SOUTH KOREA'S EXPERIENCE WITH SMART INFRASTRUCTURE SERVICES

INTEGRATED SOLID WASTE MANAGEMENT

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1. EXECUTIVE SUMMARY

In South Korea, waste management policies have evolved from open dumping to safe disposal, further to recycling and waste-to-energy conversion. Various policies were introduced to reduce waste at sources, promote recycling and ensure safe disposal. A polluter pays principle applied to all waste streams; thus, waste generators pay the cost for collection and disposal. The volume-based waste fee (VBWF) system was introduced in 1995 to reduce the amount of waste discharged and secure recyclable materials, and as has been evident, the extended producer responsibility (EPR) scheme has helped to promote recycling of packaging materials. Markets for recycled materials were expanded by the government initiative. Further, the Korean government placed emphasis on the waste-to-energy conversion. At present, an eco-friendly energy town project is welcomed by local residents as it provides economic benefits to the residents, which contributes to changing the existing negative perception of waste disposal facilities. In order to ensure safe disposal of waste, the Ministry of Environment (MoE) grants a subsidy to local governments for the installation of waste disposal facilities, resolving the shortage issue of financial resources. Now, the Korean government is accelerating the transition towards a circular economy by minimizing resource inputs, maximizing reuse and recycling of materials, and eliminating waste disposal.

Since the industrial and medical waste treatment cost was higher than that of household waste, illegal disposal or dumping was prevalent in South Korea. Waste businesses are required to register their treatment records into a web-based management system at every stage of generation, transportation and disposal. Smart technologies play a vital role to reduce illegal dumping and increase transparency in waste management, achieving a significant reduction in labor, time and operation costs for authorities and businesses. In particular, the radio frequency identification (RFID)-based management system is contributing to securing a safe treatment of a growing amount of medical waste amid the COVID-19 spread.

A case study was performed on the Hanam Union Park, an underground environmental facility complex in Hanam city, Gyeonggi province in South Korea. All the environmental facilities were installed underground while parks and sport facilities were built on the top of them. The city renovated an existing sewage treatment plant and built new waste disposal facilities–an incinerator, a food waste treatment plant, and a material recovery facility. Smart technologies were adopted to lessen the burden on the environment, yielding benefits to the city and nearby residents. The Hanam Union Park is the first of its kind in Korea to integrate waste disposal facilities and sewage treatment plants underground.

The purpose behind the underground structure was to avoid the not-in-my-backyard (NIMBY) syndrome. The NIMBY syndrome has been prevalent over the site selection, construction and operation of waste disposal facilities as they pose health risks to nearby residents and drop their real estate prices. Since the government has established an institutional framework for compensation for residents, the conflicts have been mitigated. However, it will take a considerable amount of time to reach an adequate agreement with local residents and also cost substantial compensation. The Union Park faced no oppositions from local residents during the construction and has received no complaints during the operation of the facilities. It is a very successful case of addressing a potential NIMBY phenomenon, and a growing number of local governments and residents visit the Union Park to learn how to overcome the NIMBY.

2. INTRODUCTION

South Korea is endowed with few natural resources while its economic structure heavily depends on energy and natural resources, and about 96% of energy and 90% of mineral resources depend on overseas imports. In addition, Korea is a relatively small country with 100,378 square kilometers of territory, mostly mountainous terrain. Mountains and hills occupy about 70% of the land, and around 51.8 million people live in the remaining areas.

Due to rapid economic growth, the amount of waste steadily increased, especially industrial waste. The total generation in 2017 amounted to 429,531 ton/day, and household and industrial waste accounted for 53,490 ton/day (12.5%) and 376,041 ton/day (87.5%), respectively. As for the disposal of household waste, recycling dominated 61.6%, followed by incineration with 24.9% and landfilling w ith 1 3.5% (MoE, 2019 White paper). In order to curb a growing volume of waste, the MoE has established waste management policies and programs since the late 1980s. Its priorities include reduction at source, reuse and recycling, energy recovery, and safe disposal. The first two, source reduction and reuse/recycling, are categorized under a waste minimization policy. In South Korea, the waste minimization for household waste normally begins from a consumption stage. A volume-based waste fee (VBWF) system for household waste was implemented nationwide in 1995. Every household is required to discard its wastes into pre-paid standard garbage bags; however, the households are able to take out their recyclable wastes free of charge. As of 2017, 99.9% of households (21,616,000 out of 21,633,000 households) receive waste collection services from municipalities or private contractors. To reduce waste during a production stage, various economic instruments were introduced. A waste charge system encourages manufacturers to consider environmental impact during the production phase. The extended producer responsibility (EPR) scheme promotes the recycling of packaging materials, and a bottle deposit program facilitates the reuse of glass bottles. These initiatives have contributed to the reuse and recycling of wastes while cutting the amount of final disposal. The success on recycling policies largely depends on the creation of domestic recycling markets. As an effort to reduce a growing dependence on foreign energy, the Korean government is placing emphasis on renewable energy sources to generate 20% of electricity by 2030 from the current 7.6%, including waste, biomass, solar, hydro, and wind. Among the renewable sources, waste takes up 46.2% of the electricity generation (Ministry of Trade, Industry and Energy, 2018).

Considering the scarcity of natural resources and limited spaces for waste disposal facilities, the government is moving towards a circular economy, or a resource circulation society in Korean term, which aims at continual use of input resources, promotion of reuse and recycling, and minimization of waste disposal. The MoE promulgated the Framework Act on Resources Circulation in 2018 and set up the Master Plan of a Resource-Circulating Society. The plan sets the resource circulation goals for different industrial sectors. Waste disposal taxes are imposed on the incineration and landfilling of waste.

Smart technologies have been widely adopted by the government to increase transparency and cut the cost and labor for waste management. The public expressed their concerns over the health risks of industrial waste, especially hazardous waste. In order to ensure the safe treatment, the MoE obliged waste businesses to issue manifests of transfer and takeover and submit them to environmental authorities at each stage of generation, transportation, and disposal in 1991, which could provide proof that the waste was transferred from generators to final disposal facilities. However, the initiative required an unexpected amount of labor, time and operation costs for the authorities and the businesses. Thus, the MoE upgraded the manual system to a web-based waste disposal verification system called Allbaro

System in 2002. The system electronically processes the manifests circulating among all the businesses and the authorities. Since the adoption of a digitalized system, the IT technology has provided one of the most important and core tools for managing waste in a transparent and cost-effective manner. The Allbaro system applies to industrial, medical and food waste. Currently, the MoE runs a waste disposal verification system, a RFID-based medical waste management system, and a smokestack telemetering system for incinerators.

By the early 1990s, all wastes ended up in open dump sites, which caused environmental and social problems such as soil and ground water contamination, and negative health effects to nearby residents. South Korea began to build small-scale incinerators in 1980s and sanitary landfills in 1990s. However, the location, construction and operation of landfills and incinerators have triggered intense backlash from local residents. Further, rapid urbanization and expansion of cities made it difficult to secure spaces for waste disposal facilities. In other words, building waste disposal facilities was time-consuming and difficult process for the government. Thus, the MoE promulgated the Promotion of Installation of Waste Disposal Facilities and Assistance, etc. to Adjacent Areas Act. According to this Act, the government creates a resident support fund and establishes a communication channel between municipalities and local residents when building over certain size of waste disposal facilities. Although the Act ensures compensation to local residents and helps attract them to a negotiation table, it still requires more work on settling a sound agreement with them.

The Ministry of Land, Infrastructure and Transport released a housing development project in Hanam city in 2007 which aimed to build 38,315 apartments accommodating around 94,000 residents. The Korea Land and Housing Corporation (LH) as a developer is responsible for treating the waste and sewage generating from the planned apartment complex. The LH, a state-owned company, could either build its own waste and sewage treatment plants or pay the construction cost to Hanam city. The LH chose to pay 303.1 billion Korean Won (KRW) (US$ 245.2 million, US$ 1=KRW 1,236) to the city for constructing the facilities from 2011 to 2015. In order to avoid the opposition from residents and finish the construction in time. Hanam city installed all the environmental facilities underground while locating parks and sports facilities on the top of them, hence the name, the Hanam Union Park. Consequently, the LH was able to save time to negotiate with the local residents and did not pay any compensation to them. There have been no complaints from the nearby residents so far. Thus, many municipalities regard the Union Park as a role model and prefer to establish the underground structure addressing the NIMBY issue when they install waste disposal facilities, even though the cost will be much higher. For the facilities of the Union Park, modern technologies were adopted to treat waste and wastewater and to purify odor and are contributing to the energy saving for heating and cooling the park facilities and the extra income to the city by selling recyclable materials and animal feed produced from food waste.

3. KOREA'S EXPERIENCES

3.1 WASTE GENERATION AND DISPOSAL

The Waste Management Act defines wastes as substances that have become no longer useful for human life and business activities, including garbage, burnt refuse, sludge, waste oil, waste acids, waste alkalis, and animal carcasses. Wastes are divided into household waste and industrial waste depending on the sources. The industrial waste includes general industrial waste, hazardous waste, medical waste, and construction debris. Local governments are responsible for household waste while businesses have the responsibility for industrial waste. All waste generators pay the cost for collection and disposal of their wastes.

A total waste generation continuously increased with about 5% of annual growth during the 2000s. As of 2017, 429,531 tons of waste was produced daily, and 12.4% of the total amount was household waste amounting to 53,490 tons per day. Industrial waste and construction debris showed a steady growth due to the expansion of economic activities as well as a construction boom, accounting for 41.9% and 45.7%, respectively (MoE, 2017). Figure 1 shows the generation of household, industrial and construction waste between 1995 and 2017.

FIGURE 1. WASTE GENERATION

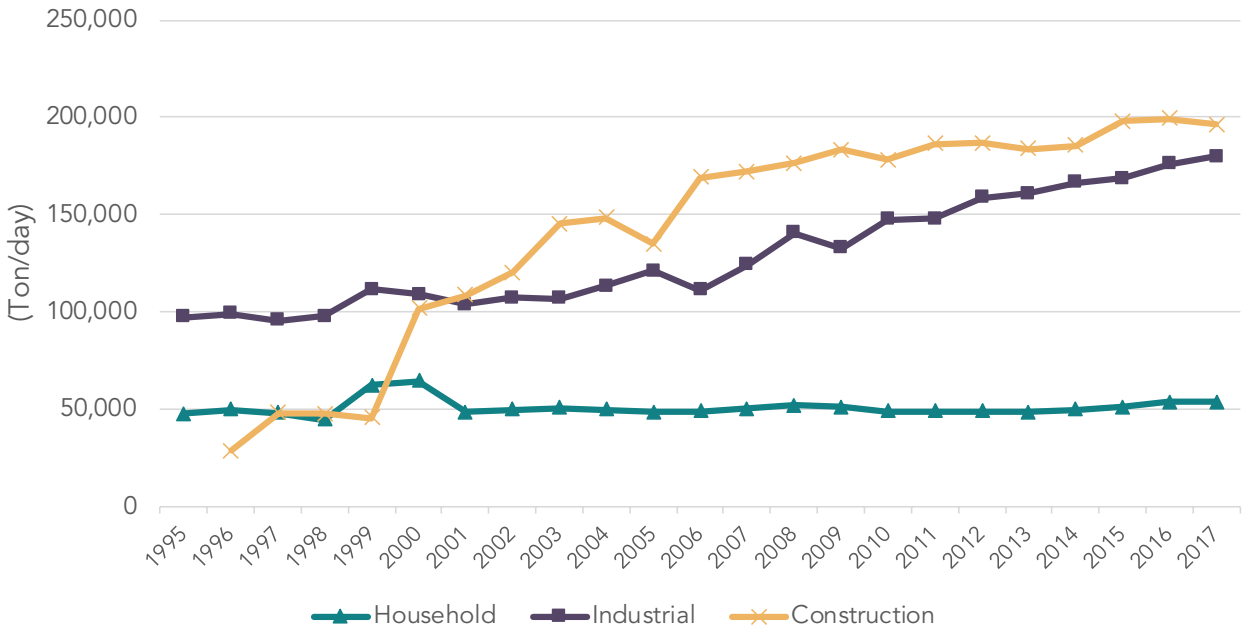
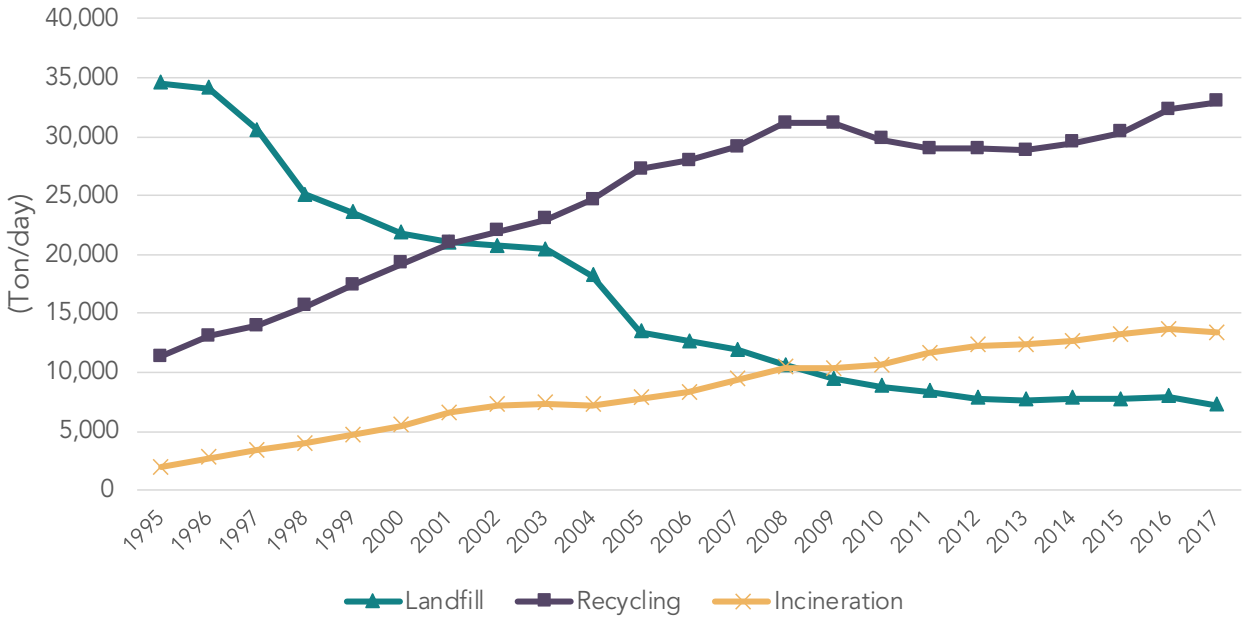


Figure 2 indicates a trend of household waste treatment (MoE, 2019). In 1995, 72.3% of household waste reached dump sites or sanitary landfills, 23.7% recycled, and 4% burnt at incinerators. The landfilling in 2017 dropped to 13.5% while recycling and incineration increased to 61.6% and 24.9%, respectively. The high rate of recycling was achieved with the eager participation of citizens in source segregation and an expanded market for recycled materials. Municipalities preferred incinerators as they needed relatively small land than that would be required for landfills.

FIGURE 2. HOUSEHOLD WASTE TREATMENT



3.2 INSTITUTIONAL FRAMEWORK

3.2.1 EVOLUTION OF LEGISLATION

South Korea was an agricultural society where waste was not social and environmental issues. With the Filth Cleaning Act of 1961, local governments were responsible for collecting garbage, excreta, and other wastes from households, commercial areas, tourist attractions and streets. Economic growth accompanying the expansion of a manufacturing sector led to an increase in industrial waste generation. The Environmental Preservation Act was promulgated in 1978 to tackle emerging industrial waste. A polluter pays principle applied to the treatment of industrial waste, and business owners were required to dispose of their wastes. The Filth Cleaning Act and the Environment Preservation Act were merged into the Waste Management Act in 1986 to deal with household and industrial waste in one legislation. The Act encourages the reuse and recycling of waste before the final disposal.

During the 1990s, it became more difficult to build waste disposal facilities due to the opposition from local residents whereas waste generation continued to rise. There was a growing need to decrease a total volume of waste by minimizing waste generation at the source and maximizing the reuse and recycling of them as much as possible. The MoE promulgated the Act on Promotion of Saving and Recycling of Resources in 1992, which introduced new approaches such as a waste charge system, an extended producer responsibility (EPR), and a deposit-refund system. In order to control import and export of hazardous wastes, the Act relating to Transboundary Movement of Hazardous Wastes and their Disposal was developed in 1994.

As NIMBY syndrome prevailed throughout the society, there was a strong need to facilitate a dialogue between the government and residents. The Act on Promotion of Installation of Waste Disposal Facilities and Assistance to Adjacent Areas was passed in the National Assembly in 1995. The Act requires the government to create a resident support fund, which is used for the compensation to local residents for their losses caused by planned waste disposal facilities, and organize a resident support consultative committee, which functions as a communication channel between the government and the residents. The committee members participate in selecting sites and monitoring the operation of facilities.

With active rebuilding and development during the 2000s, the amount of construction debris continued to grow, accounting for around 50% of the total generation. In order to increase the use of recycled construction wastes, the MoE came up with the Construction Waste Recycling Promotion Act in 2003. The government and state-owned companies are obliged to use recycled aggregates for the construction of roads, industrial complexes, housing complexes, and environmental facilities. As for electronics and motor vehicle, the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles put into place in 2007, emphasizing manufacturers' role in the recycling of electrical and electronic products and vehicles. The Act also requires the manufacturers to improve material composition of their products for an easier recycling process.

The Korean economy heavily depends on overseas resources. In every corner of Korean society, over-consumption of resources and energy is common. The Framework Act on Resources Circulation of 2018 aims at creating a resource circulation society by minimizing the input of natural resources, maximizing the reuse and recycling, and reducing final disposal of wastes. Table 1 shows the list of the legislation by periods.

TABLE 1. WASTE LEGISLATION

UNTIL 1980S	1990S - EARLY 2000S	LATE 2000S - PRESENT
DISPOSAL	RECYCLING/DISPOSAL	RESOURCE CIRCULATION
• Filth Cleaning Act (1961) Environmental Preservation Act (1977) • Waste Management Act (1986)	• Act on Promotion of Saving and Recycling of Resources (1992) • Act on Transboundary Movement of Hazardous Wastes (1994) • Act on Promotion of Installation of Waste Disposal Facilities and Support for Adjacent Areas (1995) • Act on Construction Waste Recycling Promotion (2003)	• Act on Management and Use of Livestock Excreta (2006) • Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles (2007) • Framework Act on Resources Circulation (2018)

Table 2 represents the waste laws with per capita Gross Domestic Product (GDP) (current US dollars). The first incinerator was built at US$2,413 in 1984, burning 50 tons of household waste per day. Considering the level of economic development, the incineration was rather early; however, and international consultant recommended the incineration in metropolitan cities as they had difficulty in securing lands for landfill sites. The Waste Control Act was established in 1986 when the per capita GDP was US$2,835. At US$8,127, the first sanitary landfill was constructed, and recycling was encouraged by the Act on Promotion of Savings and Recycling of Resources, which was in 1992. South Korea introduced the EPR and the Construction Waste Recycling Act at US$14,673 in 2003. The government turned its eyes on energy recovery from wastes and biomass in 2008 of which the per capita GDP was US$21,350. A circular economy or a resource circulation society became the core of waste management policies of Korea at US$33,340 in 2018.

TABLE 2. WASTE ACTS VS. PER CAPITA GDP

YEAR	PER CAPITA GDP (US$)	LEGISLATION	REMARKS
1961	94	Filth Cleaning Act	Street cleaning
1984	2,413	-	First incinerator
1986	2,835	Waste Control Act	Control of household/ industrial waste
1992	8,127	Act on Promotion of Savings and Recycling of Resources	Promotion of recycling activities First sanitary landfill
1995	12,565	Act on Promotion of Installation of Waste Disposal Facilities and Support for Adjacent Areas	Creation of resident support fund Volume-based garbage fee system
2003	14,673	Act on Construction Waste Recycling Promotion	Recycling of construction waste Extended producer responsibility (EPR)
2005	19,403	Act on Promotion of Purchase of Green Products	Green public procurement Ban on direct landfilling of food waste
2007	24,086	Act on Resource Circulation of Electrical/Electronic Equipment, vehicles	EPR for electrical/electronic equipment and vehicles
2018	33,340	Act on Resources Circulation	Resource circulation goals Introduction of waste disposal charge

3.2.2 ADMINISTRATIVE FRAMEWORK

The Waste Management Act states that the primary responsibility for household waste belongs to the local government, including provinces, metropolitan cities, and municipalities (cities, counties, and districts). Municipalities are responsible for collection, transportation, and disposal of household waste while provinces and metropolitan cities support the activities of municipalities in their jurisdiction. Most municipalities entrust parts of their responsibility to private companies with a short or a long-term contract. Industrial waste treatment is the responsibility of generators, business operators.

Ministries under the Korean government carry various responsibilities for the wastes that are generated under their jurisdiction. The MoE establishes a regulatory framework, developing strategies and

policies for all waste streams. The ministry provides technical and financial support to local governments to build waste disposal facilities. The Ministry of Trade, Industry and Energy (MOTIE) has the primary responsibility for fostering resource circulation industries, developing new and renewable energy, and transforming into resource-efficiency industrial structure. For example, the MOTIE created the Eco-Industrial Park Master Plan in 2003. The Plan was to build infrastructure to reduce, recover, reuse, and recycle waste and wasted energy by maximizing the economic and social benefits within industrial complexes. The Ministry of Land, Infrastructure and Transport (MOLIT) promotes the use of recycled aggregates for the construction of roads, industrial complexes, housing complexes, and environmental infrastructure. The ministry also introduces a quality certification system and implements quality standards for recycled aggregates in order to guarantee the quality of them. The Ministry of Oceans and Fisheries (MOF) is responsible for addressing wastes in oceans. The 2nd Marine Waste Management Plan (2014-2018) guides the prevention, collection and disposal of ocean wastes. The Plan was formulated by the joint efforts of relevant ministries according to the Act on Marine Environment Management. The ministry also plans to draft comprehensive measures for reduction of marine plastic wastes (MOF, 2019). The Ministry of Agriculture, Food and Rural Affairs (MAFRA) promotes energy generation from biomass and regulates compost and animal feed manufactured from organic wastes. The role and responsibility of the various stakeholders are listed in Table 3.

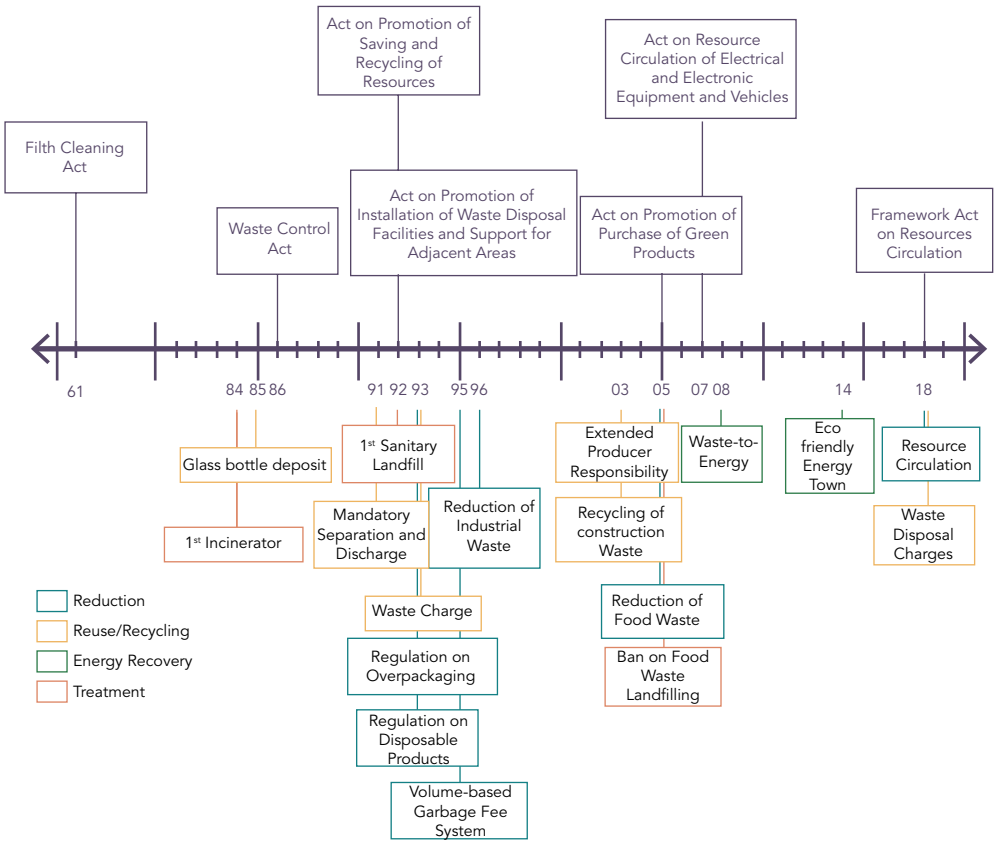
TABLE 3. DISTRIBUTION OF FUNCTIONS

ENTITY	ROLE AND RESPONSIBILITY
Ministry of Environment	To e stablish regulatory framework and develop strategies and policies To provide technical and financial support to local government
Ministry of Trade, Industry, and Energy	To foster resource circulation industry To develop new and renewable energy
Ministry of Land, Infrastructure and Transport	To promote the use of recycled construction wastes To introduce quality certification system for recycled aggregate
Ministry of Oceans and Fisheries	To manage ocean waste including marine plastics
Ministry of Agriculture, Food and Rural Affairs	To manage compost and animal feed produced from organic wastes To produce energy from biomass
Province, Metropolitan city	To provide financial support to municipalities To coordinate projects among municipalities
City, County, District	To collect and dispose of municipal waste To install and operate waste disposal facilities
Business, Developer	To dispose of industrial waste To treat waste generating from development project

3.3 WASTE MANAGEMENT POLICIES AND PROGRAMS

Waste management in South Korea began with street cleaning in 1961 and has been evolved from open dumping to safe disposal. In order to reduce the amount of final disposal and enhance resource efficiency, the MoE focuses on reduction, reuse and recycling, and energy recovery. Currently, Korea is focusing to create a resource circulation society. Figure 3 illustrates an evolution for waste legislation and major policies in a timeline (Seo, 2020).

FIGURE 3. EVOLUTION OF WASTE LEGISLATION AND MAJOR POLICIES



3.3.1 REDUCTION AT SOURCES

VOLUME-BASED WASTE FEE SYSTEM

Up until 1990, local governments collected household waste on a door-to-door basis and levied garbage fees on the property taxes on the size of houses or apartments buildings. In order to reduce waste at sources, the mandatory source separation was introduced in 1991, which was then replaced by a pre-paid bag system in 1995. A volume-based waste fee (VBWF) system was to minimize the amount of wastes discharged and secure recyclable materials by segregating wastes at sources. It requires home waste generators to buy standard garbage bags and throw away their wastes into the bags while they discard recyclable wastes at no cost, including metal cans, bottles, plastics, and paper. The more garbage they discard, the more they have to pay for the bags. For the first year of its implementation, citizens joined the initiative with a high participation rate of almost 100%. Per capita generation of household waste dropped from 1.33 kg/day in 1994 to 0.95 kg/day in 2012. Since then, the daily waste volume has remained around 0.94 kg/capita/day to 1.05 kg/capita/day. Initially, the system applied only to household waste and was then expanded to the waste

generated from commercial, institutional, and industrial sources with similar properties to household waste. Improper discharge of garbage such as the use of other bags and illegal dumping is subject to a fine of 200,000 KRW (US$ 162), or the waste in non-official garbage bags are not collected by municipalities or private contractors.

As of 2017, 99.9% of municipalities (3,496 out of total 3,500) and 21.62 million among 21.63 million households participated in the system. Every municipality sells its garbage bag of which prices vary from municipality to municipality. A total of 3,496 municipalities sold 1.1 billion bags and earned 621.7 billion KRW (US$ 503 million), increased by 8.7% (1.01 billion bags) and 7.9% (576.4 billion KRW) in 2016, respectively, while 1.24 billion bags were manufactured at the cost of 82.7 billion KRW. The average unit prices of bags are 256 KRW (US$ 0.21) for 10 liters and 503 KRW (US$ 0.41) for 20 liters, respectively (MoE, 2019). Local governments are securing parts of the budget for waste management by selling the garbage bags as well as recyclable materials.

Eighteen years of the VBWF implementation (1995-2012) yielded 19,560 billion KRW (US$ 15.8 billion) of economic benefits. The economic gains were attributed to the cost reduction of waste disposal such as incineration and landfilling (14,830 billion KRW, US$ 12.0 billion) and the economic value of increased recyclable materials (4,730 billion KRW, US$ 3.83 billion). The accumulated volume of waste reduction reached 102.7 million tons (MoE, 2014).

In addition to the economic benefits such as a reduction in the volume of discharged wastes, an increase in recyclable materials, and a decrease in disposal cost, the system has proven to enhance citizens' awareness and make them perceive the value of recyclables. Further, the entire process of production, distribution, and consumption of goods and services has shifted to a more environment-friendly manner. When consumers purchase products at stores, they prefer goods that generate less waste. It was frequently witnessed that they are reluctant to buy products with large packaging materials since such packaging will require more garbage bags. In response to changing consumers' attitudes, businesses have no choice but to adopt more sustainable production processes to reduce waste generation and excessive packaging. However, shortcomings remain in the system. In 2016, the price of garbage bags covered only 33.3% of the actual costs for the collection and disposal as well as bag manufacturing (Korea Environment Institute, 2018) due to municipalities' reluctance to raise the cost, avoiding the risk of opposition from the voters. In addition, some households put regular waste into recycling containers, reducing the quality of recyclables.

WASTE CHARGE SYSTEM

In 1993, a waste charge system was introduced to encourage manufacturers to consider the environmental aspects of their products at the production stage. They are required to pay the cost for disposing of hazardous and non-recyclable wastes, which would in turn reduce both the production and consumption of excess waste materials through gradual increase of the price. Products, materials, and containers that are difficult to recycle were the target of the system. As of 2019, the charge system is imposed on six items such as pesticide and poisonous substance containers, anti-freeze products, plastics, and disposable diapers. The plastic products include toys, pipes, cables and insulation products for construction; however, the charge does not apply to the packaging materials–these materials are subject to an extended producer responsibility scheme. The collected charge is used to fund local governments to install wastes disposal facilities and support recycling activities. The charge increased to 182,734 million KRW (US$ 147.8 million) in 2018 from 60,515 million KRW (US$ 49 million) in 2008.

In 2008, the Ministry of Environment (MoE) introduced a voluntary agreement for plastic producers to increase recycling of the plastics subject to the charge system. In 2019, the agreement includes 15 product categories such as electric and communication cables, polyvinyl chloride (PVC) pipes and industrial expanded polystyrene (EPS or Styrofoam). Recycling targets set by the MoE and producers

are renewed on a yearly basis. Producers who meet the recycling targets are exempted from the charge. When failing to meet the target, they have to pay for the non-compliance charge. A 2016 performance assessment of the agreement revealed that 198,000 tons of plastic was recycled. It brought economic benefits worth of 171.7 billion KRW (US$ 139 million) due to the increase of recyclable materials and the cost savings for disposal: 127.8 billion KRW for increased recyclables and 43.9 billion KRW for the cost saving to burn or bury the recyclables. The voluntary agreement for plastic producers also contributed to the reduction of 177,000 tons of carbon dioxide (CO_2) (Korea Environment Corporation, 2016).

DISPOSAL PRODUCTS AND OVER-PACKAGING

Along with the increase of living standards, the use of disposables and packaging materials have been overflowing in Korean society. Since packaging materials occupy the majority of household waste, the MoE developed guidelines to control disposables and over-packaging in 1993. For example, in large restaurants, the use of single-use cups, platters and containers made with synthetic resin–polyethylene (PE), polystyrene (PS), polypropylene (PS), expanded polystyrene (EPS), polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS)–were banned. The criteria for packaging materials and methods were also introduced: PVC packaging and packaging that uses PVC for lamination or coating are prohibited to replace them with recyclable or eco-friendly alternatives. Manufacturers must keep the packaging space, the ratio of vacant space to the total packaging volume, of 10% to 35%, so the products should occupy 65% to 90% of the total packaging volume.

In addition, the MoE concluded a voluntary agreement in 2002 with 13 major coffee and fast-food chains using large volume of single-use products. The agreement aimed to reduce the use of disposable products, retrieve used disposable cups, and provide incentives to customers using reusable cups. Since April 2019, the use of disposable plastic bags has been banned at large retailers nationwide. Around 13,000 big supermarkets with sales floor of 165 square meters or more cannot offer single-use bags to customers. Department stores and large shopping malls are also subject to the new initiative. Violators will face fines of 3 million KRW (US$ 2,427) (MoE' press release, 28 March 2019). Further, the MoE will introduce a single-use cup deposit program in 2021 in which about 35,000 coffee shops will be subjected to.

3.3.2 REUSE AND RECYCLING

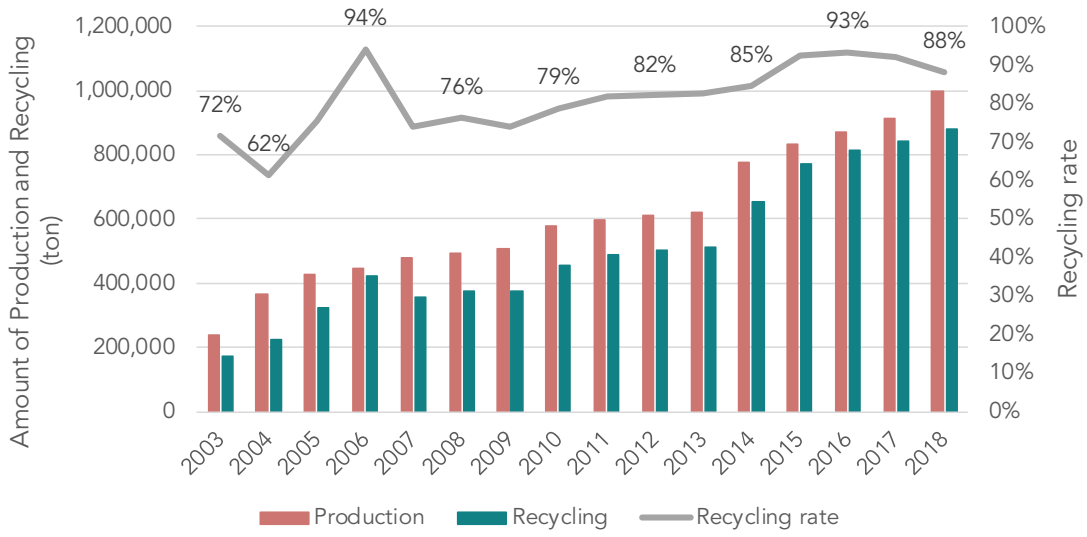
EXTENDED PRODUCER RESPONSIBILITY

An extended producer responsibility (EPR) scheme encourages manufacturers to consider environmental impacts over the whole production process: design, manufacturing, consumption and disposal. The EPR mandates producers or importers to bear the burdens of collection and recycling obligations in proportion to their production outputs. With the implementation of the EPR scheme, manufacturers are able to minimize waste generation from raw material selection, design, and production to packaging. In addition, some manufacturers are very likely to establish a retrieval system through their own sales networks.

Currently, 4 packaging materials, 7 products (tire, lubricant oil, fluorescent lamp, and farming buoy), and 10 electronic equipment (TV, refrigerator, air conditioner, and washing machine) are subject to the EPR scheme. The packaging includes PET bottles, plastics (PE, PP, PS, Styrofoam), metal cans and glass bottles. The MoE sets the recycling targets for each items every year. When fail to meet the targets, producers and importers are subjected to penalties based on the amount of non-compliance, which is three to five times more expensive than the collection and recycling cost of their products. The MoE also releases the Framework of Resource Recycling Plan every five years, setting obligatory recycling targets for each EPR item. Based on the targets, producers establish their own mid-term recycling plans.

For six years, from 2003 to 2008, of implementation, 7.44 million tons of packaging waste retrieved was recycled, which, in turn, yielded an economic benefit worth about 1,387 billion KRW (US$ 1.12 billion) (Korea Environment Corporation, 2010). In addition, the EPR has achieved a reduction of 10.4 million tons of CO_2 emissions and employed 15,702 persons (MoE, 2010). The EPR has also contributed to fostering domestic recycling markets. Figure 4 shows the performance of the EPR for synthetic resin from 2003 to 2017 (Korea Environment Corporation, 2019).

FIGURE 4. EPR PERFORMANCE FOR SYNTHETIC RESIN



As with other countries, producers and importers in Korea established a cooperative organization, the Korea Resource Circulation Service Agency (KORA), which would perform their recycling obligations on behalf of them. The KORA, a non-profit organization, was supported by the Act on Promotion of Resource Saving and Utilization and is operating the EPR scheme. As it is quite costly for producers and importers to retrieve their packaging wastes across the country independently, they resorted to pay the cost for collecting and recycling their recyclables to the KORA. Then, the KORA creates a recycling support fund with their payments and allocates the fund to recycling companies according to their performance of collection, sorting, and recycling. In 2018, the companies received the fund of 126 billion KRW (US$ 101.9 million) for their recycling activities (Personal communication with KORA).

GLASS BOTTLE DEPOSIT PROGRAM

In 1985, a bottle deposit program was devised and implemented to promote the reuse of glass bottles ensuring motivation through economic incentives. When consumers purchase liquors or soft drinks, they pay a deposit, or bond money in advance, thus the deposits were incorporated into consumer prices of each product. The deposit was refunded to consumers when they returned bottles. The reuse of bottles leads to minimize the manufacturing of new bottles, which eventually reduce the import of natural resources, energy use, and greenhouse gases.

The deposit rate was set in 1994 without a raise, and therefore, consumers lost their interest in returning bottles with only 24% of a retrieval rate. In 2016, the MoE raised the deposit from 40 KRW to 100 KRW for a Soju (the most popular Korean alcohol drink) bottle, and from 50 KRW to 130 KRW for a beer bottle. Since then, the retrieval rate has doubled from 24% in 2015 to over 60% in 2018, and the total return rate has increased from 90.7% in 2015 and to 98.4% in 2018. Currently, only 10% of the bottles are newly produced bottle; around 90% of the Soju bottles are retrieved bottles, which increased from 82% to 85% before 2016 (Personal communication with KORA).

Although the deposits are essentially the consumers' money, Soju and beer companies had managed the deposits since 1985. In order to increase the transparency in the management of the deposit (501.2 billion KRW; US$ 405.5 million in 2019), the MoE transferred the responsibility of managing the deposits to the KORA in 2016, and the KORA subsequently established the deposit payment system. From 2016 to 2019, the KORA retrieved 19.1 billion bottles and processed 1.53 million cases of payments through the web-based payment system (Personal communication with KORA).

Another initiative was the standardization of Soju bottles. In the past, 10 Soju companies used 10 different types of bottles, so each company has to collect its own bottles for reusing them. The MoE concluded a voluntary agreement for sharing a standardized Soju bottle with Soju companies in 2010, enabling them to use any bottles in producing the Soju. The agreement led to an economic benefit worth of 32.9 billion KRW (US$ 26.6 million) as the companies were able to save the cost for manufacturing 250 million new bottles, amounting to 8% out of three billion new bottles made in 2017. The Soju companies buy new bottles for 147 to 158 KRW, while they use retrieved bottles for 80 to 105 KRW covering collection, cleaning and disinfection of them (Personal communication with KORA).

FOOD WASTE RECYCLING: A WEIGHT-BASED FOOD WASTE FEE SYSTEM

Food waste was produced 15,903 tons per day, accounting for 29.7% of household waste (53,490 ton/day) in 2017. Food waste normally goes to landfills, which raise complaints from nearby residents against municipalities, the owner of landfill sites. In 1996, the Sudokwon landfill stopped receiving food waste coming from Seoul and its surrounding municipalities, and the MoE further prohibited direct landfilling of food waste in 2005. As a way to curb the growing amount, the ministry introduced a weight-based food waste fee scheme nationwide in 2014. Prior to the adoption of this scheme, municipalities collected food waste at little or no cost. However, the weight-based food waste fee scheme requires producers–households, restaurants, schools and supermarkets–to pay for their collection services according to the amount discharged. The collected food waste is converted into organic fertilizer or animal feed.

The MoE established a RFID-based food waste management system. The RFID automatically measures the amount of food waste, and then levies collection fees to households according to the weight discharged by them. As of 2018, 69,055 RFID equipment were installed at 3.68 million households in 149 municipalities (MoE, 2019). Figure 5 shows the RFID equipment installed by Yeongdengpo district (left), Seoul city and by Guri city, Gyeonggi province (right). However, in small municipalities, residents still have to buy disposal bags for food waste and deposit the bags in food-waste-only-containers.

FIGURE 5. RFID-BASED EQUIPMENT FOR FOOD WASTE

PUBLIC PROCUREMENT FOR RECYCLED PRODUCTS

In OECD countries, 12% of the GDP is spent on public procurement, which implies that public authorities are one of the major consumers (http://www.oecd.org/gov/public-procurement). European Commission describes green public procurement as "a process whereby public authorities seek to procure goods, services, and works with a reduced environmental impact throughout their life cycle when compared to goods, services, and works with the same primary function that would otherwise be procured" (http://eu.europa.eu/environment/gpp).

In order to foster the markets for recycled materials, the government recommended public institutions to purchase preferably green products such as recycled and eco-labelled products starting in 1994. Usage of green products can contribute to resource saving and result in relatively less contamination compared to the other products among the same products categories. In order to promote the use of recycled products, the MoE promulgated the Act on the Promotion of Purchase of Environment-friendly Products in 2005, introducing a green public procurement scheme. The recycled products include drainpipes, water meter protection box, rod block, brick, printing paper and toilet paper.

The total amount of green purchase has reached 3,880 billion KRW (US$ 3.14 billion) in 2019, which is a significant achievement compared to 255 billion KRW (US$ 206.3 million) in 2004 (Personal communication with Korea Environmental Industry and Technology Institute). About 920 entities including central/local governments, state-owned/local government-owned enterprises and public schools are subjected to the scheme. Along with the public procurement, the MoE has concluded a voluntary agreement with large businesses for green purchasing in 2005, and 151 companies joined this agreement.

FINANCIAL ASSISTANCE TO RECYCLING ACTIVITIES

The Ministry of Environment grants a subsidy to local governments for building new recycling facilities or renovating existing ones such as storage and sorting plants for recyclables. Among the total construction cost, 30% to 50% is borne by the MoE. A total of 445 recycling facilities received the support fund of 1181.4 billion KRW (US$ 9.56 billion) from 2001 to 2018.

The domestic recycling industries are still in a premature stage of development. Therefore, the MoE provides financial support to private sector for its facility installation, technology development and commercialization. The recycling industry promotion fund is given to a recycling business on a long-term, low-interest basis. A total of 3,874 businesses have benefitted 1,608 billion KRW (US$ 1.3 billion) between 1994 and 2018 (MoE, 2019).

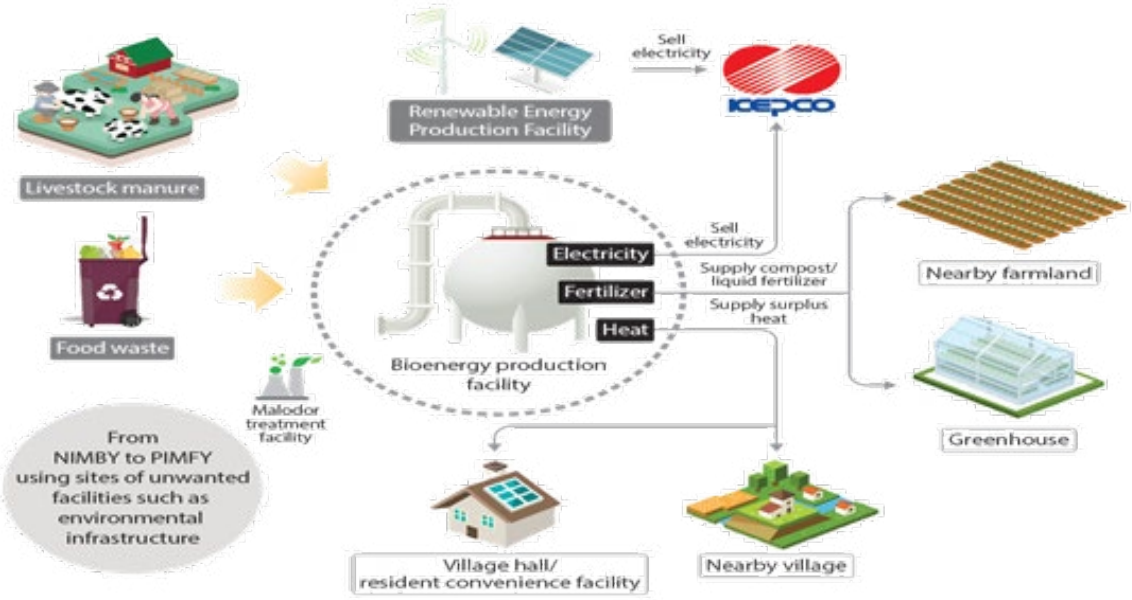
3.3.3 ENERGY RECOVERY FROM WASTES AND BIOMASS

South Korea is the tenth largest energy consumer in the world and 96% of its energy depends on overseas importation. It ranked sixth highest emitter of greenhouse gases in 2015. The government plans to generate 20% of electricity from renewable energy sources by 2030 from 7.6% in 2017. The electricity from renewable sources occupies 8.3% of the total generation in 2018, which includes waste, biomass, solar, hydro, and wind. Among the renewable energy sources, waste and biomass accounts for 46.2% and 17.8% of the electricity generation, respectively, and followed by solar (17.5%) (Korea Energy Agency, 2019). Further, the energy production cost of waste and biomass is cheaper at 10% of solar and 66% of wind power. Thus, energy production using waste has been considered as a cost-effective option at an early stage.

The MoE disclosed the Measures for Waste Resource and Biomass Energy in 2008. It mainly focuses on combustible waste, organic waste, landfill gas, and residual heat from waste incineration. The ministry plans to convert 90% of combustible waste and 36% of organic waste–food waste, sewage sludge, livestock excreta, landfilling leachate–into energy by 2020. The MoE provides local governments with subsidy and technology in order to build waste-to-energy converting facilities.

The government initiated an eco-friendly energy town project in 2014. The energy town produces electricity, heat and other forms of energy with food, livestock excreta, and biomass. It aims to improve the living environment and increase the income of residents. They sell the electricity and compost to the Korea Electric Power Corporation and nearby farmland and golf courses. The energy is also used for heating their villages in winter. The government has conducted pilot projects at Hongcheon in Gangwon province, Kwangju Metropolitan City, and Jincheon in Chungbuk province by the MoE, the Ministry of Trade, Industry and Energy, and the Ministry of Information and Communication, respectively. With the positive outcome of these pilot projects, the government plans to expand such project throughout the nation. The MoE launched the project in more 10 cities and counties, and it is carrying out feasibility studies in 7 municipalities. As many local governments show their interest in this project, the eco-energy town becomes the first example of PIMFY (Please in My Front Yard) in the field of environmental facilities in Korea. The concept of the eco-friendly energy town is illustrated in Figure 6 (MoE, 2017 Environmental Review).

FIGURE 6. ECO-FRIENDLY ENERGY TOWN



3.3.4 WASTE DISPOSAL AND FINANCING

HISTORY AND FAILURE STORY OF WASTE DISPOSAL FACILITIES

Before the early 1990s, household and industrial wastes were dumped into open spaces causing many environmental problems. In particular, leachate destroyed streams or rivers that were used for drinking and agriculture purposes. The government started to install waste disposal facilities by importing foreign technologies in 1980s.

In 1983, Seoul built the first refuse-derived fuel (RDF) manufacturing plant by adopting Danish technology. The plant failed to operate as the waste composition of two countries was different from each other: the low caloric value and high moisture contents of the domestic waste comparing to the Danish waste. The Korean government established a master plan to install 27 incinerators in 9 large cities as a part of the fifth Economic and Social Development Plan (1982-1986). The first incinerator was built in Uijeongbu city, Gyeonggi province in 1984, burning 50 tons of municipal wastes a day.

Considering the level of economic development (per capita GDP: US$2,413), the timing of adopting the incineration process was rather early; however, securing land for dump sites or landfills had been difficult tasks, and investment and operation costs of incinerators was not an important consideration. The number of small-scale incinerators had expanded by the 1990s, causing air pollution to nearby neighborhoods. Thus, the MoE banned new installation of small-scale incinerators (25 kg/hour) in 1998. The MoE and Seoul metropolitan city jointly built the Sudokwon landfill site in 1992, which opened an era of sanitary landfills in Korea.

During 1990s and 2000s, the MoE had expanded the number of waste disposal facilities throughout the country, and then, became more focused on reuse and recycling of waste. Since the direct landfilling of food waste and sludge were banned in 2005, food waste was used to produce organic fertilizer or animal feed. The facilities did not yield the best result due to technical problems and malodor(?), causing the opposition from residents.

As of 2016, there were 1,401 waste treatment facilities nationwide: 688 facilities were owned by the government, and 713 facilities by the private sector (MoE, 2018). Household waste is normally handled by public facilities while industrial wastes are treated in private ones. Table 4 summarizes the waste treatment facilities, their disposal capacities and amounts. The "others" in this table includes RDF facilities, animal feed and composting facilities, and bio-gasification plants. As for RDF manufacturing facilities there were 14 public facilities, and three more are under construction. In addition, 250 private facilities also produce RDF. Currently, 2.7 million tons of RDF are produced, and 150 boilers–paper factories, cement factories, dyeing factories, and power plants–use it as fuel replacing B-C oil. Twenty bio-gasification plants produce biogas from organic waste and 10 more plants are under design or construction.

TABLE 4. WASTE TREATMENT FACILITIES IN 2016

CATEGORY (TON/DAY)	PUBLIC FACILITY			PRIVATE FACILITY		
	NUMBER	CAPACITY	DISPOSAL	NUMBER	CAPACITY	DISPOSAL
TOTAL	**688**	**59,991**	**26,541**	**713**	**226,038**	**33,091**
Landfill	221	482	6.6	60	174	7.1
Incinerator	184	17,581	12,746	235	14,927	11,285
Others	283	42,410	13,795	418	211,111	21,806

FINANCING: SUBSIDY AND PUBLIC-PRIVATE PARTNERSHIP

In terms of financing, the MoE provides financial support to local governments for the installation of the public facilities. The ministry grants a subsidy ranging 30% to 70% of the construction cost according to the types of waste disposal facilities–incinerators, landfills, material recovery plants, and waste-to-energy conversion plants–and the financial ability of local governments. In 2019, the ministry granted a subsidy as much as 153 billion KRW (US$ 123.7 million), which is 20.5% of increase from 2018. Table 5 shows the cost sharing of/between(?) the MoE and local governments for different facilities and regions in 2020.

TABLE 5. SUBSIDY FOR WASTE DISPOSAL FACILITIES IN 2020

FACILITY	LOCAL GOVERNMENT	COST SHARING (%)		REMARKS
		MOE	LOCAL	
1) Incinerator 2) Organic waste bio-gasification 3) Recyclables recovery 4) Construction debris sorting 5) Landfill 6) Food waste treatment	Seoul city	30	70	Only for regional facilities used by two or more municipalities
	Metropolitan city	40	60	
	City and County (Regional facilities)	30 (50)	70 (50)	
	Island	50	50	
7) Landfill renovation 8) Eco-friendly energy town 9) Household waste pre-treatment 10) Marine waste sorting		50	50	30% for landfill
11) Landfill gas-to-energy		1.5 billion KRW	the rest	
12) Rural waste treatment		70 1.5 billion KRW	the rest	

Most municipalities have limited budget especially for environmental infrastructure. It mainly attributes to low utility fees and low willingness to raise the fees. For instance, the average price of a 20L garbage bag was 490 KRW in 2016 covering only 33.3% of the cost for collection, disposal and bag manufacturing (Korea Environment Institute, 2018). In case of a sewerage tariff (559.2 KRW/m^3) covered only 45.5% of the total treatment cost (1,228.3 KRW/m^3) in 2018 (Korean Statistical Information Service, 2019).

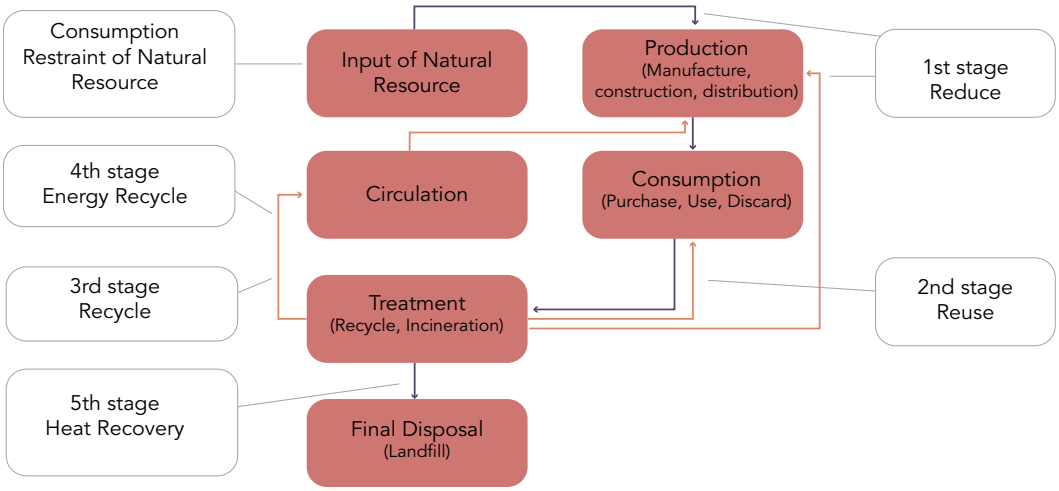
The Act on Public-Private Partnerships in Infrastructure promotes the investment of private sector in infrastructure such as electricity, roads, railroads, dams, and environmental facilities–waste disposal, wastewater treatment, and recycling facilities. The Ministry of Economy and Finance (MOEF) promotes the establishment of the public-private partnership (PPP) projects—in the categories of build-transfer-operate (BTO), build-operate-transfer (BOT), build-own-operate (BOO), and build-transfer-lease (BTL), establishing a master plan for them in infrastructure considering national investment priorities. The Public-Private Partnerships Review Committee, under the MOEF, formulates major policies concerning private sector investment and designates a concessionaire of each PPP project if the projects are qualified for the government subsidy program. The private sector is also able to propose PPP projects to the ministry.

Since municipalities faced difficulties in financing environmental infrastructure, they became interested in the PPP projects. For example, Cheonan city, South Chungcheong province, invited private investment for the construction of waste disposal facilities in 2017. The project includes an incinerator for municipal waste (200 tons/day) and sport facilities such as swimming pools. The BTO mode applied to the project worth of 79.1 billion KRW (US$ 64 million) and a concessionaire had the rights to manage and operate the facilities for 15 years upon the completion and operation of them.

3.3.5 A CIRCULAR ECONOMY

Though its economy depends heavily on overseas resources, over-consumption of resources and energy was prevalent in Korea. About 56% of recyclable wastes ends up in landfills or incinerators although they can be used for secondary materials or energy (Basic Plan for Resource Circulation, 2011-2015). Meanwhile, it has become increasingly difficult to find spaces for new landfill or incinerators due to a fierce backlash from local residents and Korea's geographic characteristics of a relatively small territory with a high population density. Another emerging issue is climate change. In 2009, the Korean government announced a reduction target that cuts 37% of greenhouse gas emissions by 2030 in comparison to the 2005 level. In order to address these challenges, the government decided to create a circular economy or a resource circulation society, which aims at continual use of input resources, maximization of reuse and recycling, and minimization of final disposal of waste. The structure of the circular economy is sketched in Figure 7 (Modification from Basic Plan for Resource Circulation, 2011-2015).

FIGURE 7. STRUCTURE OF CIRCULAR ECONOMY



The Framework Act on Resources Circulation took into effect in 2018. The first Resource Circulation Framework Plan (2018-2027) sets the goal with an increasing domestic resource circulation rate from 70.3% in 2018 to 82% in 2027. The resource circulation rate refers to the ratio of the amount of reuse or recycled materials to the total input materials. The amount of landfilling out of the total waste generation will drop from 9.1% in 2018 to 3% in 2027, and the energy recovery will increase from 16.3% in 2018 to 20.3% in 2027. With an aim at promoting recycling rather than final disposal, a waste disposal charge was implemented in 2018. Table 6 illustrates the waste disposal charge. Full implementation of the Act is expected to foster recycling markets and develop recycling technologies. Further, it helps extend the life of existing landfills and incinerators.

TABLE 6. WASTE DISPOSAL CHARGE

WASTE CATEGORY		CHARGE (KRW/KG)	
		LANDFILLING	INCINERATION
Household		15	10
Industrial	Non-combustible	10	-
	Combustible	25	10
Construction		30	10

3.4 PUBLIC AWARENESS, ENVIRONMENTAL EDUCATION AND PARTNERSHIP

The Environment Administration was established in 1980 and was upgraded to the Ministry of Environment (MoE) in 1994. The new administration had limited functions and was frequently left out of the decision-making processes and budget allocation within the government. The MoE turned its eyes on mass media and civic groups who had exerted great influence on political and social issues since the military regime. In particular, mass media played a leading role in enhancing citizens' awareness and educating them on various issues such as human rights, labor, and environmental pollution. The MoE continued to provide environmental information (waste separation, water conservation, dioxins, air pollution, etc.) to the press and advertise them in TVs, newspapers and radios. Well-informed citizens contributed to waste reduction and source segregation, and waste segregation at sources was the first step toward 3Rs (reduction, reuse and recycling) in South Korea.

Since 1990s, the MoE has focused on environmental education in schools and included environmental content in "Ethics" or "Natural Science" of primary, middle and high school curriculums. It also provided supplementary materials and training programs to teachers during summer and winter breaks at no cost. The MoE enacted the Environmental Education Promotion Act in 2008, which requires the establishment of the Environmental Education Master Plan in consultation with the Ministry of Education every five years.

Before and after the military regime, religious organizations and civil groups had strong influence over Korean society as a whole. They frequently suspended or delayed the construction of environment-destructive development projects such as dams, railroads, industrial complexes, and roads. In order to take advantage of their power, the MoE created the Civic Groups Council for Environmental Consultation in 1994. The Council offers advices on major policies and carries out joint monitoring and surveys on environmental issues such as the safety of tap water, pollution accidents and dioxins. The public tends to trust the findings of civic groups more than the government as they had little trust on the government. About 10 to 20 major environmental NGOs and consumer groups participated in the Council, and the vice-minister of the MoE is one of the co-chairs. The ministry also established the Religious Groups Council for Environmental Consultation and Implementation in 2000. It implements action plans for major environmental policies among their believers. Christian, Buddhist and Catholic organizations are member of the Council. The religious organizations and civil groups played a significant role in drawing the attention of the government, politicians, and the public to environmental issues and helped the MoE secure its budget and expand its functions and responsibilities.

3.5 ICT-BASED WASTE MANAGEMENT

According to Article 45 of the Waste Management Act (Electronic process of manifest: waste transfer and takeover), the MoE has developed an electronic information processing program. (?) Article 18 (Business waste treatment) stipulates that those who produce, transport, or dispose of industrial wastes are required to register their treatment records into a web-based system at every stage of generation, transportation, and final disposal of wastes. Concerning medical waste, a radio-frequency identification (RFID)-based technology is implemented to input and track the treatment records. Currently, the MoE established a web-based waste disposal verification system, a recyclables trade system, a RFID-based medical waste management system, a RFID-based food waste fee charging system, a reporting and payment system for EPR, a refund system for glass bottles, and a smokestack telemetering system.

ICT technologies in waste management contribute to preventing illegal disposal as authorities can easily track and verify the treatment records submitted by generators, transporters, and disposal businesses on a real-time basis. The technologies have enhanced the work efficiency of businesses and administrative organizations due to lessen their paperwork. The MoE named the Korea Environment Corporation (K-eco) as an operation entity of the system. The K-eco is a state-owned organization under the MoE of whose mission contributes to the eco-friendly national development through the improvement of the environment and promotion of resource circulation.

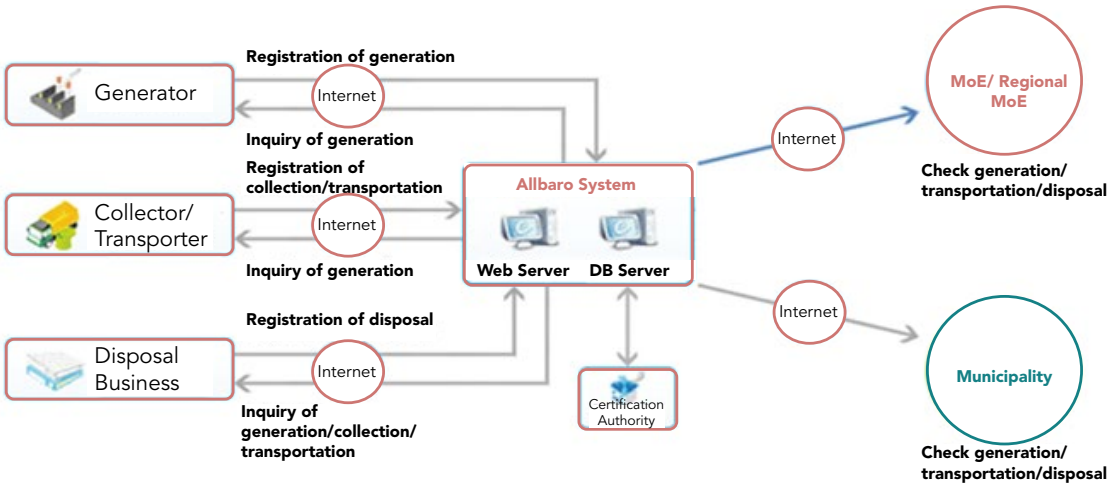
3.5.1 WEB-BASED WASTE DISPOSAL VERIFICATION SYSTEM (ALLBARO SYSTEM)

Since industrial waste, especially hazardous waste, and medical waste require strict management and safe disposal, their treatment costs are more expensive than that of household waste. For instance, the treatment cost for medical waste was 1,004,000 KRW/ton while the cost for household waste was 62,076 KRW/ton in 2019. Thus, illegal dumping or disposal had been common in Korea. Before the start of business operation, generators of industrial waste must report the types and amount to local authorities. If the generators do not report or provide false information, they are imprisoned for up to two years or fined 10 million KRW (US$ 8,090). Dumping or burning industrial waste illegally, violators are subject to imprisonment for up to 7 years, or by a fine of 70 million KRW (US$ 56,630).

The MoE introduced a waste disposal verification system in 1991 in order to track the flow of hazardous waste. A producer issued a document on the amount, types and characteristics of its waste generated; a transporter also issued a document of the same kind for the takeover from the producer and the transfer to a disposal business; and the disposal business issued a document on the disposal amount of the waste received from the transporter. Then, the producer, transporter and disposal business sent the documents to environmental authorities. The scope of the system expanded to include general industrial waste in 1999. However, it demanded excessive amounts of administrative works, as authorities manually checked the treatment records submitted from generators, transporters and disposal businesses. To overcome the drawback, the MoE established a web-based waste disposal verification system (Allbaro System) in 2002, replacing the former manual system. The Allbaro system can easily track the entire treatment processes from generation, transport to final disposal on the web.

The 2007-revised Waste Management Act requires mandatory creation of an electronic information on manifests (takeover and transfer) of wastes at every stage of generation, transportation and disposal. Producers, transporters and disposal businesses input their treatment records into a web-based system. Therefore, authorities also can verify on a real-time basis whether wastes are legitimately transported and disposed of, which helps prevent illegal disposal of them. Construction and medical wastes were subject to the system in 2008. Since 2011, all industrial wastes have been the subject of the system. Figure 8 depicts the Allbaro system. In 2018, the system handled 145.5 million tons of industrial wastes and processed 12.2 million manifests. The users of the system reached 372,766 business entities (MoE, 2019).

FIGURE 8. ALLBARO SYSTEM



3.5.2 ON-LINE RECYCLABLES TRADE SYSTEM

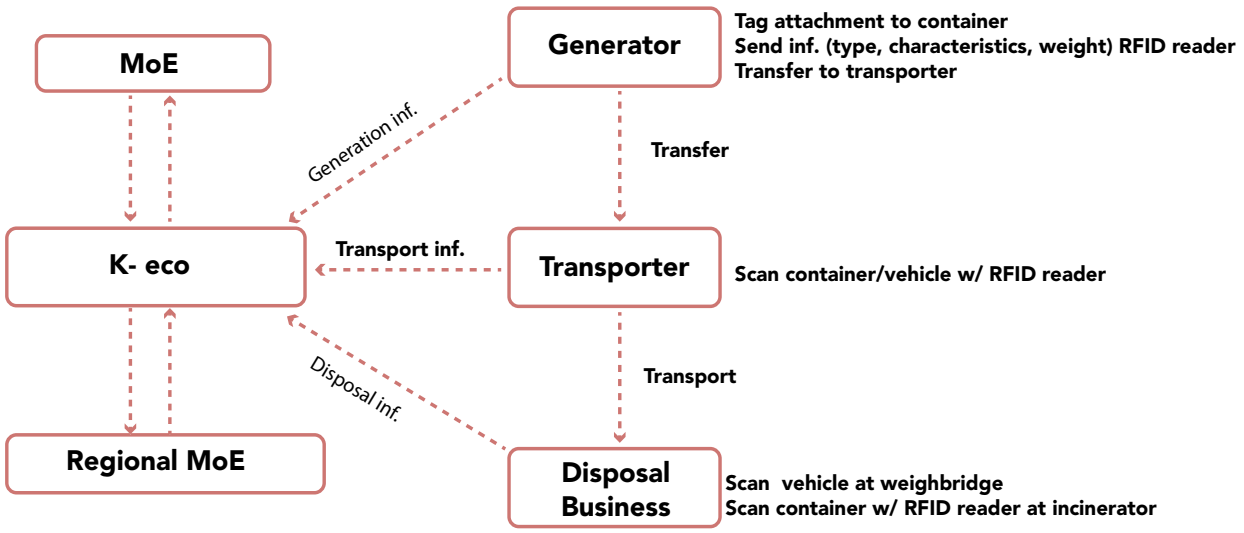
The Framework Act on Resource Circulation requires the MoE to establish a trade platform for recyclable materials, which provides sellers and buyers with information on recyclable wastes. Sellers upload the type, characteristics, amount and quality of recyclable materials to be sold, then buyers can search information on the price, quality, and location of them in order to purchase what they want through the system. It functions as an online market for sellers and buyers to promote the reuse and recycling of used products and recyclable materials. An electronic bidding is available to facilitate online trade of recyclables. For supporting convenient transactions, electronic payment services are available for safe account transfer and payment. Figure 9 shows the outlook of the web-based waste trade system (MoE, Environmental Review 2017). As of 2016, around 800,000 users joined the membership.

FIGURE 9. ON-LINE RECYCLABLES TRADE SYSTEM

3.5.3 RFID-BASED MEDICAL WASTE MANAGEMENT SYSTEM

Medical waste amounted to 221,592 tons in 2016 and went up by 9.0% from the previous year. For the past five years, the generation sharply rose up to 50%. Considering the infectious characteristics, it is necessary to ensure safe management for the whole processes of discharge to final disposal. All handlers are obliged to use the containers dedicated to medical waste. Further, the Waste Management Act mandates generators, transporters and disposal businesses to register all treatment manifests in the electronic information processing program by using RFID technology. Electronic tags are attached to the containers, and the tags contains types, characteristics of waste, and ID numbers of handlers. Businesses shall transmit their records of transfer and takeover to authorities; thus, the authorities are able to track the discharge, transport, and disposal on a real-time basis. Figure 10 sketches the system.

FIGURE 10. RFID-BASED MEDICAL WASTE MANAGEMENT SYSTE



4. CASE STUDY: UNION PARK IN HANAM CITY

4.1 BACKGROUND AND ACTORS

Hanam city is located in Gyeonggi province, neighboring to Seoul Metropolitan city. It covers an area of 93.03 square kilometers and has a population of 275,384, including 117,734 households as of February 2020. The population has been steadily growing from 109,486 in 1989 when it promoted to the city. Hanam had a sewage treatment plant but no waste disposal facilities. The city disposes of municipal waste either at a landfill in Incheon metropolitan city or at an incinerator in Yangju city, Gyeonggi province. Hanam pays the cost for the landfilling and incineration to the two facility owners.

The Ministry of Land, Infrastructure and Transportation (MOLIT) released a housing development project constructing a large-scale apartment complex in Hanam city in 2007. The project creates 38,315 households accommodating about 94,000 people. The Korea Land and Housing Corporation (LH), a developer, carried out the project between 2009 and 2016. The LH is a state-owned company under the MOLIT, contributing to housing stability and land development. The company obliged to treat both municipal waste and sewage generating from the planned apartment complex. The LH had two options:

It could build waste and sewage treatment facilities or pay the construction cost to Hanam city. The LH chose to pay the cost for such treatment to Hanam city instead of constructing the facilities in the housing lot. The city and the LH set up a Modernization of Existing Environmental Facilities and Park Development (the Hanam Union Park). The city renovated the existing sewage plant to meet the growing demand and newly added an incinerator and a food waste processing plant at the same site where the existing sewage treatment plant was located. Waste disposal facilities and sewage treatment plants were installed underground in order to avoid possible complaints and protests from nearby residents during the construction and after the operation begins. The waste facilities dispose of the only waste generated from the new apartment complex while the sewage plant handles the wastewater produced from the whole city including the apartment complex. Table 7 shows the functions of all the stakeholders.

TABLE 7. FUNCTIONS OF STAKEHOLDERS

STAKEHOLDER	FUNCTION
MOLIT	To plan the apartment complex construction
Hanam city	To manage municipal waste and sewage To review a LH plan for waste and sewage treatment To construct the treatment facilities for LH
LH	To construct the apartment complex Responsible for waste and sewage coming from the complex To pay the construction cost to the city
MoE	To review an environmental impact assessment

The Union Park is an underground environmental facility complex with parks, sport facilities and a Union Tower (smokestack), which includes an incinerator, a food waste processing plant, a recyclable waste sorting and compacting facility, a sewage treatment plant, and a sludge treatment facility. Modern technologies were applied to treat waste and sewage. Special attention was made to prevent odor from leaking out to residential areas. No complaints have been filed so far, serving as a model of smart infrastructure to treat waste and sewage as well as to address NIMBY (not-in-my-backyards). Thus, the Union Park becomes a hot spot for local government officials to learn the achievement.

4.2 UNDERGROUND FACILITIES AGAINST NIMBY

4.2.1 DISTRUST ON THE GOVERNMENT AND ENVIRONMENTAL CONFLICTS

The military government ruled South Korea for about 30 years, and it poured most of national resources into economic development and infrastructure. In the process of expanding infrastructure, citizens' property rights were frequently damaged and little information was given. The protests of citizens were suppressed by police forces, and thus, citizens have had little trust on the government. Through nationwide uprising against the military regime in 1987 (1987 Civil Revolution), a democratic government came in to replace the former autocratic government. Since then, it became a common

practice for citizens to resist unfair exercise of public power or possible damages of their rights and properties caused by the government policies. In addition, a concentrated population of 51million people in a small territory leads difficulties in securing the land for waste disposal facilities. Korea experienced several hundreds of protests by local residents and confrontations between police force and protesters over environmental facility construction. In 2006, 17 people were injured during the confrontation over a landfill construction in Namyangju city. Currently, the construction of 20 public and 31 private landfills and incinerators are delayed or suspended, failing to reach an agreement with residents.

4.2.2 CONFLICTS OVER WASTE DISPOSAL FACILITIES

The first case of the conflicts occurred at the Sudokwon landfill in 1992. When the MoE released a plan to dispose of general industrial waste at the landfill in addition to municipal waste, breaking its promise to bury only the municipal waste. Thousands of residents poured into the streets blocking the landfill gate, however, the government mobilized police force to crack down the protests. After 26 times of negotiations between the MoE and the residents, they accepted the MoE's plan to bring in general industrial waste into the landfill while the MoE planned to provide a resident support fund every year. Another case happened at an incinerator (150 ton/day) at a Mokdong apartment complex in Yangcheon district, Seoul city. The incinerator treated municipal waste coming from the apartment and its own district. The city expanded the capacity from 150 to 400 ton/day to burn the waste of two more neighboring districts in 1996; however, the new incinerator burnt only 234 ton/day generating only from its district due to the opposition from the residents. In 2006, after 10 years of dialogues, the city reached an agreement with the resident to burn the waste from two more districts. Jeju city, a tourist island, concluded a negotiation in a relatively short period. In 2012, the city announced a plan to build a landfill (2.4 million tons) and an incinerator (500 ton/day) of which construction cost was 205.8 billion KRW (US$ 166.5 million). From the beginning, Jeju proposed a resident support fund of 60 billion KRW (US$ 48.5 million) to local community in 2014, and the residents accepted the proposal by a community referendum. The compensation amounted to almost 30% of the construction cost. The facilities were open from 2019.

Eunpyung district in Seoul city is not able to start the construction of a material recovery plant (150 ton/day, 8 billion KRW) despite seven years of negotiation from 2013. The district faced a strong opposition from its district and adjacent cities in Gyeonggi province. As there had been no progress in the negotiation with the residents, the district changed the original ground plant into an underground one (150 ton/day, 74.5 billion KRW; US$ 60.3 million) in 2018, benchmarking the Union Park. The underground plant costs nine times more than the original ground one; however, the district puts more weight on the agreement with the residents than the construction cost. It is still holding public hearings and dialogues with the local people to obtain their consent.

4.2.3 UNDERGROUND FACILITIES

The first underground facility was built in Jisan-dong, Daegu metropolitan city in 2002. The region was rural when a sewage treatment plant first operated but is now a populated area. When expanding the capacity of the existing plant, the city decided to make use of the underground to avoid possible opposition from the residents. Recently, Anyang city in Gyeonggi province also built an underground facility in 2017. The old sewage treatment plant (250,000m^3/day) caused many complaints from nearby residents due to odor, and the city had to move the plant to underground (321.8 billion KRW; US$ 260 million).

4.2.4 INSTITUTIONAL FRAMEWORK FOR NIMBY

A NIMBY syndrome is prevalent over the site selection, construction and operation of incinerators and landfills as the construction of waste disposal facilities can lead to health risks to nearby residents and drop their real estate value. In order to facilitate the site selection and construction of waste facilities, the MoE developed the Act on Promoting the Installation of Waste Disposal Facilities and Supporting the Adjacent Areas. The Act aims to improve the welfare of residents through various community support programs. When building new landfills and incinerators or enlarging existing facilities to a certain scale, municipalities must create a resident support fund. The fund is used to compensate the losses caused by construction or operation of waste disposal facilities such as health damage and the price drop of their properties, for the residents. It also requires the creation of a resident support consultative committee, which functions as a communication channel between the government and resident. It consists of the members of a municipality assembly, resident representatives, experts recommended by residents and municipalities, and officials. Since then, residents have resorted to dialogue rather than protests, and the number of protests has gradually fallen. However, it still requires time to reach an agreement with local residents. Thus, municipalities prefer to build underground structure to facilitate the necessary procedures regardless of a high construction cost.

4.3 REGULATION ON THE FACILITY INSTALLATION

The Act on Promoting the Installation of Waste Disposal Facilities and Supporting the Adjacent Areas gives developers responsibility for waste disposal generated in development projects. Developers who construct housing complexes, industrial complexes and tourist resorts of over a certain size are required to build waste disposal facilities. As for a housing complex with more than 300,000 square meters, developers such as the LH is required to install incinerators and food waste processing plants or pay the amount equivalent to the expenses for such installation to municipalities concerned. With the payment by developers, municipalities can ensure installation of waste disposal facilities that will treat the waste produced from planned projects.

In addition, the Sewerage Act of the MoE stipulates that municipalities may fully or partially charge expenses required for construction works of public sewerage systems on project developers or construction entities or require them to conduct necessary construction works. The Act applies to new construction or extension of existing public sewerage systems when development projects increase the amount of wastewater. The projects include urban development, industrial complex development, and tourist resort development. Therefore, the LH had to either pay the construction cost to the Hanam city or build a sewage treatment plant to deal with the wastewater coming from the apartment complex.

4.4 COSTS AND BENEFITS

The LH finances housing development projects through the land value capture. They secure financial resources by selling created housing lot to private construction companies. In other words, the LH purchases lands at a low price, builds infrastructure such as school, roads, waterworks, sewerage, and waste disposal facilities and then sells the lands to private construction companies at a high price for housing or commercial purposes.

The LH paid 303.1 billion KRW (US$ 245.2 million) to Hanam city for the construction of the waste and sewage treatment facilities, otherwise, the LH had to build them in the planned apartment complex. The company was able to save part of the land for building additional apartments, in which,

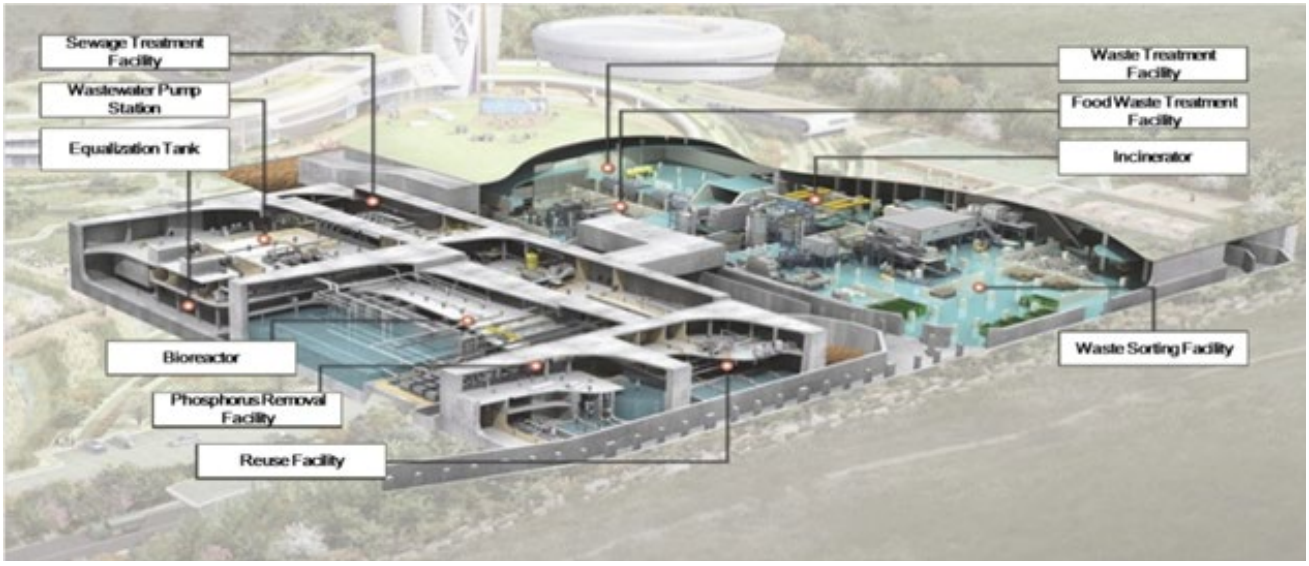
waste disposal facilities were supposed to be installed. Further, the LH skipped a negotiation process for building waste disposal facilities and did not pay compensation to the residents and had the benefit of shortening such administrative procedure as a construction permit from Hanam city and an approval for an environmental impact assessment from an environmental authority.

In South Korea, waste disposal facilities such as incinerators and food waste treatment facilities in residential areas cause complaints from nearby residents and lower real estate prices. Since food waste processing causes unpleasant odors, many municipalities are suffering from piled-up complaints. Hanam city has experienced no such complaints so far (Personal communication with the Union Park), since the apartment complex of the LH has no such facilities. All the facilities were located in areas where the old sewage treatment plant was in operation. Moreover, the steam generating from the incinerator is used to dry food waste for further treatment and is supplied to the park facilities for heating and cooling purposes. However, since the capacity of the incinerator is relatively small (48 ton/day), the Union Park is buying the rest of the electricity from a power company.

4.5 IMPLEMENTATION AND TECHNOLOGIES

The waste facilities are newly built with an incinerator (48 tons/day), a food waste treatment facility (80 tons/day), a material recovery facility (50 tons/day), a recyclable waste compacting facility, and odor purification facilities. As for the sewage treatment, a sewage treatment plant (32,000 tons/day), a sludge treatment facility, a phosphorus removal facility, a bioreactor, and a wastewater relay-pump station have been renovated and expanded. Figure 11 shows a diagram of the 25-meter-deeep underground facilities.

FIGURE 11.ENVIRONMENTAL FACILITIES



The list of waste treatment facilities and their technologies are given in Table 8. The incinerator is a continuous stoker that burns the waste coming from the apartment complex. Considering the concern of residents over air pollutants (dioxin, nitrogen oxides, acid vapor, and dust), advanced technologies, including selective non-catalytic reduction (SNCR), semi-dry reactor, bag filter and selective catalytic reduction (SCR), are applied to treat exhaust gases. The newly built waste sorting facility can segregate 50 tons of recyclables into metal cans, bottles, paper, and plastics, daily. An infrared optical sorting scanner classifies plastics into PET bottle, polyethylene (PE), polypropylene (PP), and polystyrene (PS). Styrofoam is also separately collected. About 20 to 25 tons of recyclables were sold to recycling companies as

much as 360 million KRW (US$ 0.29 million) in 2018. Some plastics are used to manufacture refuse-derived fuel (RDF) in an RDF fabricator. The food waste treatment facility produces 63 tons of animal feed daily. The fodder is sold to livestock farmers raising chickens and ducks. Food waste leachate is treated by pressurized floatation and physiochemical processing, in which organic matters, suspended solids and remaining oil are removed, and acidic water is neutralized. Anhydrous salt RTO and 3-level medical fluid scrubber are applied to control odor, and 6-step-sealed system is equipped to prevent odor from leaking out to the atmosphere.

TABLE 8. SUMMARY OF SOLID WASTE FACILITIES

FACILITY	CAPACITY	PROJECT COST (MILLION KRW)	TECHNOLOGY
Incinerator	48 tons/day	31,975	Continuous Stoker type
Food waste treatment	80 tons/day	38,594	Conversion into dry feed
Recyclables sorting	50 tons/day	17.091	Automatic/Manual
Leachate/Oil treatment	134 m^3/day	823	Pressurized flotation Physiochemical processing
Deodorization	-	-	Anhydrous salt RTO 3-level medicinal fluid scrubber

In fact, the 105m-high Union Tower is a smokestack of the incinerator. At the stack, monitoring devices measure four types of air pollutants every 5 minutes and send the data to the control center of the Korea Environment Corporation with 30-minute intervals, which is called the Smokestack Telemetering System (TMS). The monitors measure particles, hydrogen chloride (HCl), nitrogen oxides (NOx), and carbon monoxide (CO) together with oxygen, temperature and flow rate of exhaust gases. In addition to the four pollutants, Hanam city manually measures the dioxin every six months according to the Persistent Organic Pollutants Control Act. The four pollutants and dioxin levels are open to the public. Further, at the land boundary of the facilities, a continuous odor monitoring for ammonia concentration is being conducted to be kept below 0.01 ppm.

The ground facility is dedicated to recreational purposes for local residents. As seen in Figure 12, a multi-purpose gym, a swimming pool for children, and sport facilities (tennis and basketball courts etc.) are ready for service to the citizens free of charge. The Union Tower functions as an observatory with a good view of the Han River and surrounding mountains. Visitors have a free access to the observatory by elevators. The city organizes tour programs from the underground environmental complex to the Tower for their residents and visitors.

FIGURE 12. VIEW OF THE UNION PARK

2,4 OUTCOME

It has become more difficult to secure spaces for waste disposal facilities due to community opposition; thus, the construction cost and period have been increasing as well. However, the construction of the Union Park was proceeded as scheduled without any delay. Although there are apartment buildings about 100 meters away from the facilities, no complaints have been filed by nearby residents for odor or air emission during the operation of the facilities (Personal communication with Resource Circulation Division, Hanam city). In many local governments, officials spend their time and resources in handling complaints during the process of selection, construction and operation of waste disposal facilities.

As the Union Park presents a great example of overcoming the difficulty in negotiating with local people and reducing administrative procedures for construction, it has become the hot spot for field trips by local governments and their residents. As of July 2019, 1.8 million people have visited the Union Park. Recently, municipalities prefer the underground structure dealing with a NIMBY even though the cost will be much higher than that of a ground-level structure.

3, IMPLICATIONS AND RECOMMENDATIONS FOR LAC COUNTRIES

3,/ ADDRESSING NIMBY AND UNDERGROUND STRUCTURE

In South Korea, as the underground facility is considered as a means of avoiding NIMBY, many local governments prefer to build underground facilities even though the construction cost will be more expensive. However, the underground structure is not a good option to those who have limited budgets or enough land for the construction of waste disposal facilities.

Korea's experience in addressing NIMBY is that compensation should be made for their losses caused by the installation and operation of waste disposal facilities, and a communication channel is needed to attract residents to a negotiation table. About 10% of waste tipping fees is used to subsidize the increase of income and the promotion of welfare of the residents in affected areas. The participation of community

representatives is encouraged to resolve or prevent conflicts, and the representatives are allowed to participate in the whole process from the site selection to operation of the facilities. With the request of the resident representatives, municipalities can assign local residents to monitor the processes of incoming wastes, their disposal, emission control and leachate treatment. When conflicts rise over the construction and operation of waste disposal facilities, the government must provide the facts over the conflict and provide information on the health risks as well as available control measures. In Korea, independent experts and civic groups have played a significant role in bridging the gap between the government and residents. The general public tends to trust independent experts and civic groups rather than the government.

Waste disposal facilities are never welcomed in Korea or in any part of the world. However, this story will be different if these facilities can provide economic benefits to local people and improve their living conditions. The eco-friendly energy town produces electricity, heat and fertilizer with food waste and livestock manure. Residents sell the electricity to an electric power company and the fertilizer to nearby farmers and golf courses and they use the heat for warming their homes in winter. As local people showed their satisfaction with this project, many municipalities are rushing to the government to apply. Waste disposal facilities should change to provide social and economic benefits to local people in the future.

5.2 SMART TECHNOLOGIES IN THE UNION PARK

Smart technologies were adopted to treat waste and to purify odor, yielding benefits to the city and the nearby residents. The residual heat from the incinerator is used for heating and cooling the park facilities and for drying food waste to produce animal feed. The recyclable materials and the animal feed secure an extra income to the city. In addition, advanced technologies were used to eliminate odor and air pollutants such as dioxins, providing a clean environment for the residents. Thus, the residents have raised no complaints so far, which is a rare case in South Korea.

5.3 PROMOTION OF RECYCLING ACTIVITIES

5.3.1 ECONOMIC INCENTIVES

Economic incentives are regarded as useful tools in waste reduction and recycling, which begins with waste segregation at sources. Source segregation was backed up by the volume-based garbage fee system, replacing a flat collection fee. The collection fee is charged to the amount of waste disposed while it is not charged to recyclable wastes. The system has contributed to the increase in recyclable materials while reducing waste discharge. Various economic instruments proved to contribute to change citizens' behavior and manufacturers' production patterns in Korea.

5.3.2 RECYCLING MARKETS

A market should be created to promote the reuse of recyclables as secondary materials. In Korea, the government has been playing a leading role in creating the market for recycled products. The MoE introduced the green public procurement scheme to promote the use of resource-saving products, which recommends the government and public institutions to purchase such products. The Construction Waste Recycling Act requires the governments, public institutions and state-owned companies to use recycled aggregates for roads, industrial complexes, housing complexes and environmental infrastructure. The extended producer responsibility (EPR) scheme also contributes to fostering the recycling market for packaging materials.

5.3.3 PRODUCT PRODUCER'S ROLE

Producers should bear more responsibility to collect and recycle their wastes, and the EPR proves to be an effective scheme for this. The recycling support fund raised from producers has served to promote recycling businesses, guaranteeing the competitiveness of their businesses such as collection, sorting and recycled-product manufacturing. Further, producers have become interested in replacing packaging materials by recycled products or easy-recycling materials in order to reduce the share of the recycling support fund.

5.4 SELECTION OF FOREIGN TECHNOLOGIES

South Korea adopted various foreign technologies to address soring waste generation in a relatively short period, not fully considering its technical capacity and waste characteristics. It eventually led to countless failures in operating waste disposal facilities such as RDF plants, incinerators and food waste processing plants, which resulted in wasting substantial government budget. When importing foreign technologies, careful consideration should be given to economic, social and environmental circumstances as well as human capacities of each country.

5.5 FINANCING FOR WASTE DISPOSAL FACILITY

Local governments are responsible for the construction and operation of waste disposal facilities. Most municipalities place lower priority on the facilities than other development projects, and thus, they are frequently in trouble due to lack of financial resources. The MoE grants subsidy to them covering 30% to 70% of the construction cost. When still having difficulty in securing the rest of the construction cost, municipalities can take advantage of public-private partnership (PPP) projects. The PPP projects can be an option to secure environmental facilities.

5.6 WEB-BASED WASTE MANAGEMENT

The web-based management system has been proved to ensure the safe disposal of waste in the whole process of discharge to final disposal. For instance, the spread of the COVID-19 raises a concern over the safe disposal of medical waste. The RFID technology can track the discharge, transportation and disposal of medical waste on a real-time basis. Illegal dumping or disposal of medical waste has not been reported so far. Further, it also contributed to preventing illegal disposal of industrial waste and cutting paperwork for authorities and businesses.

5.7 INNOVATIVE GOVERNANCE SCHEME

Due to rapid economic growth and worsening environmental pollution, the general public demanded a safe and clean environment. As a result, the work of the MoE has continued to increase; however, the ministry also faced the shortage of manpower and the lack of expertise to deal with emerging issues. Since the expansion of each ministry's function and manpower is strictly regulated, the MoE created affiliated organizations such as the Korea Environment Corporation and the Korea Resource Circulation Service Agency to conduct various activities delegated by the ministry. The affiliated organizations can support the MoE in solving issues such as the lack of its expertise and manpower.

5.8 AWARENESS RAISING AND PUBLIC PARTICIPATION

There is a need to enhance public awareness since source reduction and separation are promoted with active participation of citizens. Well-informed citizens can contribute to source reduction and separation as they are the largest contributors to household waste generation. Unlike the expectation, the nationwide volume-based garbage fee system was settled in a relatively short period with the citizens' participation and understanding of the system. From the beginning, the MoE conducted a massive publicity campaign on the system in various media outlets including TV channels, newspapers and radios.

The civic and religious groups have also supported the MoE to establish laws and major policies. Establishing relevant laws and policies requires an agreement with other ministries, especially the development-oriented ministries, which means a tough negotiation is expected. Such groups played a significant role in drawing the attention of the mass media and politicians to environmental issues, which was a great help to reach an agreement with the ministries. With their support, the MoE, a new ministry, was acquiring more functions and responsibilities despite the opposition of other ministries and industrial sectors.

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