

# Sustainable Development Goals

## Policy Brief Series

NO. 4



*Empowered lives.  
Resilient nations.*

### Examples of Korea's Successful Policies in Waste Management & Lessons Learned that Could Apply in Other Countries



UNDP  
May 2017

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This publication has been possible because of the generous support of the Ministry of Foreign Affairs, Republic of Korea, to the UNDP Seoul Policy Centre

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# **Sustainable Development Goals**

## **Policy Brief Series No.4**

Examples of Korea's Successful Policies in Waste Management  
& Lessons Learned that Could Apply in Other Countries

## Acronyms

CSR	Corporate Social Responsibility
KERC	Korea Electronics Recycling Cooperative
MOTIE	Ministry of Trade, industry and Energy
MHW	Ministry of Health and Welfare
MOE	Ministry of Environment
NGO	Non-Governmental Organization
NRE	New and Renewable Energy
PCBs	Printed Circuit Boards
RFID	Radio Frequency IDentification
SDP	Service Delivery Plan
SRF	Solid Refuse Fuel
EPR	Extended Producer Responsibility
USPC	UNDP Seoul Policy Centre

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# 1. Introduction

## 1.1 Background

The UNDP supported the people and government of Korea during the country's development phase after the Korean war. Since Korea joined the OECD in 2009, the UNDP closed its assistance office, and in 2011, established the UNDP Seoul Policy Centre (USPC) with the goal of furthering partnerships between Korea and the developing world. USPC is currently considering the viability of a Development Solutions Partnership focused on sustainable waste management of: e-waste, food waste and waste-to-energy, conveying Korean knowledge and experience in these areas.

To this end, USPC has engaged IRC to review waste management policies and practices in these three areas. The objective of this project is to research and assess examples of Korea's post-consumer waste policies that may have potential to be replicated in Middle Income, and to the extent feasible, Least Developed Countries.

## 1.2 Philosophy

The fundamental principle of the Korean government's waste management policy has been to place the burden of waste disposal onto the consumer. This has been implemented in several methods, most notably by adding the cost of disposal to the purchase price and a combined free recycling plus 'pay-as-you-throw' system, which was first introduced in 1995. While the various tactics have had varying degrees of success, the greatest impact has been a change of mind-set and, therefore, behavior by Korean consumers. Consumers now consider disposal of waste at the time of purchase. For example, when purchasing products at the grocery store, consumers can be seen throwing away outer packaging and taking home their products with only minimal packaging. Thus, they leave the burden of waste disposal to the retailer. This practice is in fact beneficial as it concentrates waste in a central location where it can be easily collected (in relatively clean conditions). Furthermore, it has led retailers to pressure their suppliers to reduce packaging. Thus the obligation by individual consumers to pay for their wastes have had systematic impact on the use of packaging and recyclability of products. Nevertheless, a recent analysis of residential waste by the Korean government revealed that the vast majority of pay-for-disposal waste continues to be packaging, primarily plastic.

## 1.3 Organization of this report

Herein, we will examine e-waste, food waste and waste-to-energy. Each topic has a *General Description* (to put it into context) and *Lessons Learned* (the lessons that could be applied to other countries). It also presents how other countries can capitalize on the lessons learned.

## 2. E-waste

### 2.1 General description

E-waste normally refers to electrical and electronic appliances and equipment. The Korean government has designated 17 different products as constituting e-waste, a broader definition than most other developed countries.

These products have several important characteristics: First, their purchase is irregular and difficult to predict. Waste products also contain harmful (and often valuable) materials. They usually involve considerable packaging materials used to transport them without damage. While the packaging materials are cardboard, plastic, polystyrene, etc., they too could be considered a component of e-waste.

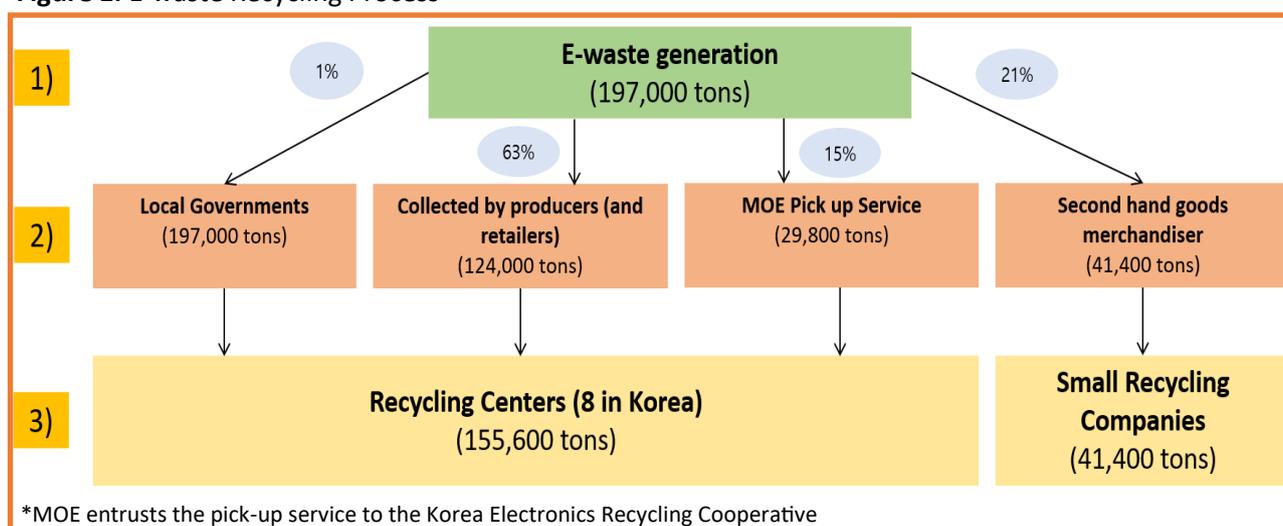
In general, e-waste flows into two distinctive channels, reuse of second-hand appliances (20%) and recycling of end-of-life products (80%). It can reasonably be argued that reuse of second hand appliances is not strictly e-waste. However, it delays the disposal of and extends the useful life of electric and electronic equipment. As such, it helps to reduce the volume of e-waste being disposed of annually. It can be safely assumed that countries in early stages of development use (and reuse) equipments longer than developed countries where appliances are replaced for form and function. It is a legitimate waste management tool to extend the useful life of electric and electronic equipment.

### 2.2 E-waste recycling process

Disposal of electric and electronic equipment is divided into three steps:

- 1) Consumers discontinue use due to product failure or desire to upgrade
- 2) Used products are picked up from consumers and either reused or recycled
- 3) Recycling centers disassemble end-of-life equipment and extract useful materials

**Figure 1.** E-waste Recycling Process



Source: Compiled by IRC, 2015

## When consumers wish to dispose of electric and electronic products, they have four options.

- (a) The most common practice is to replace used appliances with new ones. Korean consumers replace household appliances once every five years on average. When replacement goods (such as refrigerators) are delivered, the consumer most often requests the delivery company (representing the supplier) to haul away the used appliance and any packaging materials putting the waste disposal burden on the supplier. This accounts for collection of almost two thirds of all e-waste. Suppliers then either refurbish them and then donate them to charities or send them to recycling centers. As the quantity of refurbished appliances does not appear in statistics, it is safe to assume that the quantity is negligible.

The Extended Producer Responsibility (EPR) concept (introduced in 2003) places the burden for disposal of end-of-life electronics on the supplier. Sellers are obliged to recycle a certain volume (by weight) of electric and electronic items in 17 categories including televisions, refrigerators, air conditioning system, washing machines, computers, mobile phones, audio devices, copy machines, facsimiles, printers and seven types of packaging materials. The minimum volume of each item recycled is determined by the Ministry of Environment (MOE) based on sales of new equipment announced annually. The producers / suppliers collectively form the Korea Electronics Recycling Cooperative (KERC) which allocates to each supplier its quota for meeting the minimum volume set by the MOE.

- b) Another option for consumers is to sell their old goods to second hand stores. This accounts for about 20% of "e-waste disposal".\* However, classification of second hand products as e-waste seems inappropriate as it is not yet 'waste'. Second hand stores will pick up used appliances if they are in reusable condition. Second hand stores also sometimes repair broken appliances, thus, converting potential 'waste' back into usable equipment. This reduces the volumes going to recycling centers. Furthermore, when second hand equipment is not reusable, they are sent on to recycling centers for dismantling and recycling. In Korea, the second hand stores are reluctant to pick up broken or excessively old appliances because Korean consumers tend to be picky so very old appliances are difficult to sell. However, in some countries, second hand stores can be a useful channel to collect used electric and electronic equipment and postpone the cost of recycling.
- c) Third, consumers can pay a fee to the local municipality for disposal purposes. This is accomplished by purchasing a sticker at the district local office, affixing it to the goods to be disposed of and leaving the item on the street on a designated day (this applies to any large item such as furniture and not only e-waste). This practice is declining (for electronic products) following the introduction of the free pick-up service (as explained below).

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\* The percentage of electronics that are resold as used equipment is an estimation based on data collected by the consultants of this report

- d) Waste electronic goods pick-up service (MOE): Finally, consumers can request a free pick-up service from the MOE. This system was introduced in 2014 with the goal of improving the recycling rate of electronic products. It is managed by the KEREC. The MOE has witnessed an increase in the amount of e-waste that will be recycled as a result of the free pick-up service. According to the MOE, cities that introduced the free pick-up service recorded an increase in e-waste collection of 1.5 to 6 times compared to the previous year. In 2014, the first year of the free pick-up service, 270,000 items were collected nationwide (3.9 kg per person). The volume was almost double the record of 2013. In 2016, MOE targeted collecting 800,000 items. For 2018, the Ministry has set a collection goal of 6kg per person.

## The collected e-waste goes to recycling centers

Eventually, all electric and electronic equipment in the 17 categories end up in recycling centers. There were 9 such centers nationwide as of 2013. They receive waste materials at no cost, disassemble them and separate e-waste into different product categories such as scrap iron, nonferrous metal scrap, copper, plastic and Printed Circuit Boards (PCBs).

**Table 1.** Economic Benefit Analysis

Economic Benefit Analysis	
Recycled material sales	1,844,000 KRW / Ton (Seoul Resource Center, 2012)
Incineration / Landfill cost saving	140,000 KRW / Ton
Reduction of material imports	1,120,000 KRW / Ton

Source: MOE Press Release, "Successful positioning of e-waste free pick-up program", 2015, October 26

Based on these figures, the economic benefit from the sale of recyclable materials from e-waste would be approximately 363 billion KRW (of which 221 billion KRW represents reduced imports or outflow of foreign exchange) and 27 billion KRW reduced investment in landfill.

Recycling centers are public organizations or social enterprises supported by central or regional governments and large size private companies (producers of electric and electronic goods). For example, the Seoul Resource Center which is the recycling center that covers Seoul City is a public organization established by the Seoul City government. Seoul Resource Center is operated by a social enterprise named "Eco City Seoul". The research center in Asan was established and has been operated by Samsung Electronics.

Each year, the MOE sets goals for recycling based on the sales of new electric and electronic equipment. This is a key component of the EPR concept. In spite of the introduction of free pick-up service, recycling of e-waste falls far short of MOE goals. Producers are financially obliged to meet the goals set by the MOE. Therefore, to make up the differences between their targets and what they actually recycle, producers purchase credits from the KEREC.

**Table 2.** Ratio of Collection to MOE Recycling Targets

Ratio of Collection to MOE Recycling Targets (Collected volume / Government target volume)	
Large-size electronic goods (white goods)	92%
Communication equipment for offices	71%
Mid-size electronic goods	57%
Small-size electronic goods	57%
Smartphones	4%

Source: KERC report, 26 October 2016

## 2.3 Lessons learned

### EPR system

The extended producer responsibility (EPR) system is the fundamental policy that has stimulated Korea's e-waste recycling system. The EPR system places the burden of disposal on the supplier. It dramatically increases the probability that a significant portion of used equipment will be properly recycled. This system reduces the amount of equipment disposed in landfills or otherwise dumped illegally otherwise. By establishing a recycling obligation and recycling quota, it channels nearly two thirds of electric and electronic waste into a proper disposal system.

**Government's Role:** The government needs to establish a recycling obligation, fix quotas and manage a policing mechanism. In Korea, the government mandated the creation of the KERC which was established and is managed by the industry to insure that the EPR system functions properly. The financial burden falls primarily on the producers.

### Free pick-up service

One key success factor for the e-waste recycling system in Korea is the free pick-up service. Consumers that replace appliances place responsibility for pick-up on the supplier of the new appliances. Second hand stores pick-up used appliances. For true 'waste', the MOE mandates that KERC provide free pick-up. All of these costs are borne by industry and not the government.

**Government's Role:** Incorporating free pick-up into the EPR obligation would facilitate recycling without additional investment by the government.

## Second-hand white goods market

As Korea developed and became more affluent, more and more consumers disposed of functioning electric and electronic equipment and replaced them with new products that offer better design and functionality. While the equipment is fully functional, it is no longer wanted and, thus, could be considered 'e-waste'. Project consultants estimate that approximately 20% of used electric and electronic equipment is re-sold through second hand stores. The MOE encourages reusing second-hand goods to reduce the volume of e-waste. The Ministry requires each regional government to establish a minimum number of second-hand goods stores to facilitate the utilization of second hand white goods. The second-hand stores collect and buy second-hand electronic goods and white goods from households and repair them for selling purposes. This system helps consumers overcome one of the biggest challenges– the burden of disposing of used goods. Indeed, disposing of electronic goods can be difficult so households often sell or donate them to second hand stores who pick them up for free.

Based on MOE's regulations, there must be a minimum of 382 second-hand goods stores nationwide. However, as of July 2012, there were 825 stores. This suggests that this activity is profit generating and may require little government support.

**Table 3.** Status of Second Hand Stores

Status of Second Hand Stores				
Total	Private	Established by Regional Governments		
		Subtotal	<i>Directly Managed</i>	<i>Contracted</i>
825	708	117	25	92

Source: MOE, July 2012

**Government's Role:** Governments benefit from encouraging the reuse and extending the use of electronic and electric equipment. It delays the timing of disposal of equipment easing the burden of recycling costs. Furthermore, it could conceivably reduce the introduction of new equipment and thus the total volume of electric and electronic appliances introduced to the environment. The reuse market is largely self-sustaining and therefore would require little government expenditure. The government would merely need to establish proper regulations for used equipment and create an eco-system for the stakeholders to communicate and allow market forces to naturally generate a second-hand market. This is likely to be even more successful in developing countries. The demand for low cost electronic goods will fuel the second hand market.

## E-waste collection app for smartphones

A start-up named *Sugoking* has developed a business collecting and selling reusable, second hand and scrap items such as clothing, furniture, computers and scrap metal. Consumers contact *Sugoking* using the app and after *Sugoking* picks up the items, they pay consumers in cash or credit that they can use to purchase products online.

**Government's Role:** Encourage private sector to develop these tools or even making a one-time investment in developing a communication tool such as a smart app would be inexpensive and relatively easy to implement.

## Proper disposal of waste from used equipment

Second-hand stores are 'for-profit' entities that wish to acquire only usable and resalable equipment. However, in the process, they also acquire electric and electronic equipments that cannot be refurbished and used. Their role is to separate usable from unusable appliances. The challenge is that they sometimes remove high value parts from the e-waste and then dispose of the remainder of the appliances improperly. An important role of second-hand stores is to insure that unusable second-hand goods are channeled into the proper recycling facilities.

**Government Role:** The government could provide credits to the second-hand electronics sellers according to the amount of e-waste they send to recycling centers. Stores can then sell the credits to electronics suppliers to meet their recycling quotas.

## Refurbishing and reselling & CSR donations

Some Korean electronics manufacturers take advantage of the EPR e-waste recycling requirements to create a profitable business. They refurbish returned electronic products and sell them at a discounted price of 20% ~ 50% of the original price.

Small electronic goods makers such as Coway, Dongyang Magic and Cuckoo donate their refurbished or re-manufactured products to charities. These activities bring benefits to manufacturers. Corporate Social Responsibility (CSR) activities promote their company image and it helps meet their target recycling obligations.

**Government's Role:** Public recognition (awards and media coverage) of companies that refurbish equipment and donate it to charities (and thus keep it out of recycling centers or landfill) would encourage this behavior at very little cost.

## Smartphones

Smartphones are expensive items and contain sensitive personal information. Consumers are reluctant to throw them away even when they buy a new phone. According to KEREC, the collection of cellular phones before the smartphone era was around 80% but now it has dropped to 4%. One of the reasons why the recycling rate of the smartphones is very low is that there is a healthy market for second-hand smartphones which are exported to other countries. Exported smartphones are either used in developing countries or recycled in more advanced countries. Only a few countries such as Japan and Belgium have sufficient technology to extract valuable materials from old smartphones.

**Government's Role:** To encourage the export of waste smart phones efficiently, governments must establish appropriate rules and regulations. In Korea, used smartphones are classified as “waste” while some countries classify used smartphones as “resource for recycling”. The classification makes a big difference in documentation, logistics and storage. Classifying used smartphones as a 'resource' will facilitate the export value of used smartphones.

## Large scale recycling centers managed by suppliers

Eventually, all e-waste should be disassembled and recycled. Korea has opted for a small number of large sized recycling centers managed by the KEREC, the recycling entity of the producers rather than a larger number of smaller facilities. This is the final step in the EPC concept. Large recycling centers supervised by the KEREC can be held accountable for the proper disposal of e-waste. On the other hand, small-sized recycling entities do not make efforts to maximize recycling rate. Instead, they try to maximize profits so they recycle profitable materials or items and often illegally dispose of the rest.

**Government's Role:** To maximize recycling rates, governments could establish EPR regulations, free pick-up service and large size recycling centers to establish a sustainable recycling cycle from households to disposal. The cost of this system would be paid by e-goods suppliers.

## 2.4 Conclusions

The most important factors for e-waste recycling are the EPR system, the free pick-up infrastructure and the recycling centers. To support the system operate smoothly, in addition to the regulations, constant education and promotion of e-waste recycling to each interest group: households, pick-up service firms, recycling centers, second-hand stores and electronic goods manufacturers is needed.

## 3. Food waste

### 3.1 General description

Separation of food waste from normal waste was first introduced in 1995. The Korean government's policy on waste food has developed through two stages, the first phase focused on converting food waste to a resource and then in the second phase, focused on reduction of food waste.

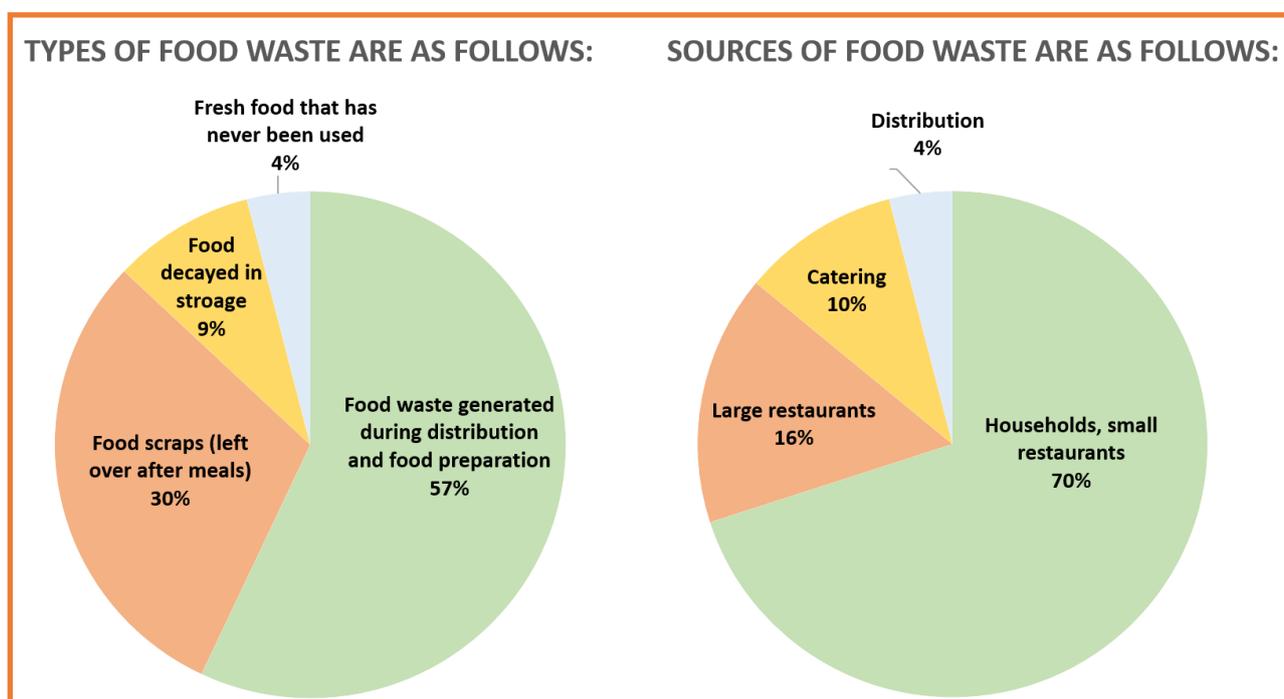
In 1996, the Korean government established the "Food Waste Reduction, Resource Recovery Plan" which introduced two directions for food waste management policy: reduction of waste and converting food waste into resource. In 2005, dumping food waste in landfills was banned. The policy's goal was to ensure that food waste was converted into a resource.

In 2010, focus was shifted from utilizing waste as a resource to reducing waste. The "Comprehensive Measures to Reduce Food Waste" was announced and the volume-based food waste disposal system was introduced with the primary focus on reducing waste volume. By charging for food waste disposal, households were incentivized to minimize food waste.

Consumers are required to pay for food waste disposal in one of three ways. First, households can dispose of food waste into bins equipped with an Radio Frequency Identification (RFID) payment system. Most commonly applied in apartment complexes, food waste bins are placed on a scale. When food waste is added to the bin, the change in weight is measured and the appropriate charge is paid using a RFID chip reader. This is the most successful method of food waste collection as it allocates cost in proportion to waste disposed, is sanitary and allows for accurate data collection to help manage the system. However, it requires sophisticated electronic tracking and payment systems. Also, it is most efficient in areas with high concentrations of people. Second, consumers can pre-purchase stickers or chips which are attached to food waste bins. Third, households can buy plastic bags specifically for food waste. These two systems are simple to implement but are open to abuse, less accurate at allocating costs and generate unsanitary conditions.

To make the policies effective, central and regional governments have made considerable effort to promote and communicate the system with all the stakeholders including consumers and restaurants.

Figure 2. Origin of Food Waste



Source: The Ministry of Environment, 2013

The food waste system is effective. There was a dramatic drop in volume of food waste with the introduction of the fee for food waste disposal introduced in 2010.

Table 4. Food Waste Recycling

Year	Collected Food Waste (1,000 Tons)	Food Waste Recycled Products sold (1,000 Tons)	Number of Companies in Food Waste Recycling Sector (Unit)
2014	1,127	534	621
2013	1,001	359	584
2012	929	304	282
2011	670	588	278
2010	1,073	239	327
2009	1,582	200	383
2008	1,862	422	363
2007	1,799	545	330
2006	1,794	419	323
2005	1,647	506	225

Source: Statistics Korea, 2015, [www.kostat.go.kr](http://www.kostat.go.kr), accessed 2 May 2017

## Food waste collection

Collection companies are licensed by district governments to collect food waste and deliver it to food processing facilities. Food collection is restricted to 8pm to 4am in order not to inconvenience residents. There were 114 permitted food waste collection companies in Seoul in 2014.

## Processing

There are around 240 licensed food waste processing facilities in Korea of which 100 are public and 140 privately owned. These companies focus on the following:

**Table 5.** Focus Area of Licensed Food Waste Processing Facilities

No. of Companies	Focus of Work
20	Weight Reduction (The waste is then further processed by burning, burying or treatment as sewage)
115	Making Feed
86	Making Fertilizer
13	Anaerobic Mineralization
6	Others

Source: Authors, 2017

Food waste is recycled to feed (53%) and fertilizer (46%). The process is inefficient because in Korea, waste food is 80% water and has a rather high salinity level. Removing the water and salt from the food waste is very expensive. The resulting feed and fertilizer is not cost competitive and therefore incentives are required to attract companies to participate in this business. \*

## Funding

According to the MOE's plan, food waste producers such as households or restaurants contribute 80% of total food waste management cost while regional governments contribute the remaining 20%.

Facility investment: The central government contributes 30% of the cost of building waste processing facilities, regional governments contribute 10% ~ 35% and private investors contribute the rest.

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\* Flat land is scarce and expensive in Korea. Transporting food waste to rural areas can also be expensive. However, as described later in the report, in terms of "pre-cooked waste food", there are successful composting practices

## 3.2 Lessons learned

### Pay-as-you-throw

The underlying concept of food waste recycling is to charge households and restaurants in proportion to the amount of food waste that they discharge. In Korea, the benefits from the resources generated from the waste are minimal but it has contributed to a change in the mindset of consumers leading to a reduction in the disposal of waste food. The biggest costs are collection and transportation of food waste and processing it into a useful form – feed, fertilizer or fuel. A hidden cost is the impact of improper disposal of food waste by restaurants and households.

**Government's Role:** The government must create a pay-as-you-throw system through regulations, whichever technology is used. In the Korean experience, this system is not revenue neutral. The cost charged to consumers and the resources recovered generate only some of the revenue needed to recover the cost of the system. The government must calculate appropriate fees carefully. The fees should be sufficient to cover the costs of the system. However, if the fees are too high, households and restaurants will dispose of their food waste in an improper manner.

### Quality of end products

Around 90% of the output of recycled food waste is feed and fertilizer. The feed is provided for chicken, duck, and pig farms. The popularity of the feed depends on its quality. For example, Naen Co., Ltd, a private food waste processing facility in Seoul, provides feed made from food waste to around 200 regular customers. The farmers said the quality of the feed is inferior to commercial feed but utilize it because it is free since they can save around 30% of feed cost by using free feed.

Naen Co., Ltd. has recorded profits for all but one of the past 10 years. The main revenue stream of the company is fees from regional governments for processing food waste. Many other food waste processing facilities are burdened due to the increasing stock of unused feed. Farmers refuse to take the feed even though it is free because the quality of is poor.

The key to success is maintaining high quality products even when made from waste. While feed and fertilizer cannot compete with commercial products, the greatest benefit is that food waste has been reused rather than disposed in landfills.

**Government's Role:** A grading system to evaluate the quality of feed and fertilizer would encourage processors to improve the quality of their products and increase the volume of food waste reused rather than burned. Countries that have a more friendly quality of food waste (less salt and water than Korean cuisine) would find creating high quality feed and fertilizer easier to accomplish.

## Box 1. Success Story of Gumi City

The most effective way for collecting food waste in Korea is the food waste container controlled by the RFID system. This incurs a cost for the container, for issuing RFID cards and for maintaining the RFID devices.

Gumi is a mid-sized size city with about 420,000 residents. Gumi has reduced food waste by 20% since 2012 reducing the city budget by 300 Million KRW.

Gumi City introduced RFID food waste bins actively beginning in 2012. Now, there are more than 1,100 RFID food waste bins in the city. The city has worked hard to communicate the benefits of the system to citizens. Apartment complex residents voluntarily cooperate with the city to provide good quality food waste from households.

The city also builds and operates a food waste processing facility producing good quality feed which is provided for free to more than 50 farmers in and around the city.

The operation of the food waste processing facility is entrusted to a private company named Jayang. According to Mr. Park, Yang-kyu, the CEO of Jayang, the feed from his facility is very popular with farmers while many other food waste processing facilities must pay to incinerate their food waste.

**Government's Role:** The government must oversee the development of the hardware and software for plastic bins and the RFID system. The system can help reduce the quantity of food waste generated resulting in significant cost savings system wide. The benefits of the system outside of waste recycling are the introduction of high technology monitoring and micropayment tools that could stimulate development in Middle Income Countries

## Food bank

The Ministry of Health and Welfare (MHW) designated the Korea Social Welfare Association as the National Food Bank in 2000. Large food companies and even individuals donate surplus food to the National Food Bank instead of disposing it as waste. The National Food Bank is primarily a welfare organization but it also helps reduce food waste.

**Government's Role:** Governments can create exchanges that connect food companies to Non Governmental Organizations (NGOs) that provide surplus food to needy citizens. Costs would be limited to a relatively small up-front development cost. Educating food companies and NGOs would be important but this too involves a very limited number of players and, once established, would require very little maintenance. Countries with existing food processing industry associations could tap the relevant organization to take responsibility for establishing and managing the process. An added benefit would be to reduce the government's social costs of caring for the needy.

## Distribution of commercially unsellable fruits and vegetables

Mainstream retailers only purchase produce that has visual appeal to customers. Food processing companies purchase only fruits and vegetables that can be processed by equipment. This results in high volumes of perfectly edible but deformed or unattractive fruits and vegetables. Recently, a few start-up companies in Korea (ie. Farmerspace, <http://www.fspace.co.kr/> and Good F&B <http://www.goodfnb.com/sub/main.php>) are attempting to distribute fruits and vegetables that fail to enter into commercial markets because they are visually unappealing, deformed, small or oversized. These companies bridge farmers and consumers who are happy to purchase less than perfect fruits and vegetables at a more economical price. These companies also contribute to the reduction of waste food. At the same time, they contribute to the welfare of farmers by creating a distribution channel for commercially unappealing products and generating revenue.

**Government's Role:** This waste reduction process has arisen in Korea without the involvement of governments. In countries where this process has not occurred naturally, promotional activities to appeal to environmentally conscious consumers and to entrepreneurial distributors would likely stimulate this business potential. In low wage countries, deformed fruits and vegetables that cannot be processed by machinery could be processed by hand not only reducing waste, creating revenue for farmers but also creating jobs for unskilled labors.

## Jeju tangerines

Jeju island is the largest island off the coast of Korean Peninsula and is famous for tangerines. The farmers in Jeju are very proud of the reputation and quality of their tangerines. The Tangerine Farmers' Association in Jeju has strict quality guideline for the products they distribute. Recently, some farmers have begun to sell their tangerines that do not meet the quality guidelines through the new distribution companies for visually unappealing fruits and vegetables. The association is trying to ban the activity to preserve the brand reputation of Jeju tangerines.

**Government's Role:** The government could easily require the industry association to permit the sale of tangerines that do not meet guidelines in un-branded form. Food processors such as juice producers could be encouraged to purchase fruit that does not meet the association's guidelines. Budget requirements for linking farmers with food processors would be minimal.

## Failure of plastic bag project of Seoul city

According to the City of Seoul, waste plastic bags account for up to 60% of total waste from residential areas. While a few large-sized apartment complexes have successfully collected and recycled plastic bags, most residential areas dispose of their plastic bags in (pay-as-you-throw) garbage bags which are buried in landfills. The Seoul City government would like to recycle those waste plastic bags.

The city introduced special, free rubbish bags exclusively for used plastic bags. The city expected citizens to carefully follow the policy. However, the project failed and the city discontinued the project after seven months. Some citizens took advantage of the free disposal bags for waste plastic bags and treated them as standard pay-as-you-throw bags. Other citizens disposed of dirty waste plastic bags that could not be recycled.

**Government's Role:** The reason for the failure in the Seoul city example was the lack of communication and education on the newly introduced recycling category as well as ineffective enforcement of this process. Adequate preparation in terms of communication and advocacy and education utilizing tools before launching the project and strictly enforcing compliance from the beginning could have resulted in a successful project.\*

## Pre-cooked food waste

### Box 2. Success Story of Seoul

Seoul city (like many others in the world) provides small vegetable garden plots for citizens in the outskirts of the city. One project collected pre-cooked food waste and converted it to fertilizers at a garden plot near Seoul. The project was launched by "Womenlink", a regional civic group and actively assisted by the local government. Womenlink recruited households to separate raw food waste prior to cooking (which was not contaminated with water and salt) from normal food waste. The local government picked up the pre-cooked food waste and delivered it to the garden plots. The vegetable matter was composted together with fallen leaves combined with a 'starter' material. The only equipment required was a small excavator. Within one year, the food waste was converted to compost and used as fertilizer.

In 2012, the garden plot processed 45 tons of food waste, increasing to 85 tons in 2013, 114 tons in 2014 and more than 300 tons expected in 2016. The project started with one apartment complex and in 2016, 11,210 households in 12 apartment complexes participated. The project reduced food waste, generated fertilizer for the gardens and was used to educate students about an environmentally friendly life style.

The regional government spent 58 Million KRW for the promotion of the project and supporting maintenance cost for the garden plot. In turn, it reduced the cost of food waste by 26 million KRW and fallen leaf incineration cost by 8 million KRW. Citizens also reduced their cost of disposing of food waste by 23 million KRW. An additional benefit was an increase in the quality of the soil in the garden plots.

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\* Incentives not being right was not identified as a problem in this case. Incentives that were used to attract consumers to recycle glass, plastics and other recyclable products such as free pick-up of recyclable materials were used in this case also.

**Government's Role:** In the above example, the project reduced total societal cost of the project but it actually increased the burden on the local government. To make this type of project a success, recruiting a civic group to lead the project and taking responsibility for recruiting participants would be most beneficial. It would also require promotion of the 'virtuous circle' to appeal to citizens' sense of social responsibility. In this example, the fees for food waste were reduced by 70% which would also appeal to citizens. It would demonstrate to citizens that they can contribute personally to the improvement of the environment.

Separating 'pre-cooked' food waste from other food waste could be applied across all countries and in rural as well as urban locations. The cost benefit of separating food waste and doubling the collections infrastructure must be weighed against the benefits of reduced food waste and producing quality compost. It is likely to be more successful in countries with higher levels of agrarian population than Korea.

## Breeding fly larvae on food waste

Insect larvae production is a business with a promising future. The market size is expected to grow from 10 Billion USD today to 35 Billion USD by 2020, according to the Rural Development Administration. In Korea, several agricultural organizations such as the Chungbuk Insects Resource Research Institute started to use food waste as a medium to breed insects, specifically *ptecticus tenebrifer* which is a kind of fly larvae. Fly larvae is one of the ingredients of good quality feed and can also be sold as bait for fishermen. Larvae can also be organic feed for livestock such as cows, pigs and chickens. At the same time, it reduces food waste processed by less economical facilities.

One egg producer in Korea is selling its eggs at three times the average price. The chickens eat only organic feed and much of it is larvae of *ptecticus tenebrifer* raised on food waste medium.

**Government's Role:** Governments can task agricultural research organizations in their countries to generate specifications for food waste that make a suitable medium for insects. For insect farmers, food waste is a beneficial and economical source of medium for growing larvae but they need to know what type of food waste is best for each species of insect.

## 3.3 Conclusions

Government support is needed to reduce and recycle food waste. Rules and regulations for the industry, resolving conflicts among the interested parties will encourage a smooth functioning food waste disposal regime.

Communication and education among the participants in the food waste recycling chain are important. Particular focus must be on communicating with households and small restaurants on how to properly separate, prepare and dispose of waste.

## 4. Waste to Energy

### 4.1 General description

Waste to energy accounts for more than 60% of all New and Renewable Energy (NRE) power generation in Korea and stood at 14,335 GWh as of the end of 2014 according to a report by the Ministry of Trade, industry and Energy (MOTIE). In addition, 390 million liters of bio diesel for motorized vehicles are produced annually.

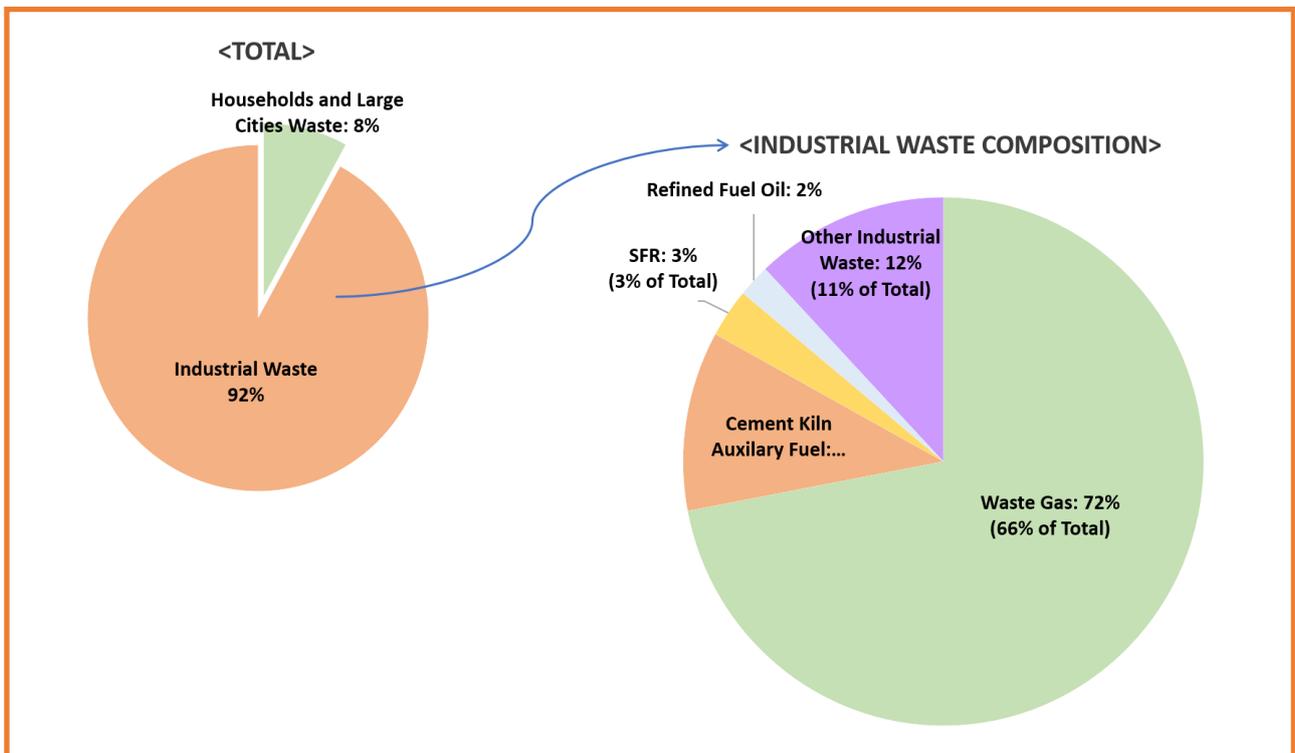
**Table 6. Types of Waste Used in Waste-to-Energy and Their Use**

Feedstock	Burnable waste is converted to Solid Refuse Fuel (SRF) from organic waste
Sludge	SRF (39%), Bio-gas (61%)
Food waste	Feed (53%), Fertilizer (46%), Bio-gas (1%)
Livestock excrement	Compost (90%), Others (10%)

Source: Authors, 2017

Sources of waste used in waste-to-energy: Household waste accounts for a small percentage of total feedstock for waste to energy with the bulk coming from industry. Approximately two thirds comes from waste gas from industrial plants.

**Figure 3. Sources of Waste Used in Waste-to-Energy**



Source: Korea New & Renewable Energy Center, 2015

**Table 7.** Waste to Energy

Waste to Energy (Unit: TOE)						
Year	2010	2011	2012	2013	2014	2015
Total (TOE)	4,862,296	5,121,534	5,998,509	6,502,414	6,904,733	8,075,181
Waste Gas	2,114,825	2,175,167	2,999,138	3,343,253	4,148,491	5,345,343
Industrial Waste	851,834	873,206	860,472	886,943	780,801	925,376
Household Waste	94,406	184,506	147,247	169,121	157,178	611,235
Garbage from large cities	717,671	753,252	748,372	698,870	725,420	-
Cement Kiln Auxiliary Fuel	618,082	681,415	752,890	899,151	837,114	807,229
SRF	93,275	220,171	261,022	286,419	58,935	207,638
Refined Fuel Oil	227,497	233,816	229,368	218,657	196,794	178,360
Waste Wood	144,706	-	-	-	-	-

NOTE: Some of the waste used to generate energy is imported.

Source: Korea New & Renewable Energy Center

**Waste-to-Energy:** Welcron Kangwon is an industrial plant engineering company that also manufactures waste heat recovery boilers and has won several waste-to-energy plant projects. The company acquired Tomorrow Energy, a local incineration company in 2014. Welcron Kwangwon is selling waste heat to a nearby industrial complex from Tomorrow Energy's waste incineration plant.

**Food Waste Biomass:** The MOE established the "Waste Resources and Biomass Energy Action Plan" in 2009 with a budget of 633 Billion KRW from public and private sectors for building food waste biogas facilities between 2009 and 2020. As of June 2014, 10 food waste biogas facilities had been built utilizing a budget of 340 Billion KRW (110 Billion KRW from the government and 230 Billion KRW from the private sector). Eight more facilities will be built by 2020. This project should be carefully monitored to evaluate its success as it is likely to have applicability to Service Delivery Plans (SDPs) in the future.

## 4.2 Lessons learned

### Landfill mining – extracting energy from Nanji landfill

Nanjido was Seoul city's waste landfill from 1978 to 1993. Waste was dumped indiscriminately including household waste, construction waste, sewage sludge, and industrial wastes. By the time the land fill closed, it had formed two large mounds 100 meters high.

After several years, as the waste rotted, foul odors and harmful gas began emitting from the landfill polluting the nearby air and water as well as destroying the ecosystems of the neighboring areas. The city of

Seoul began the restoration of Nanjido first by stabilizing the site followed by park construction.

1) Creating Recreational Parks: Haneul and Noeul Parks were built on the mountain of trash. Pyeonghwa Park and Nanjicheon Park were built on the flatlands around the landfill. Nanjido’s land-use category was changed from landfill to natural grassland, ownership was transferred to the city of Seoul protecting the area from for-profit development. Before 2002, there were 271 species of plants in 60 families on Nanjido. By 2010, after the park had been completed, the number of plants increased to 502 species in 95 families.

2) Recovering Methane Gas: Methane is generated from the Nanjido landfill. The city of Seoul installed 106 methane gas extraction wells at the interval of 120m throughout the site. The gases are channeled into wells using fans, which are then used to provide heating for 3 public sites including the World Cup Stadium, 40 office buildings, and 16,335 households in the surrounding residential areas.

From January 2002 to December 2015, gases collected from the landfill accumulated to 254,000,000 m<sup>3</sup>. According to the Worldcup Stadium website, 9.3 billion KRW of revenue was generated or about 36.6 KRW per m<sup>3</sup>. Data is available only on the revenue generated and not on production cost of methane from Nanjido. Furthermore, cost comparison of methane gas production across facilities is difficult. The production cost of methane gas at other facilities in Korea in 2012 was as follows:

**Table 8.** The Production Cost of Methane Gas at Other Facilities in Korea in 2012

Facilities	Production cost (KRW/m <sup>3</sup> )	Operator
Dongdaemun	1,220	Korean
Sokcho	926	Korean
Ulsan	306	Swedish company

NOTE: The significant variation in production cost is a function of operating efficiency.

Determining the 'market price' of methane gas is challenging as it is not a normally traded commodity. However, methane is the major component of natural gas so the cost of natural gas is used as a surrogate. Natural gas from the Russian pipeline in Europe in February 2016 sold at 147.2 USD per 1,000 m<sup>3</sup> which is 161.92 KRW/m<sup>3</sup>. Clearly the production cost of methane gas is much higher than its market value.\* While there is some cost recovery from the sale of methane gas, the environmental benefits of the project are even greater.\*\*

3) Hydrogen Gas Station in Nanji: Korea Gas Safety Corporation (KGSC) is operating a hydrogen gas station at Nanji Park. This corporation converts the waste methane gas from the site into hydrogen fuel for cars which is 99.99% pure. It is of sufficient quality to use in Seoul City owned busses. The facility can produce up to 720 Nm<sup>3</sup> of hydrogen a day. The market price of nitrogen gas is 300 to 400 KRW per Nm<sup>3</sup>.

\* Today Energy, <http://www.todayenergy.kr/news/articleView.html?idxno=113818>

\*\* Source: Seoul City Worldcup Park, [http://worldcuppark.seoul.go.kr/history/stabilization3\\_4.html](http://worldcuppark.seoul.go.kr/history/stabilization3_4.html)

**Government's Role:** Many countries have legacy\* landfills, many of which are near (or in) urban areas. These landfills are often health hazards and require cleanup. The Nanjido example shows that cleanup costs can be used to generate positive social (aesthetic) and economic returns. The cleanup process can tap methane gas and hydrogen gas, which rather than being discharged into the atmosphere and causing greenhouse gases emission, they can be captured and generate revenue to help defray the cost of clean-up. However, the government must drive the project, either undertaking it itself or assigning it to a private company as a concession.

## Operation of biogas plants

The MOE established a plan in 2009 encouraging regional governments and private companies to build and operate bio gas facilities. According to a government inspection in 2014, the performance of many of the facilities was poor. Reasons attributed to failure were all preventable. Some facilities were managed poorly and inefficiently, others had mal-functions and still others failed to meet regulations even with good equipment. It is not sufficient to establish a plan but proper implementation is also important.

**Government's Role:** Biogas plants have the potential to be economically viable if properly managed. The government must support management skills through education and by providing oversight of operations.

## Wooden pellets for thermal power plants

According to Mr. Kim, Jong-yeop\*\*, Chief of the Waste Energy Center, 2,030,000 tons of Solid Refuse Fuel (SRF) were used in 2015 in Korea. This is equivalent to 1,010,000 tons of fossil fuel. 450,000 tons of SFR were imported in 2015 in the form of pellets palm, cashew nut shells or waste wood. They were imported from Vietnam (180,000 tons), Indonesia (240,000 tons) and Malaysia (30,000 tons). Korea has assisted various developing countries to dispose of their waste and converted it to energy.

**Government's Role:** If the waste that Korea is importing were converted to energy in the host country, the power generated could be utilized within these countries. As it would eliminate the transportation costs of shipping to Korea, it would be even more efficient. Korea has sufficient technology to convert SRF into energy and could provide technology to the governments of partner countries. This process is expected to be revenue generating for host governments.

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\* Waste remaining from nation's nuclear production and development programs.

\*\* Interview with Kim, Jong-yeop, *Today Energy*, March 2016.

## 4.3 Conclusions

The waste of every country has its own unique characteristics which in turn determine the technologies that can best be applied for converting waste to energy. The required investment will also depend on the technology applied. Therefore, any country wishing to convert waste to energy must first carefully analyze the makeup of their waste.

Many waste-to-energy technologies cannot compete directly with commercial operations. However, if the reduction in cost of waste disposal is factored into the equation, then the option can become attractive. Government incentives to encourage private companies to convert waste to energy in many cases would cost less than the expenditure associated with disposal.

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