largely recognized due to nationwide enforcement and continuous monitoring to prevent illegal activities such as refusal to use the designated plastic bags. Thus, the legal framework is an important successful factor for policy initiatives implementation. In LDCs and MICs, however, the laws, regulations, guidelines and enforcement mechanisms related to waste management are often less developed.

Challenge

As the economy develops and societies become more industrialized and urbanized, the quantity and types of waste increase and become more diverse. In order to cope with the accumulated waste, including industrial and medical waste, the legal and institutional framework should be clearly and comprehensively developed and implemented. However, in LDCs and MICs, the Ministry in charge of environmental issues or waste management usually does not have enough institutional capacity and skilled staff to continuously develop and put in place a robust regulatory framework, and monitor the enforcement of policies and laws.

Box 4:

Case study 1: Legal framework for waste management

KMOE established and developed the laws related to the waste management to implement the principle of "3R" (Reduce, Reuse and Recycle). Based on a firm legal foundation, these policies can be implemented well in the private sector.

Legal framework for waste management in Korea

Activity	Law	Relevant Policy
Reducing	Waste Control Act	VBWF system
Recycling	Act on Promotion of Saving and Recycling of Resources	EPR system
	Act on the Resource Circulation of Electrical and Electronic Equipment and Vehicles	ECOAS system
E-manifest	Waste Control Act	Allbaro system &RFID on medical waste

Case study 2: VBWF system in Sri Lanka and Allbaro system in Vietnam

K-eco introduced an e-manifest system for integrated management on hazardous wastes in Vietnam with the support of KOICA, under an ODA-grant project in 2014. The system has not been implemented fully with the private sector due to lack of legal foundation. The Korean VBWF system was also introduced in Sri Lanka in May 2016, by the Waste Management Authority (WMA) of West Province with the cooperation of KOICA. However, the VBWF system was implemented as a pilot project without establishment of relevant law to firmly support the new system.

3.3. Financing for sustainable development

Budget for public service

If a new waste management system is introduced or the implementation of a new system is being monitored, the necessary funding needs to be secured. However, the government budget often does not have the resources for this. This means that the central government needs to seek other financing sources for the stable implementation of the new waste management system. Most LDCs can procure financial resources for installation or introduction of advanced practice. However, some waste management systems are not developed based on market-based instruments, which may complicate the situation.

Challenge

In LDCs and even in some MICs it is a challenging task to find the financial sources to ensure that the new system can operate well on the basis of a sustainable structure with a firm financial basis. Financial sources can only get the firm foundation when the relevant legal framework is established.

Box 5: Postponement of full-scale operation of Allbaro system in Vietnam – The Allbaro system in Korea requires around USD 3.27 mln and 26 staff for its operation and maintenance. Operation costs are covered from a national funding source by KMOE and the resources are allocated to K-eco for providing a public service to the private sector. However, the Vietnam government is facing difficulties with securing funds for operational costs to run the Allbaro system, and consequently, the system is currently operated on a pilot basis.

Revitalizing actions for PPP projects

PPP projects in the environmental area have been considered as an innovative and new financing source. They hold the promise of treating waste steadily and generating profit through the project. However, successful examples in the waste management sector are rare in LDCs and MICs. PPP projects in the environmental area are usually focused on Waste to Energy projects such as incineration, and power generation projects using LFG or biomass. WtE projects need not only large investments, but also advanced technology comparing to a landfill project, thus, the risk is also high compared to other infrastructure projects like roads, bridges and water facilities. Consequently, most of LDCs tend to provide waste just as a raw material.

Challenge

To attract foreign investment from developed countries, LDCs and MICs should share the risk and profit. The key issue in PPP project is not technology but rather firms' cash flow and guarantee for the construction and operation period. Most LDCs have not introduced any type of PPP Act and there have not been any successful PPP models in the environmental area. Thus, an approach seems to be needed where the initial risk is shared and where each player covers some portion of the equity investment, underpinned by a clear legal framework that ensures contract enforceability.

Box 6: Case Study: Failure of WtE projects in Mexico and Costa Rica and the outlook for other countries – K-eco had developed the WtE projects in Mexico and Costa Rica in 2013 and 2014, respectively. The main components of two projects were very similar. It suggested constructing an incineration plant for disposal of MSW and then generating electricity using the steam from incinerator. Both projects have been terminated due to the same reasons.

(i) According to the pre-Feasibility Study (FS), the facility was not feasible unless a tipping fee for waste is raised and it required a type of incentive, such as Feed-In-Tariff (FIT), to sell electricity. Suggestion of sharp tipping fee increase caused a situation in which municipalities were reluctant to invest, providing just MSW for raw fuel of incineration plant. If municipalities considered to invest some portion to the WtE project, the increase of the tipping fee would be considerably reduced.

(ii) There were no guarantee tools for PPP projects. In case of decreasing the waste receiving amount and low calorific value of MSW, guarantee tools for the operation stage are required. However, stakeholders could not reach mutual consent for stable operations.

Compared to landfill projects, incineration plants or LFG power generation projects need comparatively large amount of investment to carry out FS, including waste composition analysis, soil and topographical surveys. New LFG power generation projects are being developed in Myanmar, Iran and Pakistan. Based on the above experience, it will be desirable to proceed and develop the project with the participation and ownership of each Municipality, including the provision of a portion of investment.

IV. Recommendations for LDCs and MICs

- **Volume-Based Waste Fee System to limit waste generation**

The traditional method of "Expanding Landfills" for MSW management in LDCs and MICs is no longer an efficient way to accommodate rapidly increasing MSW generation stemming from industrialization and urbanization. In order to solve the MSW problems and reduce waste generation, "Demand Management" should be introduced and the tariff system should be changed to reflect the real costs for collection, transportation and final disposal.

A Volume-Based Waste Fee (VBWF) system could be considered as a viable solution for MSW management, particularly for limiting waste generation. This system is developed based on the "polluter pays principle" and the tariff includes the price of a VBWF plastic bag to cover the MSW management cost. It is recommended to introduce "free of charge collection services for recyclable waste" to offset the tariff increase and provide appropriate incentives for residents. If recyclable wastes are collected free of charge, separate waste collection at the source can be more easily achieved.

- **E-waste management system to increase recycling rate.**

E-waste is composed of several high value components compared to traditional MSW. The EPR system can be suitable for the MICs, especially, if there is a case of high dependency on imported energy and resources. However, prior to introducing the EPR system, a feasibility study (FS) should be conducted to investigate the local situation and to customize it to local conditions. Through the FS, target products and targets for recycling rate can be determined. It is important not only to introduce the EPR system, but also to reflect the current industry status. Benchmarking/comparison with other country's EPR system will be a good exercise to reduce costs associated with trials and errors.

- **E-Manifest system on Industrial and Medical waste**

As the industry is developing and population is growing, industrial and medical waste generation is also increasing, including hazardous waste. An e-manifest system such as the Allbaro system in Korea can be a very effective tool for managing industrial and medical waste, and, particularly, hazardous waste. However, it is difficult to provide the service relying only on a service fee. Korea's experience and Vietnam's case show that securing a balanced operational budget is essential for stable system operation.

- **Setting the tariff for sustainable waste management**

Implementation of the waste treatment tariff will be a hard task due to potential resistance from residents. Tariff should be determined at a reasonable level to cover the costs. Practically, waste tariff is very low in most LDCs and even in some of the MICs, which makes it hard to modernize the waste management system. Thus, for instance in the case of Kazakhstan, it can be anticipated that the construction of a new sanitary landfill and rehabilitation of a dump site cannot be done unless there is a large tariff increase. If the necessary increase of the tariff does not happen and other sources of funding are not found, sustainable waste management remains out of reach.

- **Introduction of a landfill inspection system**

Usually, in most of LDCs and MICs, Municipal Solid Waste (MSW) is being landfilled without proper processing or recycling. Waste dumping is threatening residents' health and the surrounding environment, including pollution of groundwater and surface water. To construct and operate sanitary landfills, a landfill inspection system established by a public expert Institute is recommended for LDCs and MICs . If an existing or new landfill does not receive a compliance certificate from the inspection institute, the landfill would need to ceased operation until the compliance certificate is obtained.

- **Legal and institutional framework**

Korea's experience in waste management shows that a firm legal and institutional framework and proper implementation of regulations can be critical factors for achieving the efficiency of sustainable waste treatment services to both the public and private sectors.

- **Recommendation policy and practice for LDCs and MICs in a matrix**

Policy or Practice	LDCs	MICs
VBWF system	○	○
EPR system	x [1]	○
E-manifest system	△ [2]	○
Landfill inspection	○	○

Note 1: ○– Recommended /△- Can be considered for introduction / x – Too advanced /costly to introduce

Note 2:

1) The EPR system for LDCs could be considered as excessively advanced policy/practice to introduce given the prerequisites to create favorable environment first, such as developed recycling industry.
2) If hazardous and medical waste disposal was placed as social and environmental concern in LDCs, e-manifest system can be considered as a counter measure for monitoring and securing legal disposal of hazardous and medical waste—assuming the necessary funding and enforcement mechanism for its smooth and reliable operation is made available.

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VI. Annexes

Annex 1: Achievement of Allbaro System 2016

Number of vouchers (Paper document) (Unit : Copy)	E-manifest User	Benefits from saving time (Unit : Million KRW)				Financial benefits (Unit : Million KRW)		Total (Unit : Million KRW)
		Filling in information into voucher	Registering for management	Reporting to regulatory office	Auxiliary works such as visiting to regulatory office	Mailing	Voucher purchasing	
12,039,395	398,646	244,423	24,957	2,329	8,648	6,271	3,608	**290,236**
Unit cost (KRW/ copy)		20,302	2,073	193	718	521	300	24,107
Million USD		222	23	2	8	6	3	264

Source: Internal Report, K-eco (2011)

Annex 2: Allbaro operation status in 2016

(Based on the date of waste generator enrollment)

Item	Category of waste	Waste amount (Unit : Thousand tons)	Number of voucher (paper document) (Unit : copy)	E-manifest User			
				Total	Generator	Transporter	Disposer
Total	Sum	150,932	12,039,395	398,646	365,954	19,159	13,533
	Hazardous	5,339	829,468	102,159	96,069	3,724	2,366
	Medical	196	3,521,670	66,535	66,069	378	88
	Industrial	63,299	3,926,005	70,809	49,815	11,893	9,101
	Construction	82,098	3,762,252	159,143	154,001	3,164	1,978
Local Headquarters and branches							
Western Sudokwon H.Q	Sum	37,952	3,564,962	89,221	84,042	3,178	2,001
	Hazardous	1,115	214,406	17,814	16,940	559	315
	Medical	71	1,398,219	29,076	29,000	67	9
	Industrial	10,792	750,642	14,861	11,507	1,966	1,388
	Construction	25,975	1,201,695	27,470	26,595	586	289
Eastern Sudokwon H.Q	Sum	18,025	1,518,241	47,115	42,828	2,540	1,747
	Hazardous	314	81,202	9,606	8,936	399	271
	Medical	20	463,836	9,603	9,520	73	10
	Industrial	6,357	443,147	10,837	8,067	1,578	1,192
	Construction	11,334	530,056	17,069	16,305	490	274
Gangwon Branch	Sum	7,107	484,096	21,396	19,468	1,126	802
	Hazardous	46	22,864	5,624	5,312	189	123
	Medical	4	105,440	2,204	2,184	15	5
	Industrial	2,850	155,435	2,949	1,652	761	536
	Construction	4,206	200,357	10,619	10,320	161	138
Chungbuk Branch	Sum	7,458	425,564	19,867	16,932	1,601	1,334
	Hazardous	313	49,646	6,358	5,765	346	247
	Medical	6	36,477	411	355	45	11
	Industrial	4,029	194,134	4,759	2,782	1,026	951
	Construction	3,110	145,307	8,339	8,030	184	125
Chungcheong H.Q	Sum	13,128	1,015,643	40,273	36,391	2,203	1,679
	Hazardous	503	77,261	9,091	8,404	409	278

Chungcheong H.Q	**Medical**	**14**	**277,853**	**5,092**	**5,043**	**40**	**9**
	Industrial	6,755	364,061	7,499	4,923	1,398	1,178
	Construction	5,856	296,468	18,591	18,021	356	214
Jeonbuk Branch	Sum	6,424	466,623	24,177	22,061	1,187	929
	Hazardous	650	42,460	7,538	7,040	304	194
	Medical	7	121,842	2,687	2,668	13	6
	Industrial	2,126	147,641	3,085	1,780	710	595
	Construction	3,640	154,680	10,867	10,573	160	134
Honam H.Q	Sum	13,509	995,124	35,742	33,171	1,465	1,106
	Hazardous	449	61,125	9,609	9,049	336	224
	Medical	14	301,332	5,161	5,133	21	7
	Industrial	7,969	388,339	5,167	3,591	857	719
	Construction	5,076	244,328	15,805	15,398	251	156
Daegu&Kyungbuk H.Q	Sum	23,310	1,460,939	55,968	51,761	2,426	1,781
	Hazardous	840	108,781	16,752	15,903	532	317
	Medical	25	354,483	5,745	5,700	36	9
	Industrial	12,564	614,968	9,631	6,940	1,504	1,187
	Construction	9,881	382,707	23,840	23,218	354	268
Busan, Ulsan & Kyungnam H.Q	Sum	22,082	1,943,488	56,973	52,194	2,921	1,858
	Hazardous	1,101	165,109	17,649	16,744	576	329
	Medical	32	428,522	5,652	5,605	39	8
	Industrial	9,353	810,147	10,982	7,843	1,886	1,253
	Construction	11,596	539,710	22,690	22,002	420	268
Jeju Branch	Sum	1,875	158,688	7,249	6,729	339	181
	Hazardous	9	6,528	2,024	1,920	51	53
	Medical	1	30,659	824	814	5	5
	Industrial	504	57,482	1,020	725	200	95
	Construction	1,360	64,019	3,381	3,270	83	28
Other	Sum	62	6,027	665	377	173	115
	Hazardous	0	86	94	56	23	15
	Medical	0	3,007	80	47	24	9
	Industrial	0	9	19	5	7	7
	Construction	62	2,925	472	269	119	84

Annex 3: Allbaro System Operation Status (2008~2016)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Number of voucher	3,294,938	4,789,159	7,314,755	9,338,157	10,541,227	10,861,309	11,126,029	11,778,315	12,033,368
Number of user	265,671	318,736	202,037	311,432	325,008	337,690	350,577	377,517	397,981
Filling in information into voucher	66,927	97,278	148,578	189,677	214,114	220,616	225,993	239,242	244,423
Registering for management	16,660	19,988	12,670	19,530	20,381	21,176	21,984	23,674	24,957
Reporting to regulatory office	1,555	1,866	1,183	1,823	1,902	1,977	2,052	2,210	2,329
Auxiliary works such as visiting to regulatory office	2,368	3,442	5,257	6,711	7,576	7,806	7,996	8,465	8,648
Mailing	1,717	2,496	3,812	4,866	5,493	5,660	5,798	6,138	6,271
Voucher purchasing	988	1,436	2,193	2,800	3,161	3,257	3,336	3,532	3,608
Cost saving effect (unit : Million KRW)	90,215	126,505	173,692	225,407	252,627	260,491	267,159	283,260	290,236
Average (unit : Million KRW)	218,843								
Average (unit : Million USD)	198.95								

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