Contents

Diesel Vehicle Emission Control Devices

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1. Policy Implementation Period

Seoul is located in the heart of the Korean Peninsula and is surrounded by high mountains like Bukhansan, Dobongsan, and Gwanaksan, like a basin, which inhibits air dispersion at weak winds. Recently, with the population increase in the metropolitan area, the air pollutants generated from China's industrialization have affected the region. With regard to the condition of Seoul's artificial environment, the population has increased sharply since 1965, and as of 2014, more than 10.36million people are living in the city. Automobiles, which are the main cause of air pollution, increased from 450,000 in 1985 to 3,010,000 in 2014, showing a 6.7-fold increase.

Except for the days when yellow-dust storms occur, the annual PM10 concentration in Seoul has shown a decreasing trend since 2003, and as of 2014, the fine-dust concentration is 44 ㎍/㎥. Fine dust shows a seasonal pattern. The fine-dust concentration is highest in spring due to the yellow dust, followed by winter, with the highly stagnant atmosphere frequency caused by heating and radiative cooling. Its concentration is lowest in summer, with high amounts of rainfall. In addition, fine dust has seasonal characteristics; its concentration is highest in spring, when yellow-dust storms frequently occur.

To prevent environmental damages due to fine dust, protect the health of the citizens, and create a comfortable environment, the government has established air quality standards and has ensured the adequate maintenance of the air quality in Seoul despite the changes in the environmental conditions. In 1993, fine dust (PM10) was included in the national air quality standards.

In addition, with the revision of the Environmental Policy Framework Act on December 4, 2006, an enhanced standard compared to the existing environmental standards has been applied from January 1, 2007, and ultra-fine dust (PM2.5), a new item, was added and has been applied from 2015.

[1] Translation by ESL®

Table 1. National and Seoul Air Quality Standards

Item	National standard	Seoul standard	Measuring method
Sulfur dioxide (SO_2)	0.02ppm/year 0.05ppm/day 0.15ppm/hour	0.01ppm/year 0.04ppm/day 0.12ppm/hour	Ultraviolet fluorescence method
Fine dust (PM_{10})	50$\mu g/m^3$/year 100$\mu g/m^3$/day	50$\mu g/m^3$/year 100$\mu g/m^3$/day	Beta absorption method
Fine dust ($PM_{2.5}$)	25$\mu g/m^3$/year 50$\mu g/m^3$/day	25$\mu g/m^3$/year 50$\mu g/m^3$/day	Weight concentration method or equivalent automatic measuring method
Nitrogen dioxide (NO_2)	0.03ppm/year 0.06ppm/day 0.10ppm/hour	0.03ppm/year 0.06ppm/day 0.10ppm/hour	Chemical luminescence method
Ozone (O_3)	0.06ppm/8hr 0.1ppm/hr	0.06ppm/8hr 0.1ppm/hr	UV photometric method
Carbon monoxide (CO)	9ppm/8hr 25ppm/hr	9ppm/8hr 25ppm/hr	Non-dispersive infrared analysis method
Lead (Pb)	0.5$\mu g/m^3$/year	0.5$\mu g/m^3$/year	Atomic absorption spectroscopy
Benzene (C_6H_6)	5$\mu g/m^3$/year	5$\mu g/m^3$/year	Gas chromatography

In 2003, 『Special Act on Seoul Metropolitan Air Quality Improvement』 was established to improve the air quality in the capital area, where Seoul, Incheon, and Gyeonggi provinces are located, and based on this, 『Seoul Metropolitan Air Quality Control Master Plan』 established in 2005 has set the target air quality improvement levels of PM10 40 μg/m3, NO2 22 ppb by 2014.

The detailed promotion plans of 『Seoul Metropolitan Air Quality Control Master Plan 』 include the automobile management, including production and operation of cars and traffic demand management; the total load management for large establishment ; the small and pollution source management for small-and-midium sized enterprises and towns; and the eco-friendly energy and urban management projects.

The 2nd Seoul Metropolitan Air Quality Control Master Plan was established and announced in

December 2013. The 2nd Special Measures for the Seoul Metropolitan Air Quality Improvement with the target period 2015-2024 switched the policy direction from target concentration management to risk to human health. According to the regulations on 『Special Act on Seoul Metropolitan Air Quality Improvement』, Seoul's action plan for the 2nd Seoul Metropolitan Air Quality Management was established in 2014 to promote the 2nd Seoul Metropolitan Air Quality Control Master Plan , and detailed plans for the reduction of air pollutants by pollution source have been implemented to ensure eco-friendly traffic demand control through the attachment of diesel particulate filters (DPFs) to diesel vehicles for low pollution, post-management, strengthening of the allowable-emission criteria, spread of low-pollution vehicles, exhaust gas management, dissemination of the weekly no-driving day program, and review of the restrictions on driving diesel vehicles in case of failure to comply with such low-pollution measures. To reduce the pollutants discharged from businesses, the total pollutant control systems allocate yearly total allowable emissions and manage the emissions within the range of the allocated amount for large businesses. In the case of small and mid-sized businesses, promotion measures like the spread of eco-friendly energy and the expansion of the clean-energy supply have been implemented by strengthening the allowable-emission standards.

The Seoul metropolitan government selected the 20% reduction of ultra-fine dust in 2015 as an important policy project, and has strived to reduce the existing annual PM2.5 pollution level of 25 ㎍/㎥ to 20 ㎍/㎥.

2. Background Information

With respect to the atmospheric environment of the capital area, the concentration of fine dust, which causes lung cancer and premature death, reaches twice that of Tokyo. The social costs due to air pollution amounts to an annual 12 trillion won, and the number of annual premature deaths caused by fine dust is estimated to reach 20,000 in 2024. As fine dust, which, as said earlier, is harmful to the human body, is mainly generated from diesel vehicles, measures to reduce the fine-dust levels in the air in Seoul targeting diesel vehicles are needed, and therefore, fine-dust reduction measures targeting diesel vehicles have been promoted in the air quality management areas such as Seoul, Gyeonggi, and Incheon, based on the Special Act on Seoul Metropolitan Air Quality Improvement.

According to OECD in 2002, the level of fine-dust (PM10) pollution in Seoul was the worst among the large cities of the OECD countries.2 To host the 2002 World Cup events in a more pleasant environment, the South Korean government actively promoted policies and researches on the spread of no- or low-pollution vehicles. The Seoul metropolitan government proceeded with projects involving replacing diesel buses with CNG buses and turning mid-sized and large old diesel vehicles into low-pollution ones. The project of attaching an emission reduction

[2] 2011, Analysis of air quality improvement by pollution control measures, Ministry of Environment

device to diesel vehicles is included in the project of turning old diesel vehicles into low-pollution ones.

Meanwhile, Seoul's PM10 and NO2 concentrations in 2003 were 69 μg/m3 and 38 ppb, respectively, 1.9-3.6 and 1.4-1.9 times those of the major OECD cities. The social cost of the capital area due to the damages caused by such air pollution was estimated at 10 trillion won in 2000, and the number of deaths in Seoul caused by fine dust was estimated to have been 1,940 in the same year. To reduce the high fine-dust concentration in the city's air, the Seoul metropolitan government established the Seoul Metropolitan Air Quality Control Master Plan, which includes various improvement measures, among them the introduction of Total Industrial Site Volume Control System(TISVCS) by the end of 2003, the spread of low-pollution vehicles, and the management of exhaust gas from vehicle.3

Some years before 1995, the number of registered vehicles in Seoul showed a more than 10% rising trend annually due to the rapid industrialization and income increase, but the growth rate slowed down from 1995. The total number of vehicles in South Korea in 1965 was only about 40,000, but the number went beyond 10 million in 1997, increasing more than 250 times in 30 years. As of 2014, the total number of vehicles in the city is 201.2 million, and the air pollution problem caused by exhaust gases is becoming increasingly serious. In particular, 8.96 million vehicles, about 44.5% of the total number of vehicles in South Korea, are concentrated in the capital area (Seoul · Gyeeonggi · Incheon). Particularly, 15% of the vehicles are concentrated in Seoul, which also has a very high population density. Thus, air pollution caused by vehicle pollutants has become a very important issue in large cities.

Table 2. Increase in the number of vehicles in the entire country and in Seoul

(Unit: 1,000)

	1975	**1980**	**1985**	**1990**	**1995**	**2000**	**2003**	**2006**	**2009**	**2012**	**2013**	**2014**
Entire country	201	528	1,113	3,395	8,469	12,060	14,587	15,895	17,325	18,871	19,401	20,118
Seoul	85	207	446	1,194	2,043	2,441	2,777	2,857	2,955	2,969	2,974	3,014

At the end of 2014, the diesel vehicles in Seoul accounted for 33.1% of all the vehicles in the city, relatively higher than in other countries. The reason for this was that diesel oil is cheaper than gasoline oil due to the country's industrial and energy policy, and the fuel efficiency of diesel vehicles is slightly superior. In other countries, such as the United States, Japan, and Germany, the diesel vehicles account for only 3, 13, and 18% of all the vehicles, respectively.

[3] 2005, Seoul Metropolitan Air Quality Control Master Plan, Ministry of Environment

With the improvement of the engine and emission control technologies, however, the supply of diesel vehicles has increased due to their economic benefits.

Table 3. Number of registered vehicles by type

(Unit: 1,000)

Division	1994	1996	1998	2000	2004	2006	2009	2010	2012	2013	2014
Total	1,932	2,168	2,199	2,441	2,780	2,857	2,954	2,981	2,969	2,974	3,014
Diesel vehicles	433	473	471	542	797	848	854	863	899	937	997
Gasoline/gas vehicles	1,499	1,695	1,728	1,899	1,983	2,009	2,100	2,118	2,070	2,037	2,017

In 2011, the air pollution emissions from vehicles totaled 135,637 tons, which accounted for 52% of the total emissions, and 81% of the CO emissions, 45% of the nitrogen oxide (NOx) emissions, and 49% of the fine-dust emissions are generated from vehicles.

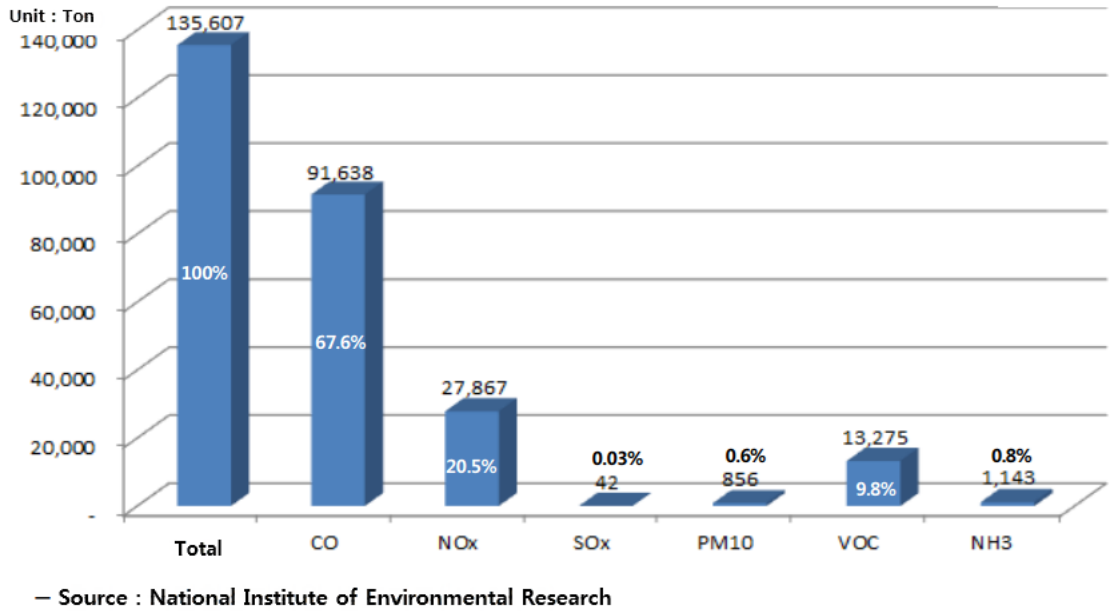


Figure 1. Pollutant emissions from vehicles

『The 1st Special Measures for Seoul Metropolitan Air Quality』seeks to secure the degree of visibility of the open sea of Incheon from Namsan on a clear day. Towards this end, an about 4 trillion won budget from both the national treasury and the local funds had been used for 10 years (2005-2014). Ninety percent of the total budget was allotted for the old-diesel-vehicle

exhaust gas reduction project, and an action plan was formulated and implemented to turn old diesel vehicles into low-pollution ones. The improvement target was set to 40μg/m3 PM10 (Tokyo) and 22ppb NO2 (Paris).

『The 2nd Special Measures for Seoul Metropolitan Air Quality』 seeks to realize a healthy 100-year-old era with clean air, and efforts were set to be made to achieve the goal from 2015 to 2024. The improvement targets were set to 20μg/m3 PM2.5, 30μg/m3 PM10, 21ppb NO2, and 60ppb O2, and the focus was expanded to include gasoline and gas cars, in addition to diesel vehicles.

In the case of specific diesel vehicles, cars whose emission warranty period has expired in accordance with Article 46 of 『Clean Air Conservation Act』; light cars and passenger cars whose emission warranty period has expired in accordance with No. 3, Annexed Table 5 of 『Enforcement Regulations of Clean Air Conservation Act』; and vehicles whose emission warranty period has expired in accordance with No. 5, Title 4 are excluded from the implementation of 『Clean Air Conservation Act』, as shown below.

Table 4. Enforcement Regulations of the Clean Air Conservation Act [Annexed Table 5]

Specific diesel vehicles		Specific diesel vehicles (excluding some vehicles)	Excluded vehicles	
No. 1 Until December 31, 2000	No. 2 January 1, 2000-June 30, 2002	No. 3 On and after July 1, 2002	No. 4 On and after January 1, 2006	No. 5 On and after January 1, 2009
All diesel vehicles	All diesel vehicles	**<Exclusions>** - Light cars (less than 800cc) - Passenger cars weighing less than 2.5 tons and with less than 8 passengers	All diesel vehicles	All diesel vehicles

Annex Table 18 of the Enforcement Regulations of the Clean Air Conservation Act regulates the exhaust gas application period depending on the production period of the diesel vehicles.

Table 5. Enforcement Regulations of the Clean Air Conservation Act [Annex Table 18]

Production period	Application period	Vehicle type				
On and before December 31, 1997		**Passenger car**	**Small truck**			
	February 2, 1991-December 31, 1992					
	January 1, 1993-December 31, 1995	5 years, 80,000㎞				
	January 1, 1996-December 31, 1997	5 years, 80,000㎞	40,000㎞			
January 1, 1998-December 31, 2000		**Light car**	**Passenger car**	**Small truck**	**Heavy-duty vehicle**	
	January 1, 1998-December 31, 1999	60,000㎞	5 years, 80,000㎞	60,000㎞	-	
	January 1, 2000-December 31, 2000	5 years, 80,000㎞	5 years, 80,000㎞	5 years, 80,000㎞	2 years, 40,000㎞	
January 1, 2001-June 30, 2002		**Light car**	**Passenger car**	**Multi-purpose car**	**Mid-sized car**	**Large car**
	January 1, 2001-June 30, 2002	5 years, 80,000㎞	5 years, 80,000㎞	5 years, 80,000㎞	5 years, 80,000㎞	2 years, 80,000㎞
July 1, 2002-December 31, 2005		**Light car**	**Passenger car 1/ passenger car 2**	**Passenger car 3/ truck 1/ truck 2**	**Passenger car 4/ truck 3**	**Construction machinery**
	July 1, 2002-December 31, 2002	5 years, 80,000㎞	5 years, 80,000㎞	5 years, 80,000㎞	2 years, 80,000㎞	
	After January 1, 2003	5 years, 80,000㎞	5 years, 80,000㎞	5 years, 80,000㎞	2 years, 160,000㎞	1 year, 20,000㎞
January 1, 2006-December 31, 2008		**Light car**	**Small passenger car**	**Small truck/mid-sized passenger car/truck**	**Large/ ultra-large passenger car/truck**	**Construction machinery**
		5 years, 80,000㎞	5 years, 80,000㎞	5 years, 80,000㎞	2 years, 160,000㎞	1 year, 20,000㎞
On and after January 1, 2009		**Light/small/mid-sized passenger car/truck**	**Large passenger car/truck**	**Ultra-large passenger car/truck**	**Construction machinery motor**	
		10 years, 160,000㎞	5 years, 80,000㎞	6 years, 200,000㎞	7 years, 500,000㎞	1 year, 20,000km
On and after January 1, 2013		10 years, 160,000㎞	6 years, 300,000㎞	7 years, 700,000㎞	10 years, 8,000 hours	
On and after January 1, 2016		10 years, 160,000㎞	6 years, 300,000㎞	7 years, 700,000㎞	10 years, 8,000 hours	

3. The Importance of the Policies

The rapid increase of automobiles accounts for 52% of the air pollution, and automobiles are considered the main source of air pollution. The fine dust, excluding the inflow from outside, is generated mostly from operating diesel vehicles. The more fuel an automobile consumes, the more the air pollutants that it releases into the air, which will adversely affect the air quality of Seoul. The air pollutants from the transport sector account for more than 70% of the total emission of air pollutants, and among such air pollutants, those coming from automobiles are increasing gradually.

Air pollution deteriorates people's health and damages properties and ecosystems. The damages caused by increased air pollutant emission are accumulated. As this problem is not contained in an individual city but spreads to the surrounding areas, its seriousness is increasing. It is natural for the number of automobiles to increase as the people's income and the goods transport increase, but Disel Particulate Filters (DPFs) must be attached to diesel vehicles to significantly reduce the emission of air pollutants from such vehicles.

The air quality of Seoul has improved substantially considering that the concentration of PM10 decreased from 60 ㎍/㎥ in 2004 to 45 ㎍/㎥ in 2015. Since recently, however, it has been increasing slightly due to the influx of air pollutants from the city's neighboring countries in Northeast Asia. The NO2 concentration has decreased slightly or has shown no change since 2008. The implementation of Phase 1 of the Seoul Action Plan on Air and Environment Improvement is considered to have lowered the pollution level near the city streets, and to have expanded the visibility distance.

The visibility distance data show much improvement owing to the better PM10 concentration in Seoul's air. The visibility distance improved from 12.3 km in 2004 to 13.1 km in 2013 on average. The number of days with an over 20 km visibility distance also partially increased from 76 days in 2007 to 202 days in 2010, 274 days in 2012, and 205 days in 2013.

Seoul, however, still needed to make the owners of diesel vehicles follow the emission reduction plan. Since January 2011, authorities have implemented administrative measures such as imposing fines on diesel vehicle owners who have not followed the plan 6 months after the notice was given, with the intention of inducing their participation in the effort.

4. Results of the Project in terms of Spreading Diesel Emission Control Devices

1) Promotion of the pilot project

Seoul carried out the In-Use Diesel Vehicle Emission Reduction Pilot Project in 2004. The city installed 280 DPFs and 150 DOCs (diesel oxidation catalysts) in its official vehicles and public transit buses, and remodeled 450 vehicles into LPG (liquefied petroleum gas) vehicles, for a total of 880 units. The expenses for DPF installation were fully shouldered by the government, and those for DOC installation and LPG remodeling were shouldered evenly by the government

and the city.

2) Full-scale implementation

After the pilot project period, the full-scale project began in 2005. With 50% of the project expense shouldered by the government and 50% shouldered by the city, the project has covered a total of 12,130 diesel vehicle units to date: 7,789 DPF installations, 1,490 DOC installations, 2,814 LPG remodeling cases, and 37 early vehicle disposals. Since 2006, 70-95% of the installation costs has been supported.

3) Mandatory installation

In 2008, the city made it mandatory to install low-emission devices in over-7-year-old diesel vehicles weighing over 3.5 tons. It supported 70-95% of the installation costs, 50% from the government and 50% from the city.

In 2009, the city extended the coverage of the In-Use Diesel Vehicle Emission Reduction Project to over-7-year-old diesel vehicles weighing over 2.5 tons. It shouldered 70-95% of the installation costs, 50% from the government and 50% from the city.

5. Policy Objectives

The objective of the In-Use Diesel Vehicle Emission Reduction Project is to protect the health of the over 10 million Seoul citizens from air pollution, and to provide a more pleasant environment for them by installing low-emission devices in diesel vehicles, remodeling such vehicle's engines into LPG engines, and encouraging the owners of old diesel vehicles to dispose of their vehicles early. The city plans to complete the project by 2019, and to maintain a safe air quality level by completing the installation of low-emission devices or carrying out other measures on the about 380,000 diesel vehicles in this city that were manufactured before the year 2005.4

Table 6. Seoul Air Quality Improvement Targets

Division	2014	2024
PM_{10}	40$\mu g/m^3$	30$\mu g/m^3$
$PM_{2.5}$	-	20$\mu g/m^3$
NO_X	22ppb	21ppb

Remarks: The target year for ultra-fine dust ($PM_{2.5}$) was set to 2018 to achieve the target earlier.

[4] In-Use Diesel Vehicle Emission Reduction Project, Seoul Urban Solutions Agency (2014)

6. Main Policy Contents

As of 2015, the city, through its In-Use Diesel Vehicle Emission Reduction Project, has installed low-emission devices like DPFs in 150,948 diesel vehicles.

According to the Special Act on Seoul Metropolitan Air Quality Improvement and local by-laws, the city made it mandatory starting on January 1, 2008 to install low-emission devices in over-7-year-old diesel vehicles weighing over 2.5 tons whose low-emission guarantee period (2 years for vehicles weighing over 3.5 tons, and 5 years for vehicles weighing under 3.5 tons) has expired. The government and the city shouldered 83-96.5% of the installation cost. Likewise, the aforementioned devices had to be installed in over-7-year-old diesel vehicles weighing between 2.5 and 3.5 tons starting in January 2009.

In particular, between 2013 and 2014, the city installed PM-NOx simultaneous-reduction devices in 106 large diesel buses as part of the Nitrogen Oxide (ultra-fine-dust inducer) Reduction Demonstration Project. After analyzing the results of the demonstration project, the city started expanding the project implementation.

Although the long-term effectiveness of the Diesel Vehicle Emission Reduction Device Installation Project has yet to be evaluated, it can be said that the air quality in Seoul has been improving based on the data obtained so far, such as a decrease in the number of days with 100 μg/m3 or more ultra-fine dust in the air and an increase in the number of days with no more than 30μg/m3 ultra-fine dust. Moreover, the number of high-emission-vehicle reports, which indicates the citizens' perception of the air pollution level in the city, has dramatically decreased.

The Diesel Vehicle Emission Reduction Device Installation Project was planned to be implemented from 2005 to 2024 for improving the air quality in the capital area. Since 2009, it has so far been implemented in five other metropolitan cities: Busan, Daejeon, Daegu, Gwangju, and Ulsan.

It is very important to make sure that the installed emission reduction devices are working as intended. Recognizing the importance of the inspection of such devices, the city has encouraged the manufacturers to inspect the devices regularly and set up the city's own inspection team. The team has been examining the vehicles with an installed emission reduction device, and has been issuing device improvement or disposal orders to the people whose vehicles failed in the inspection.

The owners of the vehicles with an installed emission reduction device can receive free after-sale (A/S) services during the 3-year warranty period (3 years or 160,000 km for DPF, 3 years or 80,000 km for DOC or for the LPG remodels). Also, the owners of vehicles with a class 1 emission reduction device can receive free filter cleaning per year at more than 40 cleaning centers in the capital area.

According to the Special Act on Seoul Metropolitan Air Quality Improvement, vehicles with an installed emission reduction device should be operated for at least 2 years after the device installation, excepting unavoidable situations like a natural disaster, a fire, or a theft. Moreover, the vehicle owners are required to return the device to the Korea Automobile Environmental Association when they are to dispose of their vehicles.

If an owner removes the device without any valid reason before the mandatory operation period, or fails to return it, the owner has to return the subsidy.

To handle the complaints regarding the installed emission reduction devices, the manufacturers of the devices operate their own A/S call centers and cleaning centers. If any dispute between an owner and a manufacturer occurs, the city will act as the arbiter.

The primary reason that DPFs are disqualified on account of their under-performance, and become subject to a removal order, is operating the vehicle under a severe environment falling outside the certification criteria. Other reasons are the lack of post-management by the manufacturer and the vehicle maintenance failure of the vehicle owners. Theoretically, the DPF can reduce the amount of exhaust emission by more than 80%. Therefore, vehicle owners should do their best to maintain the device's optimal performance level.

Once a vehicle owner removes the device from her or his vehicle, she or he is no longer qualified to receive the corresponding benefits and subsidies. Thus, the car owner is obliged to pay the environment improvement charges and to regularly subject her or his vehicle to an exhaust emission test. Moreover, the manufacturer has to return the subsidy.

Realizing the broad characteristics of air pollution, Seoul, Incheon, and Gyeonggi provinces decided to cooperate with one another starting in 2010 to maximize the improvement of their air quality, after collecting various opinions from experts and citizens. The subject vehicles are diesel vehicles weighing over 2.5 tons, that are over 7 years old, and that have not taken any corrective measure within 6 months after receiving Seoul's emission reduction order or that does not pass the total emission gas test. Any of the three aforementioned local governments can impose a 200,000 KRW fine after a one-month warning period on the owners of vehicles without an emission reduction device found in their respective jurisdictional roads. Moreover, they have set up an unmanned enforcement system using CCTVs on their main roads (e.g., Olympic Expressway), and have tightened the control over the vehicles without emission reduction devices.

• Current status of the installation of the Driving Restriction Monitoring System (operated since March 2012)

- 24 camera installations on 7 different spots on Seoul's main roads

• Implementation of the Driving Restriction Monitoring System (2014)

- Caught 746 vehicles, issued a warning to 679 vehicles, and imposed a fine on 67 vehicles

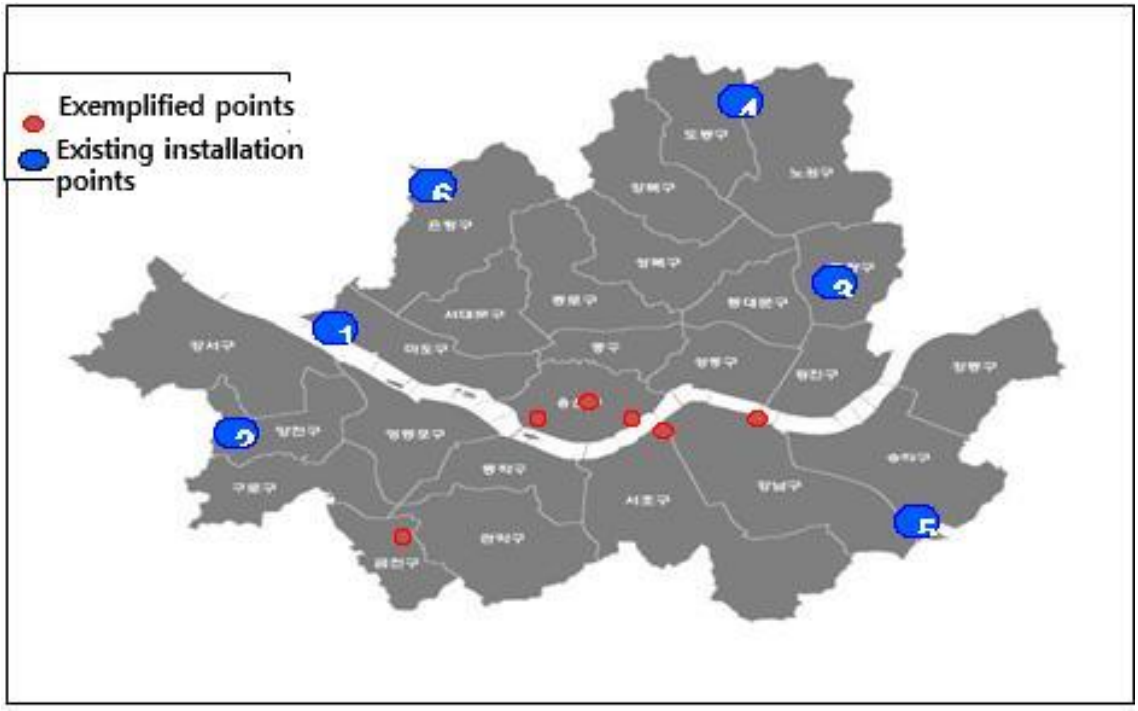


Figure 2. Status of vehicle travel restriction system installations

DPF is installed in mid-sized and large diesel vehicles, and can eliminate more than 70% of the exhaust gas by collecting pollutants like PM, depositing them in the catalyst-coated filter, and then converting them to CO2 or vapor. Partial diesel particulate filters (p-DPF) is installed in mid-sized and small diesel vehicles (weighing no more than 3.5 tons), and its catalysts convert pollutants to hazardless materials without a collection process, which relieves p-DPF of any post-management measure. DOC was installed in small diesel vehicles, but its installation has been suspended since 2010 due to its low cost-to-benefit ratio of 10:20% performance in reducing ultra-fine-dust emissions. Since the full-scale implementation of the emission reduction project with focus on the public transit buses and business vehicles in 2005, DPFs have been installed in 89,423 diesel vehicles, and they are expected to be installed in 6,600 vehicles per year until 2019. According to the Special Act on Seoul Metropolitan Air Quality Improvement and local by-laws, the owners of diesel vehicles weighing over 2.5 tons, are over 7 years old, and whose low-emission warranty period (2 years for vehicles weighing at least 3.5 tons; 5 years for vehicles weighing less than 3.5 tons) has expired can obtain subsidies from the government and the city for 90-95% of the implementation cost for any emission reduction measure, such as the installation of an emission reduction device.

Table 7. Status of DPF devices and subsidy (amount, effects)

Division			Government fund (1,000 won)	Deductible (1,000 won)	Target	Emission reduction effects	
						PM (HC)	NO_x
DPF	Natural large		5,575	511	Large: More than 11,000 cc Mid-sized: 6,000-11,000 cc Small: Less than 3,000 cc	More than 80%	-
	Natural mid-sized		5,232	477			
	Complex large		10,056	959			
	Complex mid-sized		7,809	737			
	Complex small	Van	3,672	401			
		Truck	3,764	330			

The city inspects diesel vehicles frequently to see if their emission reduction device is working properly and if their emission level is within the normal range. If any abnormal vehicle is found, the city orders correctional measures and monitors their fulfillment. If any device is found to be no longer usable, the city provides a free refurbished device in an attempt to promote the continuous use of the emission reduction device and to maintain the vehicle's optimal performance.

The diesel vehicles registered in Seoul and the metropolitan area (excluding compactcars and passenger cars) whose low-emission guarantee period has expired under the Clean Air Conservation Act are designated as "specific diesel vehicles" and are monitored with stricter emission standards rather than with the general emission standards for in-use vehicles.

A specific diesel vehicle is allowed to operate only if it passes the detailed inspection and is within the specified emission level range. If it does not satisfy the standard, the owner of the vehicle must install an emission reduction device (DPF, p-DPF, or DOC), must remodel its engine into a low-emission model, or must dispose of the vehicle.

When installing an emission reduction device on a specific diesel vehicle, its smoke concentration has to meet the certification criteria of an emission reduction device. If the device does not meet the standard, it is allowed to be installed only after fixing and re-testing the device to ensure that it meets the standard. Only vehicles whose smoke concentration meets the in-use vehicle emission standard are allowed to be disposed of early .

Generally speaking, DPFs are installed in mid-sized to large vehicles; p-DPFs are installed in mid-sized vehicles, or such vehicles are remodeled into vehicles with LPG engines; and DOC is installed in small vehicles, or such vehicles are remodeled into vehicles with LPG engines. Since 2010, however, DOC installation has been suspended, and instead, small p-DPFs have been installed in small vehicles since then.

The Korea Automobile Environmental Association kept the maintenance expenses out of the subsidies.

When the manufacturers submit an application for reimbursement of the maintenance expenses along with supporting documents to the association, the association screens the applications and then releases the funds to the device manufacturers.The maintenance cost shouldered by the association includes a 300,000 KRW annual cleaning cost for 3 years for DPF during the warranty period, and a 10,000 KRW monitoring cost.

Benefits such as exemption from the environmental improvement charges and from undergoing the precise emission test are granted to the vehicle owners who joined the low-emission initiative. The only compulsory condition for receiving the benefits is that the vehicle should be operated for at least 2 years after the installation of any emission reduction device.

The post-management of the installed device is also very important. Since the initiation of the project, the city has realized the importance of post-management and has thus encouraged the manufacturers to also focus thereon. The city has carried out inspections of the vehicles with an installed emission reduction device by organizing an inspection and monitoring team for such purpose. The team has also issued correctional or removal orders whenever needed.

7. Technical Details

As mentioned earlier in this paper, DPF stands for "diesel particulate filter." This device traps the particulates discharged from the vehicle engine at its filter, and then burns them (recycling) in the engine. Through the repetitive trapping and recycling of particulates, the device can eliminate more than 80% of the vehicle emission and thus has an excellent advantage over the other devices in terms of performance. DPFs, in most cases, are installed in mid-sized to large vehicles. For small vehicles, DPFs were not available until 2007 due to the technological limitation of such devices. The four technologies presented below are the internationally accepted post-treatment technologies, whose reliability, durability, and cost effectiveness have proven that they are practical to use in reducing the air pollutant emission of modern diesel vehicles.

Technology trapping the particulates (e.g., soot) from the vehicle exhaust and eliminating them through a burner and/or heater

Continuously regenerating trap (CRT) to be continuously cleaned or "regenerated" above a certain temperature with the catalyzed diesel particulate filter (CDPF)

Diesel oxidation catalyst (DOC), which oxidizes the gaseous matters in the exhaust gas (e.g., hydrocarbon [HC], CO, NOx) and the particulate matters (PMs) in the exhaust gas (e.g., soluble organic fractions [SOFs]) using catalysts; works similarly as the three-way catalytic converter in a gasoline engine

The technology that oxidizes harmful exhaust gas and PMs by systematically controlling the engine control technology, the catalyst post-treatment technology, and the additive technology

Table 8. Type of diesel emission control devices

Division	Pollutant reduction efficiency of the device	Warranty period	Target pollutants	Remarks
First-class	More than 80%	3 years or 160,000 km	Particulate matter (PM_{10}), nitrogen oxide (NOx)	Diesel particulate filter (DPF)
Second-class	More than 50%	3 years or 80,000 km		Partial diesel particulate filter (pDPF)
Third-class	More than 25%	3 years or 80,000 km		Diesel oxidization catalyst (DOC)

1) First-class emission control device (DPF: diesel particulate filter)

DPF traps the PMs in the exhaust gas at the catalytic filter and eliminates them by burning them at a temperature of over 550oC. It reduces the soot found in the exhaust gas from a diesel engine. Soot consists of carbon and is produced by the incomplete combustion of coal, oil, wood, or other fuels. If it is excessively accumulated, it can reduce the fuel efficiency and performance of the vehicle. DPFs are categorized in terms of the way that heat for burning PMs is provided.

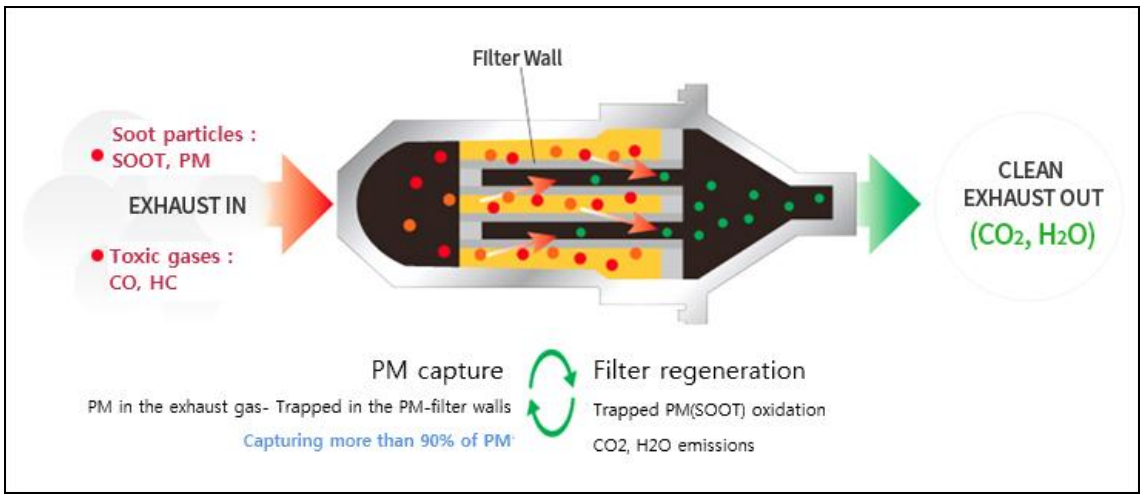


Figure 3. How DPF works?

(Source: Korea Automobile Environmental Association,

http://www.aea.or.kr/main_business/technology.php)

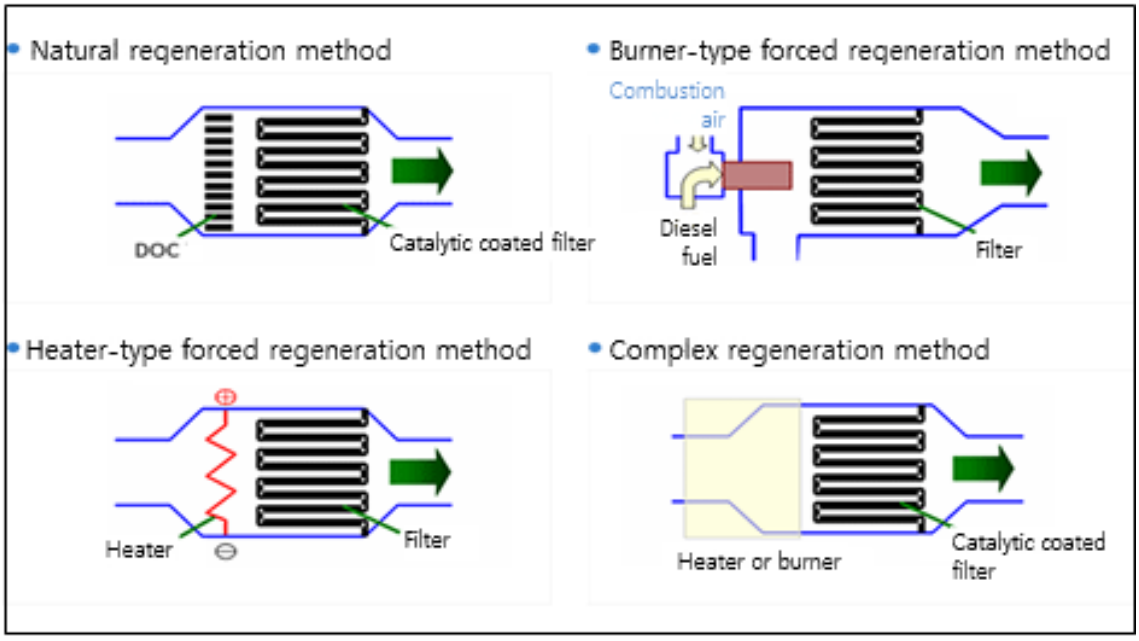


Figure 4. DPF regeneration method

(Source: Korea Automobile Environmental Association, http://www.aea.or.kr/main_business/technology.php)

PMs are classified according to the heat supply system required for the combustion, as shown below.

Table 9. Heat supply system by generative method

Type	Heat supply system	Applicable vehicles
Natural-regeneration	Engine exhaust heat	High-speed vehicles
Forced regeneration	Electric heater or auxiliary fuel injection	Low-speed vehicles
Complex regeneration	Mixed use of the natural- and force-regeneration methods	Low- and high-speed vehicles

The exhaust gas is burned again by the oxidation catalyst located at the opening of the DPF, which decreases the size of the PM. These small PMs penetrate the filter and are released to the air, but other PMs that are still big are trapped in the filter and are accumulated on it through the repetitive process until the engine control system sprays the fuel to be burned in the DPF. This burning fuel increases the temperature in the DPF, and the heat burns the accumulated PMs again to make them smaller.

The process of spraying fuels to make the big PMs small is called “regeneration.” There are different ways of setting the timing of the regeneration. One is through the pressure differences between the front and back of the filter (pressure difference sensor). Every vehicle manufacturer has a different set point for the pressure difference. Some check the engine performance regularly based on its mileage to see how negatively the PMs affect the engine performance due to the filter clogging and the resulting increased pressure in the exhaust system. Once it detects a certain level of engine underperformance, it sprays fuel into the DPF. Other manufacturers use an extra equipment (scanner) to set the regeneration timing. The pressure difference sensor and mileage methods are applied differently according to the engine control system type, vehicle type, and DPF manufacturer.

The ways of increasing the temperature in the DPF to a point that is sufficient to burn the PMs accumulated on the filter are most important and vary. Some spray extra fuels into the PDF, some use additives, some use an electric heater, and others use an extra burner. Due to the cost issue, the most common method is spraying extra fuel into the DPF to increase the temperature to over the regeneration point while checking the temperature with an exhaust gas temperature sensor. Some manufacturers, however, are using additives for such purpose.

Although DPF reduces the PM emissions into the air, it increases the costs, decreases the fuel efficiency, and has short durability, which are the limitations of this emission reduction device. Many studies have pointed out that the average lifespan of the fuel-spraying DPF in terms of mileage is around 100,000 km.

2) Second-class emission control device (p-DPF: partial diesel particulate filter)

Rolled like a cylinder with a paired layer of flat foil and corrugated foil, p-DPF has a partially open structure. Therefore, the exhaust gas passes through the space between the flat foil and the corrugated foil. p-DPF does not reduce the engine power or fuel efficiency because it does not accumulate any PM on the filter, unlike the wall-flow-type filter. Moreover, it does not need periodic management of the filter because ashes do not stay thereon.

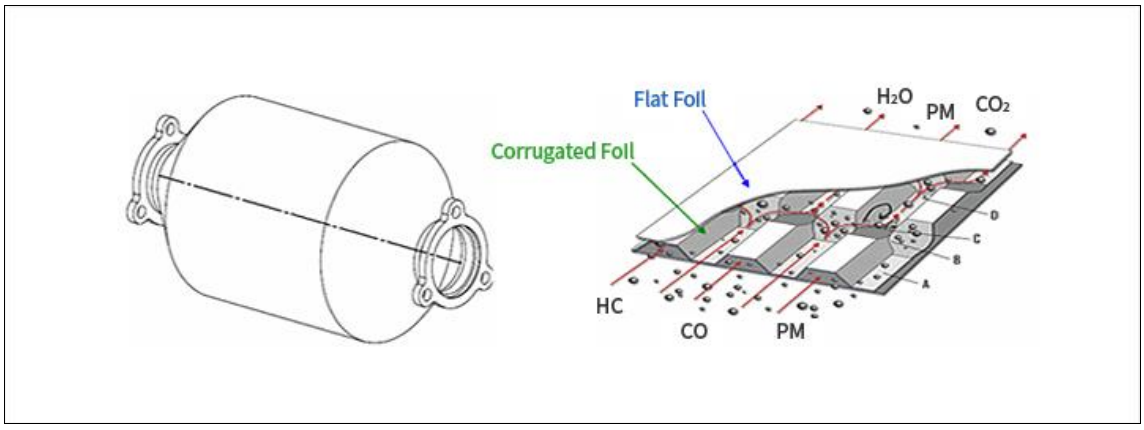


Figure 5. p-DPF structure

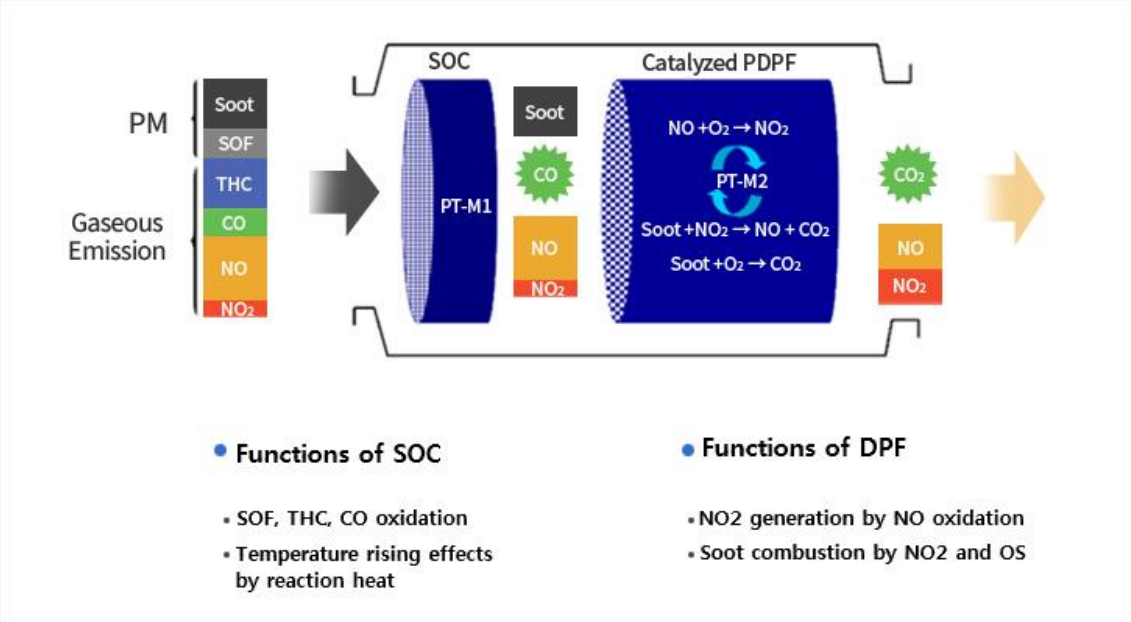


Figure 6. How p-DPF works?

3) Third-class emission control device (DOC: diesel oxidation catalyst)

When exhaust gas passes through the DOC, it reacts with the catalyst. The DOC, in this catalytic reaction, purifies the exhaust gas by oxidizing the gaseous matters (e.g., HC, CO) and the PMs (e.g., lubricant components, incompletely combusted fuels, SOFs).

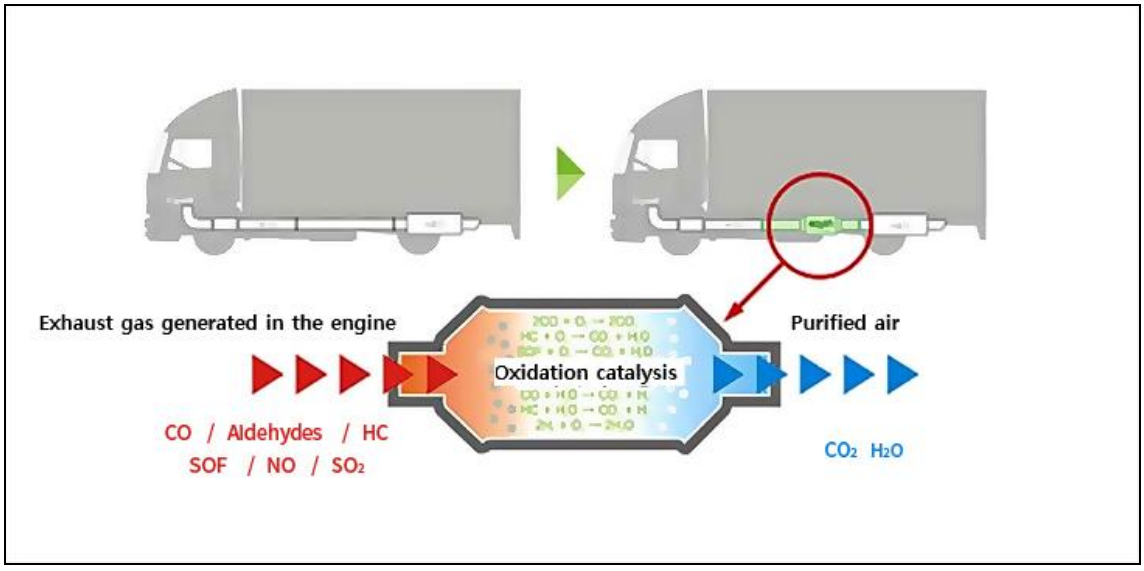


Figure 7. How DOC device controls emission

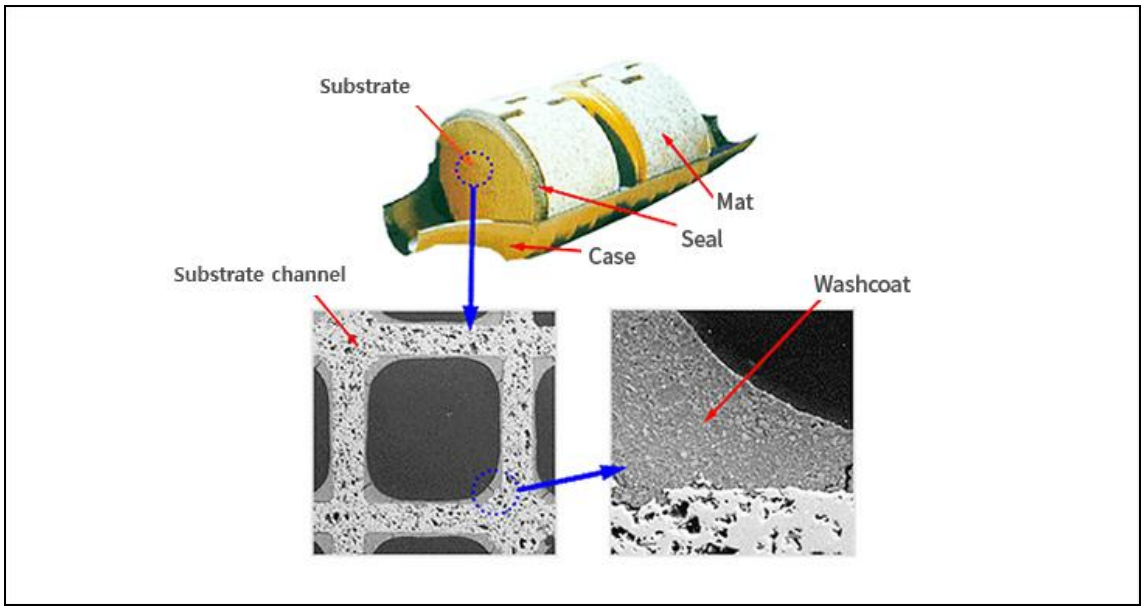


Figure 8. DOC structure

8. Policy Effects

The low-pollution vehicle project that has been implemented since 2000 has demonstrated the effect of reducing the PM10 emissions of the vehicles in Seoul by 4-22%. The concentration of PM10 measured from an air quality measurement network at the roadsides of Seoul has continuously been reduced through the years since 2005, up to 53 μg/m3 in 2014. This is almost similar to the annual environmental standard of PM10 (50 μg/m3), and as such, it can be seen that the environmental standard was met not only in the general air quality measurement station (45.8 μg/m3 in 2014) but also in the roadside air quality measurement station. In addition, the number of days when a high density of more than 100 μg/㎥ occurs has decreased, and the number of days when a low density of more than 30 μg/m3 occurs has increased. Therefore, the pollution from fine dust in Seoul has decreased, and the number of reported vehicles discharging exhaust fumes has been sharply reduced. It of course cannot be concluded that these improvements were obtained only through the low-pollution vehicle project, but this project has been evaluated to play a big role in achieving such results.

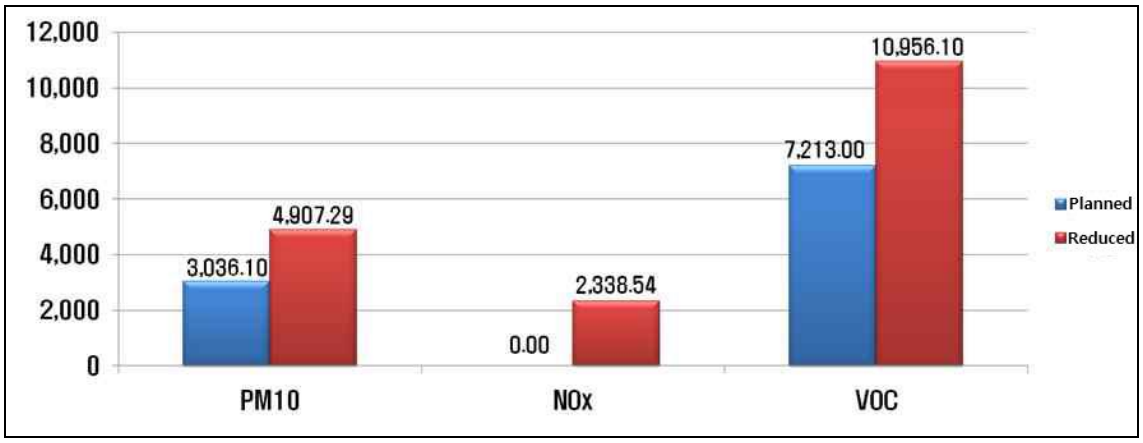


Figure 9. Reduction of pollutants by emission control devices (2007-2009) (Unit: ton)

Source: Analysis of the air quality improvement effects of pollution control measures (2011)

To reduce the NOx in the air, the Seoul metropolitan government implemented the pilot project of attaching a NOx reduction device to 444 vehicles, like the attachment of a PM-NOx simultaneous-reduction device to old construction machinery and large trucks from 2013 to 2017, to verify the feasibility of such measure, and expanded the project implementation to beyond 2015.

Table 10. Average exhaust gas reduction ratio through the implementation of the NO_x reduction pilot project

Project title/exhaust gas	**CO reduction**	**NO_X reduction**	**PM reduction**
Three-way catalytic converter	82.2%	88.4%	60.1%
PM-NO_X simultaneous-reduction device	85%	70%	80%

9. Challenges and Solutions

The project of attaching an emission control device to diesel vehicles has been carried out for the purpose of reducing fine-dust emissions, and it was evaluated to be somewhat effective in reducing diesel vehicles' fine-dust emissions. The carbon dioxide (CO2) pollution level in Seoul, however, has exceeded the environmental standards and has not shown a clear improvement trend. Given that a significant portion of the NOX emissions in Seoul is discharged from diesel vehicles, there is a need for the low-pollution diesel vehicle project to take into account the reduction not only of fine dust but also of NOX.

In this regard, the Seoul metropolitan government proceeded with the project of attaching PM-NOX simultaneous-reduction devices to 444 vehicles in 2013, including old construction machinery and large trucks, and since 2015, it has been expanding and promoting the project after the verification of its effects.

Air Pollution Monitoring Network

Jong In Dong / Won June Lee, University of Seoul[5]

1. Policy Implementation Period

Since the Air Pollution Monitoring Network was first installed and operated in 1973, the government and local government bodies have been operating monitoring networks. At the end of 2014, the Ministry of Environment was operating 148 monitoring network stations while local governments were operating a total of 506 stations in 97 cities and counties in the nation. There were 11 types of air quality monitoring stations (city air quality monitoring station, road-side air quality monitoring station, acid deposition monitoring station, background density monitoring station, suburban air quality monitoring station, heavy metal monitoring station, harmful material monitoring station, photochemical pollutant monitoring station, global atmosphere monitoring station, and monitoring station of PM 2.5 and air pollution concentration)[6].

According to domestic regulations on the installation and operation of the air pollution monitoring network, the air pollution monitoring network is by and large divided into two: the general monitoring network and concentrated monitoring network. There are a total of 10 kinds of general monitoring networks. The stations can be categorized into either the general or special air pollution monitoring network. General air quality monitoring stations check SO2, CO, NOX, O3, and PM10. The stations are then further categorized into national or local, depending on the type of operation.

[5] Translation by ESL®

[6] Ministry of Environment, 2015, Annual Report of Air Quality in Korea, 2015

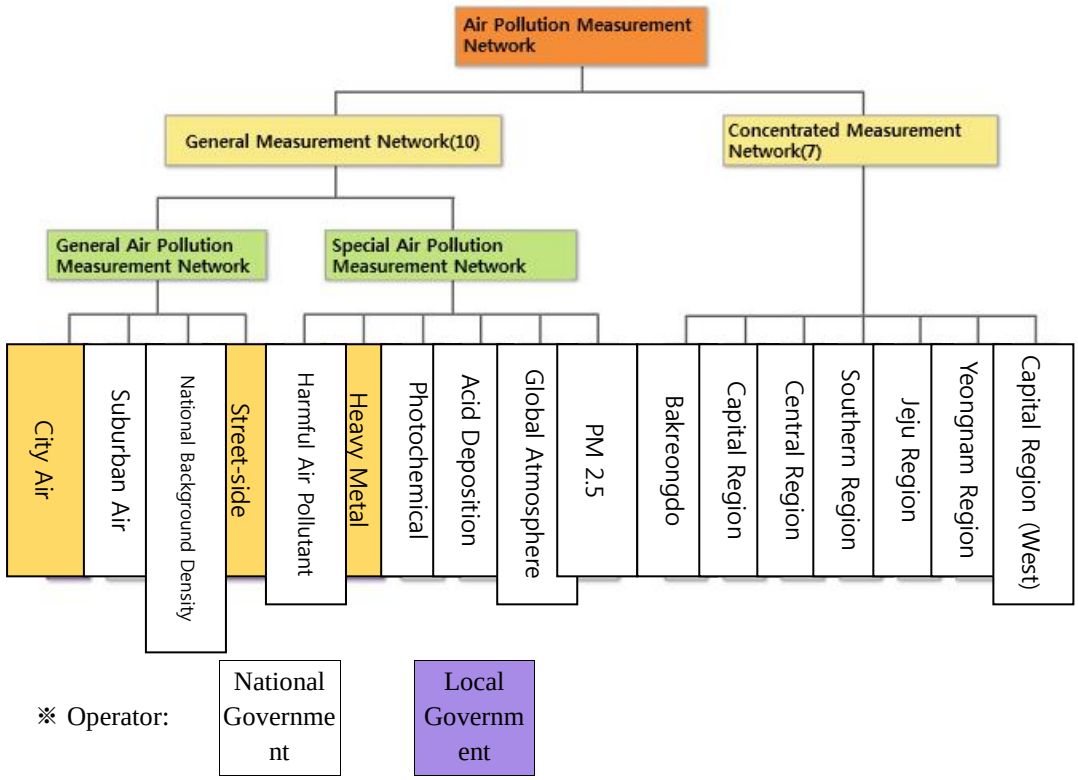


Figure 1: Categorization of Domestic Air Pollution Monitoring Network
*Source: Ministry of Environment, Air Pollution Monitoring Network Installation and Operation Manual, 2011

Seoul City began with 4 monitoring stations in 1973. Currently, there are 45 monitoring stations, operating 65 air pollution monitoring networks. 25 districts are categorized into central, northeast, northwest, southwest, southeast areas for air pollution analysis and management. There is at least 1 or more monitoring network installed for operation for each district. Among the 6 types of monitoring networks, the following monitoring stations have been recorded: 25 city, 14 road-side, 10 photochemical, 5 heavy-metal, 10 acid deposition and 1 visible distance monitoring station. The listed order is according to the number of stations7.

Table 1. Seoul City Air Pollution Monitoring Network Operation (2015)

Category	**Total**	City	Street-side	Photo chemical	Heavy Metal	Acid Deposition	Visible Distance
Total	**65**	25	14	10	5	10	1

Source: Seoul City Air Management Department

	-Central : Jongro・Junggu・Yongsangu (3

[7] Ministry of Environment, 2010, "2011~2015 Air Pollution Monitoring Network Operation Plan"

4

		Districts)
	-Northeast :	Seongdong・Gwangjin・Dongdaemun・Jungrang・Seongbuk・Gangbuk・Dobong・Nowongu (8 Districts)
	-Northwest :	Eunpyeong・Seodaemun・Mapogu (3 Districts)
	-Northsouth :	Yangcheon・Gangseo・Guro・Geumcheon・Yeongdeungpo・Dongjak・Gwanakgu (7 Districts)
	-Southeast :	Seocho・Gangnam・Songpa・Gangdonggu (4 Districts)

Figgure 2. Seoul Air Pollution Monitoring Network Distribution Status

Seoul's air pollution monitoring stations have been operated with the following number of stations until 2008: 27 city monitoring networks, 2 clean zone, and 9 road-side networks. As Seoul islargely affected by Seoul Metropolitan areas as well as China and the northwest monsoon, the monitoring networks have been re-organized in order to better understand and manage pollutants that travel long distances, the components, density and travel routes, pollutant statistics in border areas, and road-side pollutant statistics. Seoul city currently has 25 stations, 1 for each district. The city also operates 6 background monitoring networks: Gwanak Mountain station has been installed to measure pollutants that travel long distances, Namsan station for that of high altitude, and Bukhansan station to understand the air quality of the clean zone. Moreover, to manage the generational and changing statistics of pollutants from automobiles, 12 stations have been installed on expressways. More stations have been installed for exclusive median bus lanes and exclusive car lanes. There are a total of 14 road-side air pollution monitoring stations being currently operated. Therefore, Seoul City is operating a total of 45 stations (25 city stations, 6 background, 14 street-side) for the monitoring and management of air pollution.[8]

Table 2. Seoul City General and Special Air Pollution Monitoring Network Station Status

Category	General and Special Air Pollution Monitoring Network

[8] Seoul City Air Management Department Material

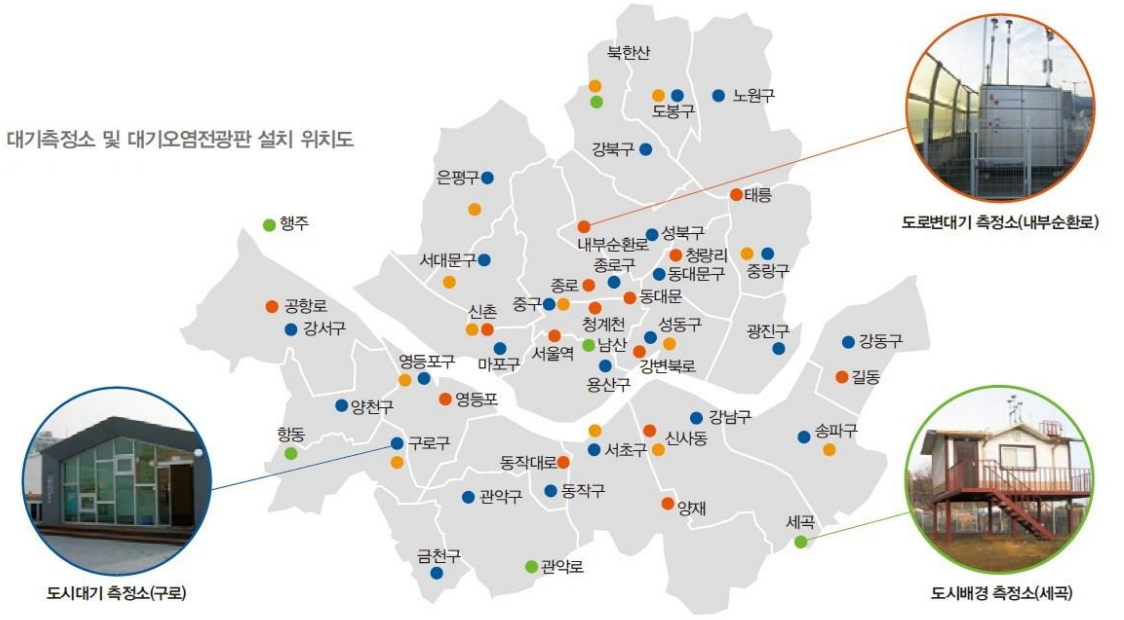
	General Air	Heavy Metal	VOC/ BTEX	Acid Rain	Mercury	Ion	EC/OC	BC	PM-1	Traffic Volume	HC	UV
City Air Quality Monitoring Station	25	4	7	8	4	3	3		4			
Road-side Air Quality Monitoring Station	14		4				1	2		3	15	9
City Background Monitoring Station	6		1	1	1	1	1		4			
Other (Researcher)	1	1		1								
Mobile Air Quality Monitoring Vehicle (6 Units)	1											1
Total	**47**	**5**	**12**	**10**	**5**	**4**	**5**	**2**	**8**	**3**	**15**	**10**

Air pollution monitoring stations are located in various areas around Seoul which are said to best represent each area's specific and idiosyncratic characteristic. The monitoring stations automatically measure air quality 24 hours a day. These results are then sent to the Seoul Public Health and Environment Research Institute, and released to the general public and citizens of the city through its website. The measured values are sent to Seoul City and the Ministry of Environment after a thorough search process. In order to enhance credibility of values, only the statistics that have achieved more than 75% measured values during the designated period are considered to be valid.[9]

Therefore, Seoul uses the measured air pollution statistics to forecast situations and warn the citizens on air pollution, evaluate air quality, and find ways to improve the air quality. The city will continue to build new monitoring stations, change aged facilities, add cutting-edge monitoring facilities and push for an integrated information system for air environment, so as to ultimately create the most trustworthy air quality management system.[10]

[9] Seoul City, 2014, "2014 Seoul Air Quality Evaluation Report"

[10] SungKyunKwan University, 2010, "Priority Ranking Analysis of Air Quality Policies in Seoul City"



Reference: Seoul Policy Archive

Figure 3. Air Quality Pollution Monitoring Station Locations

2. Background Information

Korea has achieved and undergone periods of rapid industrialization and urbanization since 1960s and this has been reflected in the almost incomparable economic growth it has also demonstrated. At the same time, the air quality of urban and industrial areas has deteriorated. More specifically, urban areas which have recorded rapid growth in terms of population have also seen increases in heating fuel consumption and automobile use; these have resulted in an increasing volume of air pollutants generated. Moreover, the situation is worsening by the day.

Air pollution in Korean metropolises continued to deteriorate over time and finally reached a point at which it couldn’t be overloooked; therefore, various actions were required to improve such a situation. The Environmental Conservation Act was enacted in 1978, and the Environmental Office was created in 1980. A number of actions and policies began to be considered.

Seoul Metropolitan Government (SMG) also went forward to improve air quality by expanding the provision of low sulfur fuel and other clean fuels, or by attaching purifiers to automobiles. However, the density of 1st pollutants exceeded general air environment standards.

To check Seoul's air quality and analyze pollution, air quality had to be measured at several locations at the same time. Therefore, SMG installed the automatic air quality pollution monitoring network. The city started to measure air quality in real-time. An air pollution alert system has been created to provide forecasts and warn the citizens so as to protect their health as the air quality can have a considerable impact. Moreover, the measured air pollution statistics

are used in various ways, such as analyzing to evaluate air pollution prevention policies, evaluations to understand whether the environmental standards have been met, providing information for forecast models or air pollution trend analysis.11

Air quality pollution monitoring stations are located in various areas around Seoul which are said to best represent each area's specific and idiosyncratic characteristic. The monitoring stations automatically measure air quality 24 hours a day. These results are then sent to the Seoul Public Health and Environment Research Institute, and released to the general public and citizens of the city through its website. The measured values are sent to SMG and the Ministry of Environment after a thorough search process. In order to secure trustworthy values, only the statistics that have achieved more than 75% measured values during the designated period are considered to be valid.12

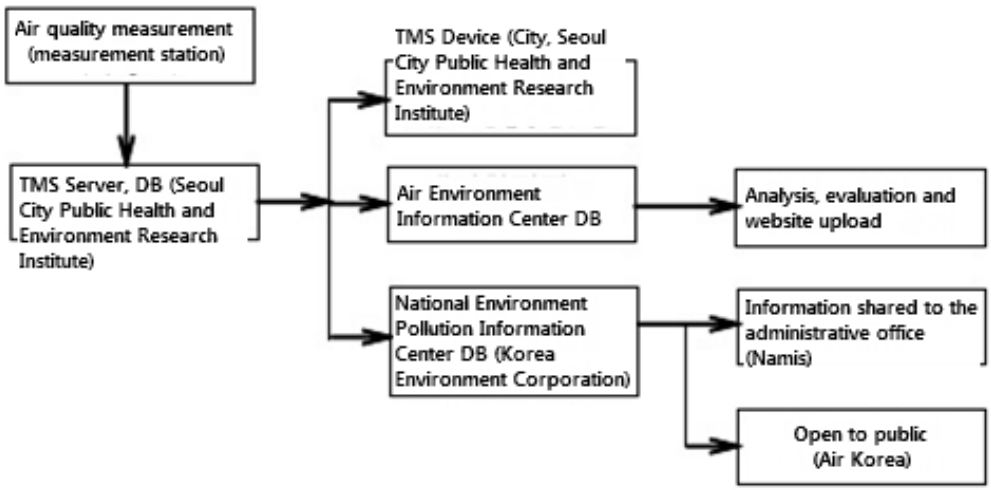


Figure 4. SMG's Air Quality Pollution Statistics Management System

3. The Importance of the Policy

The aim of a constant watch on air pollution had been about understanding the daily, monthly and seasonal changes, evaluating if the environmental standards have been met, and understanding long term change trends. However, the air pollution real-time monitoring statistics are being used as part of a forecast warning system to protect citizens' health, as part of the plans to protect the environment, the evaluation of environmental impacts, city planning, and traffic planning. The statistics are being used as important data for evaluation before and after policy planning. [13]

[11] Seoul Institute, 1994, "Efficiencies for Air Quality Monitoring Method"

[12] Seoul City. "2014 Air Quality Evaluation Report"

[13] Seoul City, 2015, "2014 White Paper of Environment"

SMG began installing and operating monitoring stations starting from late 1970s, in order to watch air pollutants and track the density changes in air pollutant. In the 1980s, semiautomatic monitoring facilities were mostly used to observe pollutants. Starting from the late 1990s, semiautomatic stations closed and now automatic facilities are mainly being used.

In the 1990s, secondary pollutants such as acid rain, ozone, or photochemical smog became a new issue for air pollution. The stations were then categorized into two types: standard air quality monitoring network or special air quality monitoring station, with "2000s Air Quality Monitoring Network Plans." The plans are modified every 5 years after then, reflecting new needs for air quality monitoring. Other than the standard materials, monitoring networks are added for environmentally important pollutants in order to more successfully develop air quality monitoring.[14]

4. Policy Objectives[15]

Through "2011-2015 Air Quality Monitoring Network Operation Plan," SMG adjusted operating system of the monitoring networks' according to the measured pollutants and size of the stations. Thus, the overall management was able to become more systematic and efficient.

The major overall direction is to automatically operate general networks without human resources so the general, special and comprehensive networks can be operated more efficiently. For comprehensive stations, there must be multiple facilities placed in the same location, and the facilities must be able to measure more than 2 pollutants.

Air pollutant concentration monitoring stations are operated for the better understanding of the air quality of the major areas, component analysis, and to find the causes of the pollutants. The stations include in-depth monitoring and research functions.

Moreover, SMG is strengthening its management on harmful pollutants such as PM2.5 or mercury. The networks have been expanded to include both density monitoring networks and component monitoring networks for PM2.5. This is to secure base materials to help decide policy directions and evaluate whether or not the material has reached environmental standards, as PM2.5 was finally included as part of the environmental standard elements in 2015. Also, previous pollutant monitoring elements have been adjusted to enable mercury monitoring, since the material requires management and regulations. SMG has installed a total of 4 mercury monitoring facilities in 2015. To strengthen harmful heavy metal monitoring, the city has included fine dust in sampling collection at the heavy metal monitoring stations and added arsenic and beryllium.

[14] Ministry of Environment, 2009, "Research for Readjustment Re-establishment of Air Pollution Monitoring Network Plans"

[15] Ministry of Environment, 2010, "2011-2015 Air Pollution Monitoring Network Operation Plan"

5. Relevance with Other Policies

SMG provides measured air pollution monitoring information to the citizens through various media channels such as the Seoul Air Environment Information (http://cleanair.seoul.go.kr), YTN weather or Mobile Seoul. This is to protect citizens' health and promote the awareness of environmental preservation, taking the role of both promoting the city's policies and that of an environmental watcher.[16]

Figure 5. Seoul Air Environment Information Service Website

The Seoul Air Quality Information Service shows air pollution on a map for each district and with quality levels represented by color. People are able to sort the results for each monitoring station, area, pollutant types and duration of time.

Air Pollution Status	Good	Ordinary	Bad	Very Bad
Color	Blue	Green	Yellow	Red

Moreover, as well as protecting citizens' health and minimizing danger to the living environment, the data is being utilized for forecasting and warning of air pollutants (finedust, ozone), as well as being used as a much larger basic data to better understand air pollution and

[16] Seoul City, 2015, "2014 White Paper of Environment"

to build air quality improvement policies.[17]

1) Fine Dust Forecast ·Warning System

Air pollution materials obtained from air pollution monitoring stations are used for air pollution warnings and the forecasting system in order to protect the citizens' health. The fine dust forecast is designed to inform the citizens when high density levels are expected. The warning is to measure the statistics in real-time and notify the citizens quickly when air pollution reaches serious levels. The system aims to protect the citizens, especially those with respiratory diseases, children or elderly citizens that are more sensitive to air pollution.

The microdust forecast and warning system is based on the rapid increase of automobiles, and the influx of high-density microdust from China. The system is to promote citizens' participation by notifying them how to act at such times, and then recommend the use of public transportation. Companies that emit such pollutants can also shorten their operation.

Air pollution forecasts are divided into 5 levels: good, ordinary, slightly bad, bad, and very bad. Forecasts are provided at 6 p.m. the previous day and 7 a.m. on the same day.

Table 3. Fine Dust Forecast System in Korea and Guide for Citizens

Category		Alert Level for Fine Dust Density (㎍/㎥)				
		Good	Ordinary	Slightly Bad	Bad	Very Bad
Forecast Material	PM_{10}	0~30	31~80	81~120	121~200	Higher than 201
	$PM_{2.5}$	0~15	16~50	51~75	76~100	Higher than 101
Action Guide	Sensitive Group	-	Outdoor activity with caution, according to health conditions	Refrain from prolonged hard outdoor activity	Refrain from hard outdoor activity (People with respiratory disease, heart disease, elderly citizens)	Restrict outdoor activity
	General Citizen	-	-		Refrain from prolonged hard outdoor activity	Refrain from outdoor activity

*Permissible Level of Fine dust PM_{10} : 24 hours 100㎍/㎥, annual 50㎍/㎥, $PM_{2.5}$: 24 hours 50㎍/㎥, annual 25㎍/㎥

*Sensitive Group: Children, elderly, adult with respiratory or heart disease

[17] Seoul Development Institute, 2008, "Study on Approaches to Effectively Link Traffic and Air Pollution Monitoring Data"

When the forecast is worse than 'slightly bad,' hospitals and senior citizen centers are notified. The elderly, children, and people with respiratory diseases are warned against outdoor activities or exercise. When it is higher than 'bad', citizens are warned against using automobiles and microdust generating businesses are encouraged to adjust their operation. When it is higher than 'very bad,' the superintendent is notified so as to protect children and students' health. They are warned against outdoor classes, and recommended to shorten school hours or have a day off.

Table 4. Details of FineDust Alert System in Korea

Target Material	Alert Level	On Standard	Off Standard
PM_{10}	Watch	Considering the weather factors, when automatic monitoring station's hourly PM_{10} density is higher than 150㎍/㎥ for more than 2 hours.	Considering the weather factors in areas that already have 'watch' signal, when automatic monitoring station's hourly PM_{10} density is lower than 100㎍/㎥.
	Warning	Considering the weather factors, when automatic monitoring station's hourly PM_{10} density is higher than 300㎍/㎥ for more than 2 hours.	Considering the weather factors in areas that already have 'watch' signal, when automatic monitoring station's hourly PM_{10} density is lower than 150㎍/㎥, then 'warning' changes to 'watch'.
$PM_{2.5}$	Watch	Considering the weather factors, when automatic monitoring station's hourly $PM_{2.5}$ density is higher than 90㎍/㎥ for more than 2 hours.	Considering the weather factors in areas that already have 'watch' signal, when automatic monitoring station's hourly $PM_{2.5}$ density is lower than 50㎍/㎥.
	Warning	Considering the weather factors, when automatic monitoring station's hourly $PM_{2.5}$ density is higher than 180㎍/㎥ for more than 2 hours.	Considering the weather factors in areas that already have 'watch' signal, when automatic monitoring station's hourly $PM_{2.5}$ density is lower than 90㎍/㎥ then 'warning' changes to 'watch'.

When real-time statistics at the air quality monitoring network shows a higher density than the standard, watch and warning signals are sent to recommend citizens against outdoor activities or classes. The schools are encouraged to take a day off. Citizens are also encouraged against using automobiles. Dust-generating businesses are advised to stop operating, and the roads are cleaned with water.

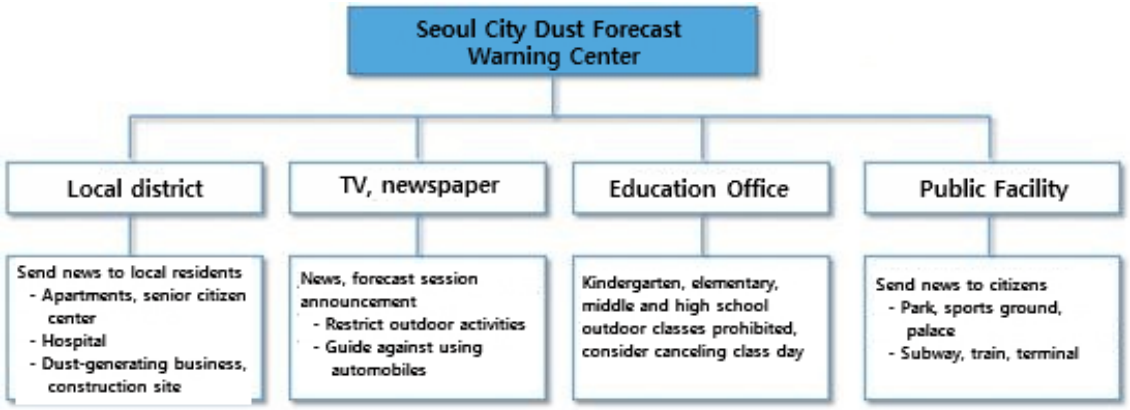


Figure 6. Seoul Fine Dust Forecast · Warning Dissemination System

When the microdust forecast is 'bad' or 'very bad,' SMG recommends against outdoor activities for children, the elderly, or people with respiratory disease. When outdoor activity is unavoidable, citizens are encouraged to wear hygienic masks, and use the 'Neighborhood Air Quality' mobile application to get updates on microdust statistics. Moreover, the citizens are encouraged to use public transportation such as buses or subways whenever possible, to reduce microdust generation.

Fine Dust Watch	Microdust Warning
• Sensitive group is recommended to restrict outdoor activity and stay indoors • General public is recommended to limit prolonged or intense outdoor activity (especially when there is pain in eyes, cough or sore throat) • In case of outdoor activity, wear yellow dust (protective) mask (for people with lung disease, consult with doctor before using) • Try not to go to areas with large traffic • Limit outdoor classes at kindergarten and elementary school • Restrict public outdoor sports facilities • Guide to restrict intense outdoor activities to citizens at park, sports facility, palace, terminal, train and subway	• For sensitive group, prohibit outdoor activity (consult with doctor before going outside) • For general public, restrict prolonged or intense outdoor activity (stay indoors if experiencing cough or sore throat) • In case of outdoor activity, wear yellow dust (protective) mask • Do not go to areas with large traffic • Prohibit outdoor classes at kindergarten and elementary school, shorten school hours or cancel class day • Limit outdoor classes at middle and high school • Stop operating public outdoor sports facilities • Guide to limit intense outdoor activities to citizens at park, sports facility, palace, terminal, train and subway

Figure 7. Guide for Citizens under Microdust Watch or Warning

Neighborhood Air Quality Mobile App '

Figure 8. Neighborhood Air Quality Mobile App

When microdust forecasts levels are higher than 'bad' (81μg/㎥), the citizens are recommended to follow the guides as shown in <Figure 9>

Figure 9. Rules for Citizen's Health when Microdust Density is High

2) Downtown Thermal Image released on the web[18]

Since February 2009, the temperature of Seoul's downtown area has been measured in real-time at the Jongrogu air pollution monitoring station with a thermo-graphic camera. The measured thermal image of the downtown is released to the public at the Seoul City Air Environment Information (http://cleanair.seoul.go.kr). Based on the Jongrogu air pollution monitoring station, the temperatures in 5 directions (Namsan, Dongdaemun, Jonggak, Gyeongbokgung, Bukhansan) are measured every 10 minutes. The results are displayed in colored images, starting from white to blue, so that the temperature can be understood at a glance.

Large cities like Seoul demonstrate a thermal island effect which means the downtown area shows higher temperatures than other part of the city. Surface temperatures of buildings could

[18] Seoul City, 2015, "2014 White Paper of Environment"

increase up to 59℃ (August 8 2014), which is about a 30℃ difference from the highest temperature, 30.3℃. This thermal island effect is due to the changed surface heat balance of buildings and roads, the increase of automobiles and fuel use that generates heat, the increase of air pollutants, and the greenhouse effect from pollutants covering the city's atmosphere, and skyscrapers that prevent the wind from blowing.

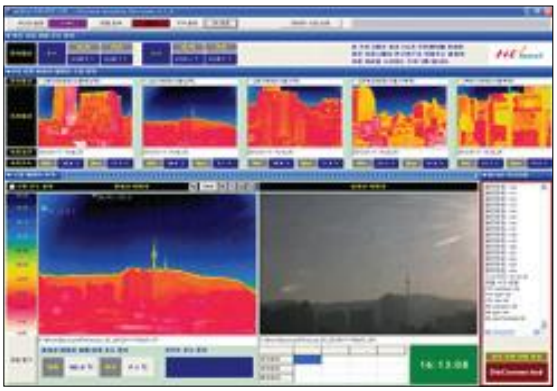


Figure 10. Display Status of City's Thermal Image

Figure 11. Jongrogu Station's Thermo-graphic Camera

3) The Operation of Seoul Ozone Forecast · Warning System [19]

SMG commenced the ozone warning system in May 1st 1995, which was the first of its kind in Korea. The city operates an ozone forecast and warning system from May 1st to September 15th every year to minimize its impact on the human body or the living environment. On the previous day, the information is sent via SMS at 6 p.m. and uploaded to the environmental information website. The same-day forecast is sent in the same manner at 9 a.m.

[19] Seoul City, 2015, "2014 White Paper of Environment"

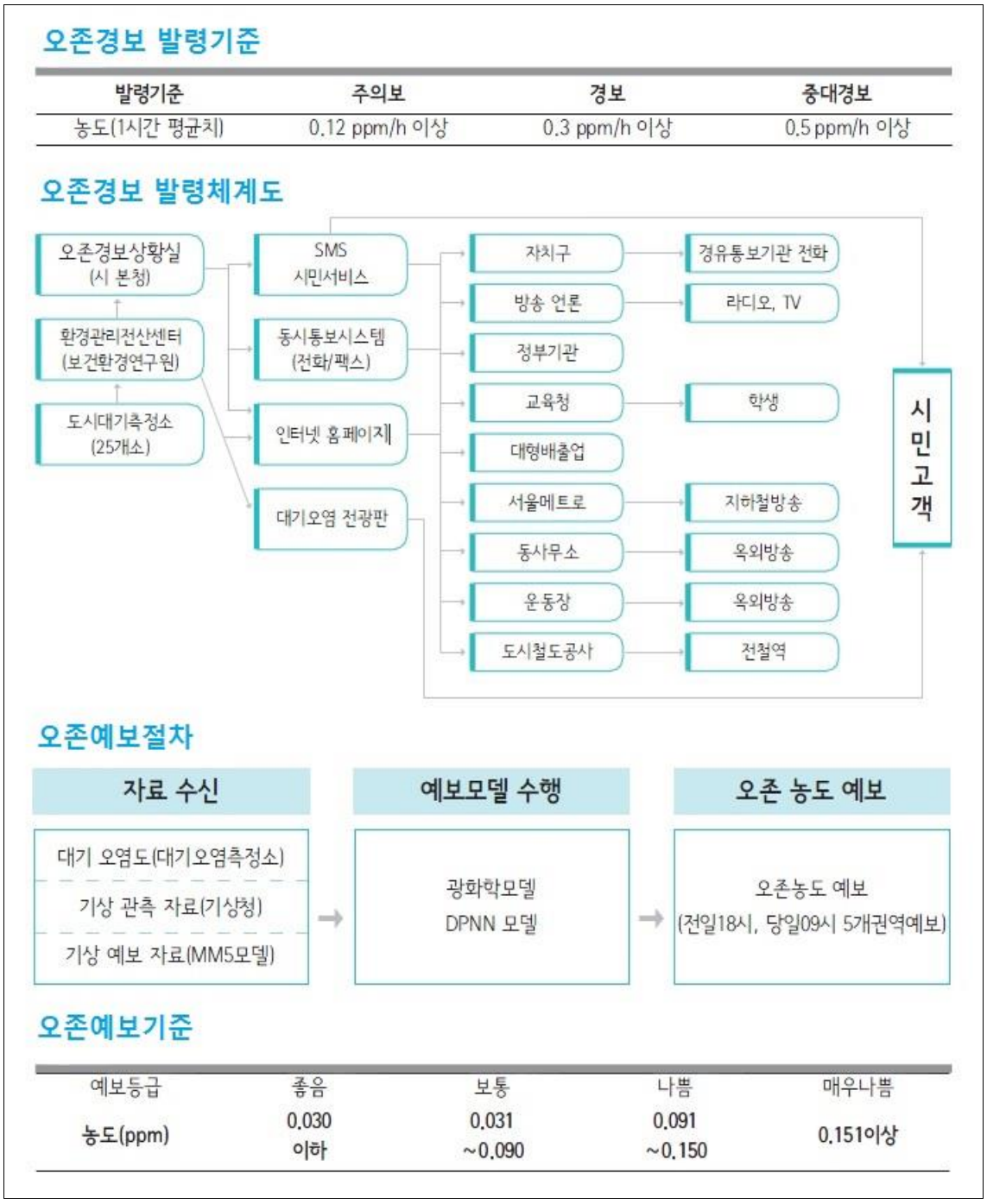


Figure 12. Seoul Ozone Forecast · Warning System Standard and Operation System

The ozone forecast and warning system included central areas since 2011 has categorized the city into 5 regions: central, northeast, northwest, southwest and southeast. When the ozone warning is on, the air environment information electronic board and SMG's commercial electronic board, broadcast media and the internet are used to inform the citizens. The elderly are warned against outdoor activities, and the citizens are encouraged to use public transportation.

4) Air Pollution Information Electronic Display Board (13 locations)[20]

Seoul City has been operating the Banpo and Seongsu Air Pollution Information Electronic Display Board since December 1992, and took over the operation of the Air Pollution Information Electronic Display Board of the SMG and Munrae from May 1993. The display board of the SMG and Munrae were originally installed and operated by the Ministry of Environment. The Air Pollution Information Electronic Display Board utilizes the statistics gained from automatic monitoring networks to display air quality information in various numbers so as to protect the citizens and promote awareness about the environment. It also promotes environmental policies and serves as environmental watcher.

Density of designated pollutants are displayed in real-time, including [sulfurous acid gas (SO2), nitrogen dioxide (NO2), ozone (O3,), microdust (PM10), ultrafine particles (PM2.5), carbon monoxide (CO)]. Environment-related promotions and guides for citizens regarding ozone or microdust warnings are also displayed.

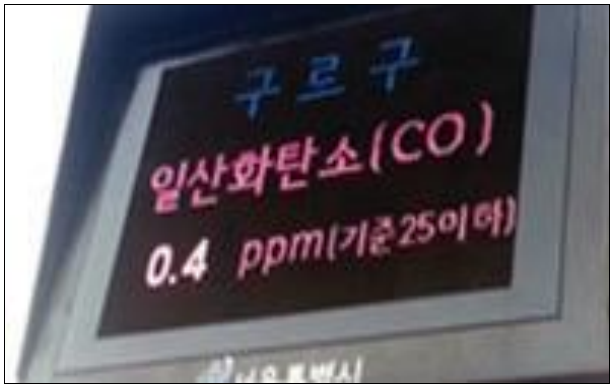


Figure 13. Air Environment Information Electronic Display Example

5) N Seoul Tower Lighting Microdust Information Service

SMG also informs pollution levels with Namsan Seoul Tower's lighting, so the citizens are able to be informed and stay up-to-date quickly and easily. Beginning in May 2011, the tower's light is blue when the air quality is good, and red when the air quality is bad. Different colors are displayed according to the condition. The service starts after sunset, until 10 p.m. (until 11 p.m. for April to September). Recently, SMG changed its standard of 'good air day' to PM2.5 from PM10 starting from 2015 February. This is since the SMG declared its intention to reduce ultrafine particles by 20% by 2018.

[20] Seoul City, 2015, “2014 White Paper of Environment”

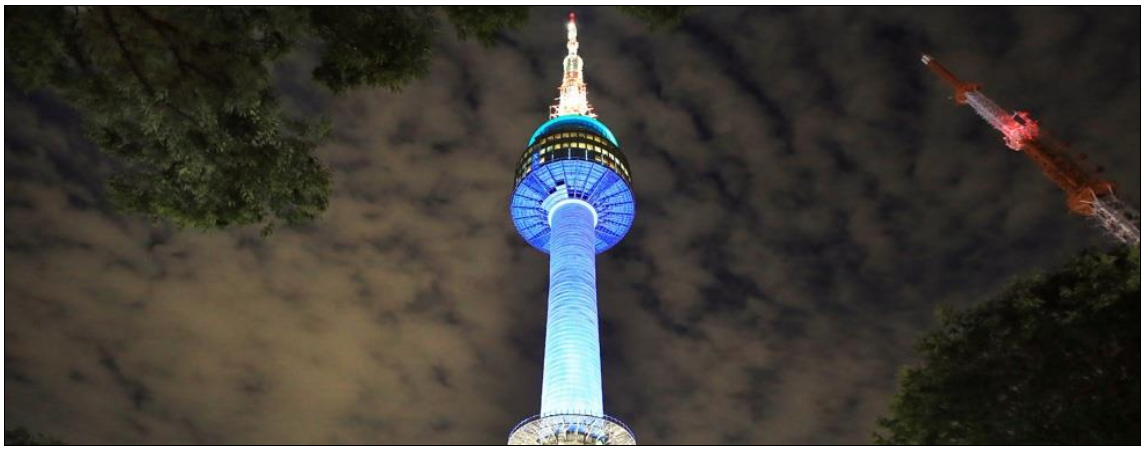


Figure 14. N Seoul Tower Informing Microdust Levelwith Lighting Color

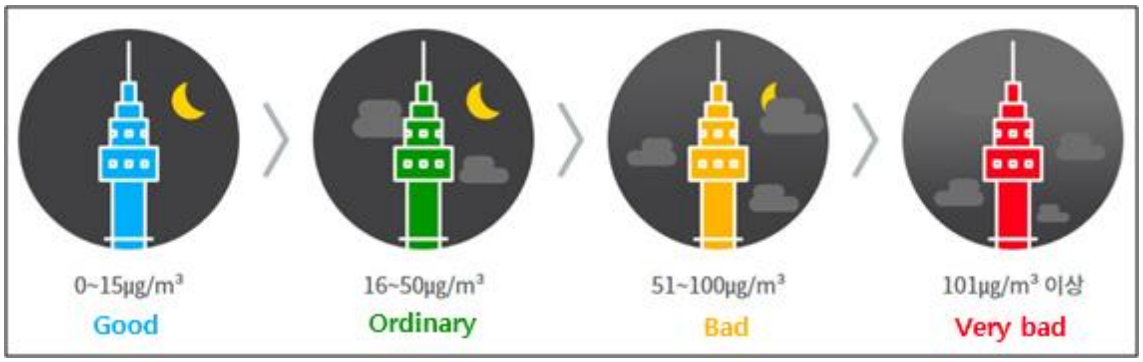


Figure 15. 4 Fine Dust Level and the color of Seoul N Tower Lighting

6. Main Policy Contents[21,22]

From the 1990s, SMG has continuously sought the improvement in monitoring network through 3 plans: 2 basic ones by the Ministry of Environment's air pollution monitoring network operation plans, and additional operation plans. The number of monitoring stations increased rapidly while the system was being organized. The city started with 4 stations in 1973, and as of 2015, there are now 45 stations.

1) City Air Quality Monitoring Network

The stations are operated to measure highly populated areas' air pollution level or whether the

[21] Seoul City, 2014, "2014 Seoul Air Quality Evaluation Report"

[22] Seoul Policy Archive, 2015, "Air Pollution Monitoring Network Management: Real-time Air Quality Monitoring System Construction for Citizen's Health

statistics met environment standards. This is to be utilized for both improving the air quality or policymaking. Each city monitoring station checks 10 basic elements – SO2, CO, NOx, PM10, PM2.5, O3, wind direction, wind speed, temperature, and humidity.

According to the Installation and Operation Manual of the Air Quality Monitoring Network (2006), city air monitoring stations are to be installed at "locations where the average air quality can be checked, while not directly affected by major pollutant generator." The location is selected at a place that can best represent the area, and where there are no buildings, trees or plants that block the facilities. In situations in which there are buildings, plants or trees around the station, a sampling station must be located where the distance to the object is more than twice the height of object, or where the straight line that connects the sample port and the top of the object is less than 30° to the horizontal line. When buildings are concentrated in the area, a sampling station should be installed at least 1.5m away from building surfaces. The sampling station's height must be within 1.5~10m, and where the representative value of the area can be obtained.

Seoul's air monitoring station is located in across Seoul at approximately 5km away from each other according to TM coordinate system. They are located away from major roads so that major pollutant generators (automobiles) cannot directly affect the statistics. Generally, they are located on top of community centers or public offices.23

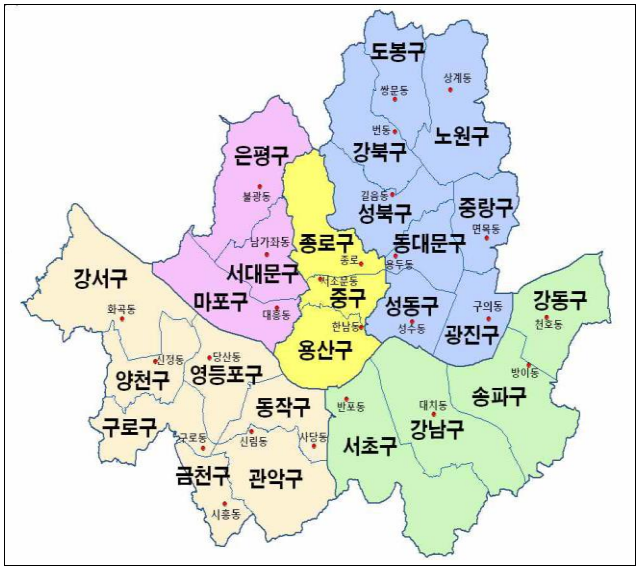


Figure 16. City Air Qualityn Monitoring Network Locations

[23] Seoul Development Institute, 2008, "Study on Approaches to Effectively Link Traffic and Air Pollution Monitoring Data"

2) Road-side Air Quality Monitoring Network[24]

Road-side stations are located in places on roads that have the largest amount of traffic in Seoul, so as to monitor components of exhaust fumes. There are 14 monitoring networks installed. SMG's 14 stations collect pollutants from the roadside air from automatic monitoring facilities. The collected data is then used to evaluate roadside air pollution and the impact on the environment. The materials are used as the main basis for policies for Seoul's roadside air quality. There are 10 stations at street-side, 2 at exclusive car lanes, and 2 at median strip.

The road-side stations measure 17~20 elementsincluding sulfurous acid gas. There are 13 air pollutants (NO, NO2, NOX, O3, CO, CH4, n-CH4, THC, SO2, TSP, PM10, PM2.5, EC/OC), 6 weather factors (wind direction, wind speed, temperature, humidity, UV radiation, solar radiation) and the amount of traffic. The statistics are sent in real-time to the Electronic Control Center of the Seoul Metropolitan Government Research Institute of Public Health and Environment, the Seoul Metropolitan GovernmentWeather and Environment Center, the National Institute of Environmental Research of the Ministry of Environment and Gyeongin Regional Environmental Office.

Figure 17. Road-side Monitoring Station
Figure 18. Exclusive Car Lane Monitoring Station
Figure 19. Median Strip Monitoring Station

3) Heavy Metal Monitoring Network

Heavy metal monitoring networks are operated to measure heavy metal densityto understand environmental impact, or to come up with policy to control harmful heavy metal. The stations measure the density of heavy metals, such as lead (Pb), cadmium (Cd), and chrome (Cr).

Mercury is measured every 24 hours by automatic facilities at Guro, Bangi, Nowon and Hannam. Heavy metals in the air can be discharged from various locations, both artificial and natural. Usually, they are attached to dust and stay in the air. Even small amounts can harm the human body.

Samples are collected every second week of the month (24 hours), and every day during the yellow dust season. A High Volume Air Sampler is used to collect sampling, and starting from January 2013, the sampling method has changed from TSP to PM10.

[24] Seoul City, 2015, “2014 White Paper of Environment”

During regular investigation, a total of 19 elements are measured: lead (Pb), cadmium (Cd), chrome (Cr), copper (Cu), manganese (Mn), iron (Fe), nickel (Ni), arsenic (As), and beryllium (Be). During the yellow dust season, aluminum (Al), calcium (Ca), magnecium (Mg) are added to the regular list. Inductive coupling plasma emission spectroscopy is used as the analysis method.

4) Mercury Monitoring Network

Mercury is the only liquid metal at room temperature, and it is accumulated through earth, water and air. In particular, air is a very important means for the material. More than 98% of mercury in the atmosphere is gas, which circulates around the earth, accumulates and reacts when it enters the ecosystem. It is very important to monitor mercury in real-time.

SMG is monitoring mercury level in the air at 4 stations, and the measured values are used as the basis for related policies.

Figure 20. In-air Mercury Monitoring Network Locations

5) Acid Deposition Monitoring Network

Acid deposition refers to all the materials that fall from the atmosphere to the ground. Acid deposition can be divided into two types: wet deposition and dry deposition. Wet deposition includes acid rain, snow or fog. Dry deposition includes particle material PM2.5, gas material NO2, and ion SO42-. They fall to the ground from their aerosol status due to gravity.

The representative form of wet deposition is acid rain, and it is when the rain's pH is less than 5.6. Acid rain is created from sulfur oxides or nitrogenous compound reactions, and it is a long-distance pollutant as it can impact large areas. Acid rain can damage buildings, bridges and other important structures. And after prolonged exposure, children and elderly may suffer skin conditions. It damages the ecosystem because the acid rain inhibits water absorption of plantsand decomposition of organic materials, and pollutes the water.

SMG has been operating 10 acid deposition monitoring stations for monitoring from 1985 up

until the present day. The station also analyzes ion composition, the major determinant of pH of acid rain and acidity of precipitation. The statistics are used for related policies. Currently, 8 stations other than clean areas (Bukhansan and Bangi) are located in residential areas. Bukhansan station is operated as the background monitoring station.25

Figure 21. The Location of SMG's Acid Rain Monitoring Stations

6) Photochemical Pollutant Monitoring Network

Large cities including Seoul record high population density and traffic, resulting in high density of ozone or nitrogen dioxide. Most of the ground-level ozone is created by photochemical reactions between nitrogenous compounds and Volatile Organic Compounds (VOCs). Therefore, it is very important to control nitrogen dioxide and VOCs, as a precursor, in order to control ozone density. VOCs are discharged from contamination sources, which creates secondary aerosol through photochemical reactions, increases the ozone density, leading to the increases in the cases of high density ozone and ozone 'watch' notifications.

Because of this, SMG has established 10 photochemical stations, and has measured elements every hour. This is done so as to monitor harmful VOCs, and to gain basic data to prepare effective policies.

Currently there are 5 VOCs stations (Gangseo, Gwangjin, Guro, Jongro, Bukhansan) and 5 BTEX stations (Songpa, Jungrang, Dongjak, Haengju, Segok) for continuous monitoring.26

[25] Seoul City, 2015, "2014 White Paper of Environment"

[26] Seoul City, 2015, "2014 White Paper of Environment"

Figure 22. Seoul City's Photochemical Pollutant Monitoring Network

7) City Background Quality Monitoring Network

As the Bukhansan monitoring station is located in a clean area, not much affected by pollutants, the from the Bukhansan stations are used to compare with Seoul's air quality. Compared to city air quality, Bukhansan area recorded low annual pollution levels in 2014 for all elements except the ozone. The clean areas show higher O3 density than the city is largely due to the high sunlight penetration ratio, resulting in high solar radiation. Therefore, the NO to NO2 ratio (NO2/NO) is higher than that of the city. Since NO is involved in O3 extinction and NO2 in O3 creation, which is why O3 equilibrium concentration is high in areas like Bukhansan station.

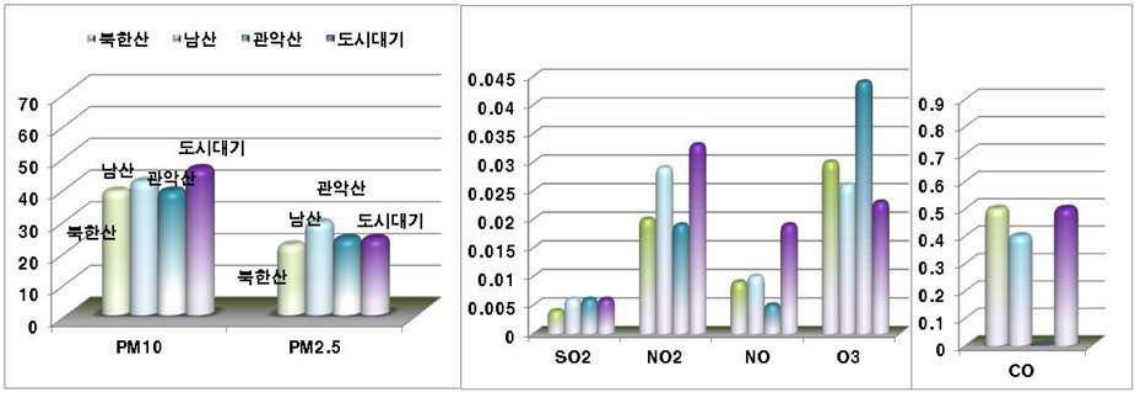


Figure 23. Air Pollution Comparison for Each Monitoring Network (in 2014)

7. Technical Details

The air quality monitoring network mainly checks pollutants such as SO2, NO2, CO, O3, PM10, and PM2.5, and weather factors such as wind direction, speed, temperature, humidity, solar radiation and the UV radiation. The monitoring methods are as follows: Each element is measured once every hour. Fluorescence is used for sulfurous acid gas (SO2), non-dispersive infrared methods for carbon monoxide, the ultra-violate photometric method for the ozone and the gravimetric method for microdust. The materials are used for evaluating air pollution or

designing air quality improvement plan.

Figure 24. Collection and Distribution System of Air Quality Data
Source: http;//env.seoul.go.kr

As for deciding the locations for pollutants sampling, there are various ways: a)calculating population and density, b)a TM coordinate system that creates grid for each a 2-3 kilometers and selects a point in each area, c)using a center of an area and straight lines in each direction to select crossing points as station, or d) using a formula according to pollution level of target areas.

Figure 25. Analytic Device within Air Quality Monitoring Station
Source: Seoul Development Institute. 2008. "Study on Approaches to Effectively Link Traffic and Air Pollution Monitoring Data"

In order to increase the accuracy of the monitoring networks, as well as contribute to the effective operation, SMG selects, installs and operates monitoring stations at locations that could offer the area's representative datawhile reflecting the environmental elements, population distribution, and distances between stations so the operation, repair and access is carried out most efficiently. Moreover, equpments within the monitoring station are placed a certain distance away from one another to minimize mutual interference.

When the location of a monitoring station is considered to be inappropriate or the station's building is being removed, the station should also be relocated. New locations are decided within the closest possible distance from the original place. The final location is decided after considering the opinions of the evaluation group of the air pollution monitoring network.

8. Policy Effects

SMG can secure basic data including cause analysis needed to come up with measure to improve air quality and understand the trends of air quality elements such as microdust, ultrafine particles or nitrogen dioxide, based on the constructed air quality monitoring system. Based on the collected material, SMG protects citizens' health by forecasting or warning the level or density of microdust, yellow dust and the ozone. Automatically collected data on air

pollution are uploaded and released in real-time on the website or its mobile applications of the Air Environment Information. This is to improve the transparency of administration, and meet the citizens' right to be informed.

SMG has been operating the microdust forecast and warning system since February 2005, according to the Ordinance on the Microdust Forecast and Warning. Moreover, the city has also been operating the ultrafine particle (PM2.5) warning system since October 2013, contributing to the protection of citizens' health.

Fine dust forecasts in 2014 showed a high accuracy rate of 70.5%: 68.5% for for the forecast made a day before, and 72.6% for the forecast made for the day. Microdust forecasts are provided to related organizations such as local governments, police, the Office of Education, and citizens who wish to receive the information via SMSs (text message). There were 2 microdust watches, 6 ultrafine particle watches, and 14 (preliminary) watches released in 201427.

9. Challenges and Solutions

Air pollution monitoring stations installed in Korea have contributed greatly to our understanding of domestic air pollution, and the creation of air quality improvement plans. SMG’s monitoring stations are installed in a more concentrated fashion compared to other areas, and this is playing an important role in evaluating air pollution policies and preparing future plans.

There are various challenges in terms of securing locations for air pollution monitoring networks due to the characteristics of Seoul as metropolis. Since the stations are mainly installed on top of public offices or schools, it is questionable whether the statistics truly and accurately reflect the area's air quality. Some stations are blocked by large apartment complexes or commercial buildings.

For this, alternative locations must be found, and mobile air monitoring vehicles can also monitor air quality for certain durations and then the station can be moved after reliable results are obtained from alternative locations.

Moreover, there have been efforts have been made to measure harmful carcinogenic pollutants, albeit low density. Strenuous efforts are made to establish relevant policies and implement them to secure various monitoring elements and to accurately evaluate the impact of the pollutants on the citizen’s health and to enhance the reliability of the stations.

[27] Seoul City, 2015, “2014 White Paper of Environment”

Nanjido Ecological Park

Jae Min Song, University of Seoul[28]

1. Timeline

Nanjido was the only large waste landfill of Seoul to bury approx. 92 million ㎥ of domestic, construction, and industrial wastes for 15 years from 1978 to 1992. In the 1970s, Seoul experienced rapid economic and exponential population growth. As the result, waste levels sharply increased forcing the city to designate the location around Nanjido (540, Seongsan-dong, Mapo-gu, Seoul) as an urban planning facility in 1978: "Waste Disposal Facility". Nanjido was a perfect landfill site for Seoul because of its accessibility, location on the outskirts and vast size. Horizontal burying was performed from 1978 to 1985 while vertical burying was performed at the primary and secondary landfills from 1986 to 1992.

Figure 1. Vehicles heading for Nanjido on the Jayuro
(source : http://worldcuppark.seoul.go.kr)

But the insanitary burying caused leachate during the entire burying period which led to serious land and water pollution. The landfill gas was also prone to catching fire at times. The

[28] Translation by ESL®

environmental arrangement of the landfill was politically highlighted in 1990. The basic master plan of the 'Seoul, Capitalization 600 Yyears-old capital city project' was established in 1992 for the strategic development of Yeouido, Yongsan, Sangam, Tukseom, and the Magok area. A special urban development plan was prepared for Sangam, where Nanjido was located, reflecting that it was a gateway of both globalization and the unification of the South and North as the key area of Northwestern Seoul. In addition, there was a need to fix the local environment in order to build a world-cup stadium following the decision to build the 2002 Korea-Japan World-Cup stadium in Sangam in May, 1998. Moreover, the 'New Seoul, Our Han River' project that included the basic millennium park plan of Seoul in 1999 also included the Nanjido landfill stabilization and park construction plans.

The Nanjido landfill stabilization and park construction plans were quickly implemented for the World Cup. The landfill stabilization project was initiated in January, 1998 and finished in October, 2002 after 4 years and 10 months. The construction company was selected and started work within 3 months of finishing the design so as to shorten the construction period. An ecological park was also constructed from October, 2000 to June, 2002 alongside the stabilization project (KSP, 2014). The waste buried under Nanjido is still being biodegraded, and Seoul estimates that the stabilization will continue until 2020.

2. Situation: Background

'Nanji' of Nanjido is a combination of orchied (Nan) and gromwell (Jichi) meaning extreme beauty. Indeed, it was a beautiful island where peanuts and sorghum were grown and a place that students visited for picnics despite the frequent floods. However, Seoul buried about 20,000 tons of waste in Nanjido following its designation as a waste landfill site as well as a solid waste handling area in 1977. With the 15 years of landfill, about 9,200 million tons of waste was piled up in mountainous forms of around 812,800 pyeong (about 246,303 m2). It was originally planned to use Nanjido as a landfill for a mere 6 years from 1978 to 1984 considering the extent of the work done there. But it was difficult to find an alternative, so most of the waste of Seoul was dumped there and Nanjido eventually had a 100m high mountain of waste standing on it.

Figure 2. Geumseongpyeongsa in Geyonggyomyeongseungcheop: Gyeomjae Jeongseon 1676-1759

(Source: http://worldcuppark.seoul.go.kr)

Nanjido landfill was operated in typically insanitary ways – without any solution for gas generation, leachate, flying waste, or the harmful insects. The excessive volume of waste caused many problems. More importantly, the insanitary operation caused land, water, and air pollution with the leachate and landfill gas while the unplanned and excessive landfill caused safety issues including ground subsidence and slope collapse. The leachate had very high Biological Oxygen Demand (BOD) of 72mg/l, Chemical Oxygen Demand (COD) of 605mg/l, and Total Nitrogen (T-N) of 1,416mg/l, which can have adverse effects on neighboring streams, The Han River is connected to the streams, and this underground water is directly connected to the health of citizens. The landfill gas generated by the waste degradation process is mainly composed of greenhouse gases such as methane and carbon dioxide; the former is very flammable and explosive so Nanjido experienced several fire accidents. At the same time, unbalanced subsidence during the degradation and the massive weight of the waste layers gradually removed space so the leachate level and possibility of slope collapse increased. In addition, the waste trucks caused serious pollution including dust and noise.

Figure 3. Nanjido Landfill
Source: World-cup Park Management Office (2006) Nanjido recovers the scent)

Besides the environmental issues, the Nanjido landfill caused social issues. The Nanjido landfill was a living foundation for the urban poor who made their living with goods found from the waste. They suffered from the odors, dust, insects, birds, and air pollutants from the trucks every day. They also lived in very poor brick housing around the waste piles provided by the Seoul City Government. In a word, they were exposed to risks of environment, health, and safety.

Figure 4. Nanjido people collecting waste

(Source: http://worldcuppark.seoul.go.kr)

From the end of 1992, Seoul began to dump its waste at the Sudokown Landfill and finally stopped using Nanjido from 1994. Nanjido had been used as Seoul landfill for 15 years from 1978 to 1993. But the environmental issues of landfill did not suddenly disappear. As the landfill ceased, social issues appeared – including jobs and housing for the urban poor. Furthermore, Seoul had to discuss how to use the once-landfill land. Academia and various industries had different ideas regarding the early development and long-term development following the stabilization of Nanjido. The 'Early Development' was to relocate the buried waste to coastal landfill sites or other locations and then redevelop it as a housing or business site. On the other hand, the 'Long-term Development following Stabilization' was to develop it in the long term when the conditions were established after installing pollution prevention facilities for landfill gas and leachate, stabilizing the land, and finally building an environmental and ecological park on the ground. After analyzing the different aspects, Seoul decided "to maintain the current situation and postpone the development while preventing environmental pollution and stabilizing it."

3. The Importance of the Policy

The Nanjido Ecological Park Development policy has had a positive role in the eco-friendly management of Seoul in many aspects.

Firstly, the Nanjido Stabilization project was a case in which Seoul took the lead in managing the waste landfill instead of the central government. In 1993, when the Nanjido landfill had ceased being used, there were no follow-up management regulations in Korea. Post-landfill management regulations were found in the Waste Management Act in 1996 for the first time in Korea focusing on "establishing engineering solutions for appropriate follow-up management of landfills to be closed after 1998 and obliging environmental management for over 20 years." In 2010, the follow-up management regulations were reinforced to extend the follow-up environment management period to 30 years. Nanjido stopped being used for the burial of waste in 1993 so it was not subject to those regulations. However, Seoul predicted political changes of sustainable waste management in Korea and overseas countries and preemptively opted for landfill stabilization and thus creating a good example of post-landfill management.

Secondly, the Nanjido Ecological Park is connected to surrounding green areas and an ecology stream for self-sustainable recovery of the ecological functions. The Nanjido Ecological Park meets the Han River, Bulkwang Stream, Hongje Stream, and Hyangdong Stream while the grass fields on their watersides is connected to that of Nanjido Ecological Park. Even though Seoul is not home to much in the way of artificial features or design, except for some food plants and improvement of the habitat around the Nanjido park, the number of animals and plants have increased around the surrounding ecological space after developing the park.

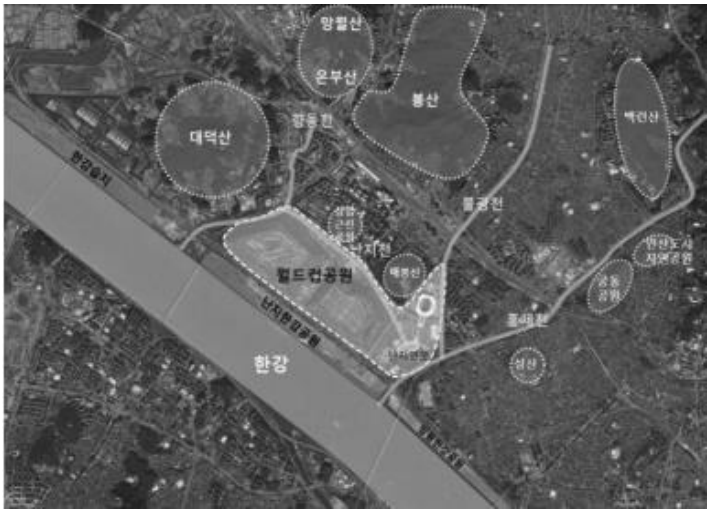


Figure 5. Green field and streams around Nanjido Ecological Park
Source: Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park")

Thirdly, the landfill gas obtained as part of the stabilization is used for district heating contributions to the 'resource cycling' city development policy of Seoul. Methane is one of the most valuable fuels, and about 232,572K ㎥ of landfill gas had been used at the Nanjido Ecological Park from 2002 to December, 2013, which amounts to about 8.2 billion KRW of economic value. The collected landfill gas is supplied to a district heating facility located in the Nanjido Ecological Park. The park has an incineration facility (capacity of 750 tons) for handling the domestic waste of neighbors while the heat is collected and then supplied to the district heating facility. It is a unique and rare occurrence to have landfill gas collection, domestic waste incineration, and district heating facilities all in one ecological park.

Figure 6. Mapo Resource Recollection Facility
(Source: https://seoulsolution.kr)

Fourthly, the awareness of citizens regarding waste management has changed as the abandoned landfill has been transformed into a park. The Nanjido landfill site was constantly negatively seen as a source of both environmental pollution and odor. But the waste handling facility was

transformed into a resting place for citizens, which is now widely known as a shining example of excellent representative environment management on the part of Seoul.

4. Relevance with Other Policies

The Nanjido Ecological Park project was connected with the Sangam New Millennium Town project and New Han River Development projects.

1) Sangam New Millennium Town Project

Sangam New Millenium Town Project was a plan focused on developing the Sangam district from 1998 to 2000. It contained long-term plans to shape Sangam as a future city as well as a new sub-center of Seoul. The first phase connects the Nanjido landfill stabilization and re-development with surrounding facilities and development plans. The slogans and ideas behind the plan include ‘Gateway City for reunified Korea’, ‘Information City for 21st century’, and ‘Eco City for coexistence of humans and the environment’. The objectives included planned development for transfer station construction and sphere development of the Gyeongui line, Yeongjongdo New Airport Railway, and Subway Line No.6; scenario developments and stage plan settings for the Nanjido landfill stabilization and future use; establishment of organization plans aligned with the city development for a successful World Cup; suggestion of ecological city design guidelines for Samgam Millennium City; and planned responses to high-speed trains.

Figure 7. Sangam New Millennium Town and Nanjido Ecological Park

(Source: https://seoulsolution.kr/)

Additionally, the land was divided into various sections (Digital Media City, an eco-friendly housing complex, and World-cup Park) to help shape Sangam as a new city combining downtown functions, distribution, housing, with parks and green fields.

2) New Han River Development

This project aimed at developing a space for the coexistence of humans and the environment: where the Han River is made fascinating with water purification, ecosystem recovery, and leisure facilities for citizens and tourists alike. Located along the Han River, the Nanjido Ecological Park was developed for landscape and water quality improvement of the Han River. The Nanji-Han River Park is the second biggest park around the Han River and provides natural purification and leisure to the citizens using the wetland developed for 2002 World Cup. For the New Han River Development, the framework plans were developed in the first half of 1999 and it got underway in 2000 with the addition and maintenance of facilities, preservation and recovery of historic sites as well as the development and promotion of green fields.

5. Policy Objectives

The millennium park framework plan for the Nanjido Ecological Park development consisted of the following political objectives: (1) to recreate the landfill as an eco-friendly space; (2) to shape the surroundings of the 2002 World Cup stadium; and (3) to contribute to developing an eco-friendly city with the open space and park functions of the Sangam New Millennium Town Arrangement project.

Nanjido, however, raised different issues – including air and water pollution, odor, harmful insects, and safety for the surroundings as an insanitary landfill for 15 years. As addressed before, discussions took place to relocate the waste and use the land for new purposes, or stabilize the waste and avoid its short-term use for the future. Finally though, a decision was made to build the Nanjido Ecological Park. By developing the ecological park, the abandoned land was recycled as an eco-friendly space for the new millennium suggesting future-oriented environmental alternatives and representing proud cultural characteristics.

The second political objective was to improve the surroundings of the Sangam World-cup Stadium by developing the Nanjido Ecological Park. Korea was selected as a host for the 2002 World Cup and Sangam was the site for main World-cup stadium in Seoul. But the surroundings were poor. It was vital to address the mountains of waste at the Nanjido landfill site, polluted streams, and housing for the poor. So, the ecological park development project was responsible for the large-scale environment rearrangements for the surroundings.

Thirdly, Seoul tried to transform Sangam into an eco-friendly town in order to to address the rapidly increasing demand for housing in the 1990s. Seoul actively developed housing sites because of the increasing demand for development and housing in the 1990s. Sangam was no= exception as it had detached houses, settlements, and faming land. Thus, it was planned to build housing to transform Sangam into a sub-center while developing a large park in Nanjido to improve the life quality of citizens and build the Sangam New Millennium Town as an eco-friendly city serving as a supporting green field.

6. Main Policy Contents

Seoul concentrated its full organizational capabilities so as to finish the Nanjido Ecological Park Development project before the World Cup. To shorten the project period, 8 projects - landfill stabilization. Pyeonghwa Park, Haneul Park, greening of surroundings, Heemang Forest, Noeul Park, Nanjicheon Park, and Najni Han River Park - were carried out at the same time. 6 departments of Seoul were engaged in the design while 5 departments took part in order placement and supervision. Moreover, many private businesses participated: 9 designers, 23 constructors, and 6 supervisors.

The Nanjido Ecological Park development consists of the landfill stabilization and park development and cost 232.2 billion KRW (140.5 billion KRW for the stabilization and 82.7 billion KRW for the park development). The expenditures were covered with the general funds of Seoul.

Mayor
- Primary Deputy Mayer
- Secondary Deputy Mayor

New 100 Year Preparation Committee

Seoul Institute (Planning & Design)

Landfill stabilization	Pyeonghwa Park development	Haneul Park development	Slope greening & Heemang Forest development	Noeul Park development	Nanjicheon Park development	Nanji-Han River development
Designed by: Waste Facility Department Ordered by: Construction Safety Management Headquarters	Designed by: Park Green Field Project Office, Han River Project Planning Group Ordered by: Park Green Field Project Office	Designed by: Landscaping Department Ordered by: Park Green Field Project Office	Designed by: Landscaping Department Ordered by: Park Green Field Project Office	Designed by: Landscaping Department Ordered by: Landscaping Department	Designed by: City Development Corporation Ordered by: Park Department, City Development Corporation	Designed by: Construction Safety Headquarters Ordered by: Construction Safety Headquarters
Designed by: 1 supplier Supervised by: 1 supplier Constructed by: 2 suppliers	Designed by: 2 suppliers Supervised by: 2 suppliers Constructed by: 4 suppliers	Designed by: 3 suppliers Supervised by: 1 supplier Constructed by: 4 suppliers	Designed by: 3 suppliers Supervised by: 1 supplier Constructed by: 3 suppliers	Designed by: 1 supplier Supervised by: 1 supplier Constructed by: 1 supplier	Designed by: 1 supplier Constructed by: 3 suppliers	Designed by: 2 suppliers Supervised by: 1 supplier Constructed by: 5 suppliers
Advice from experts	Advice from experts	Advice from experts	Advice from experts	Advice from experts	Advice from experts	Advice from experts

Figure 8. Organization for Nanjido Ecological Park Development project
Source: Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"

1) Nanjido stabilization

With the landfill finished, Nanjido is expected to be stabilized until 2020. The landfill stabilization is a process in which the organic matter is degraded for a long time and discharged as landfill gases or leachate; inorganic matter and heavy metals are leachated with the ground subsiding. Finally, it returns to its original state. The insanitary landfill was carried out for a long time so Nanjido produced leachate, odord, and harmful gases resulting in water and ground pollution around the Han River and thus serious destruction of the local ecosystem. The Nanjido stabilization aimed at addressing the environmental pollution and preparing for eco-friendly park development. The stabilization consists of leachate handling by installing barrier walls for the leachate, top molding processes to develop grass fields; gas collection and handling; and slope stabilization to prevent collapse by adjusting its incline and developing the area for the return of green space.

2) Ecological park development

The Nanjido Ecological Park has 5 parks - Pyeonghwa Park, Nanjicheon Park, Haneul Park of Landfill No.1, Noeul Park of Landfill No.2, and Nanji-Han River Park - covering approximately 1.05 million pyeong (about 318.182 m2). They were designed to be integrated and organized while having independent characteristics. The planning concept was the ‘Mutual Coexistence and Symbiosis’ for the coexistence of nature and human culture; a symbiotic relationship between environment preservation and human development, and a harmony of artificial structures and natural landscapes. In addition, the drainage and earthwork plans were reflected to prepare for the subsidence of landfill layers and observe them.

Figure 9. Bird’s-eye view of Nanjido Ecological Park
Source: http://worldcuppark.seoul.go.kr

3) Sustainable waste management

Along with the Nanjido Ecological Park development, the Mapo Resources Recollection Facility was built between the Noeul Park and Haneul Park. It is an incineration facility that handles 750 tons of domestic waste daily from Mapo, Yongsan, and Junggu. It was built from June, 2000 to December, 2003. The Nanjido Ecological Park came to have comprehensive resource recycling functions with the newly-built resources recollection facility, district heating facility, leachate treatment plant, and landfill gas collecting facility. In addition, the resources recollection facility is serving as an environmental education space by operating site visit programs for citizens and designing symbolical building for the futuristic ecological city.

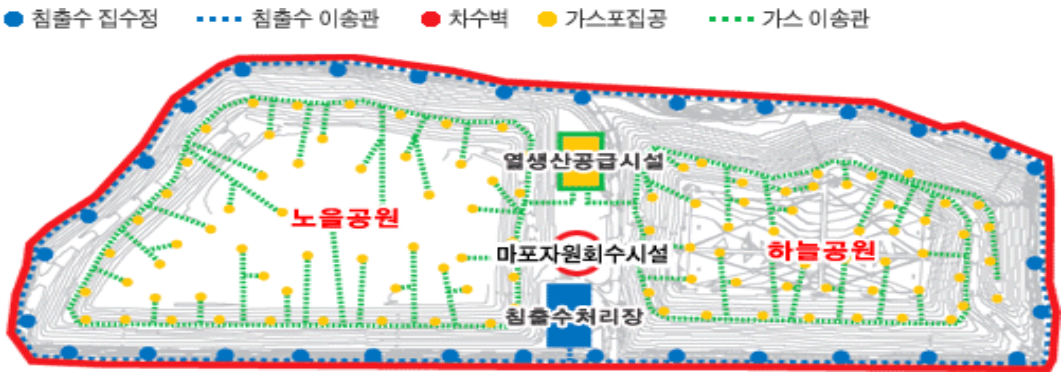
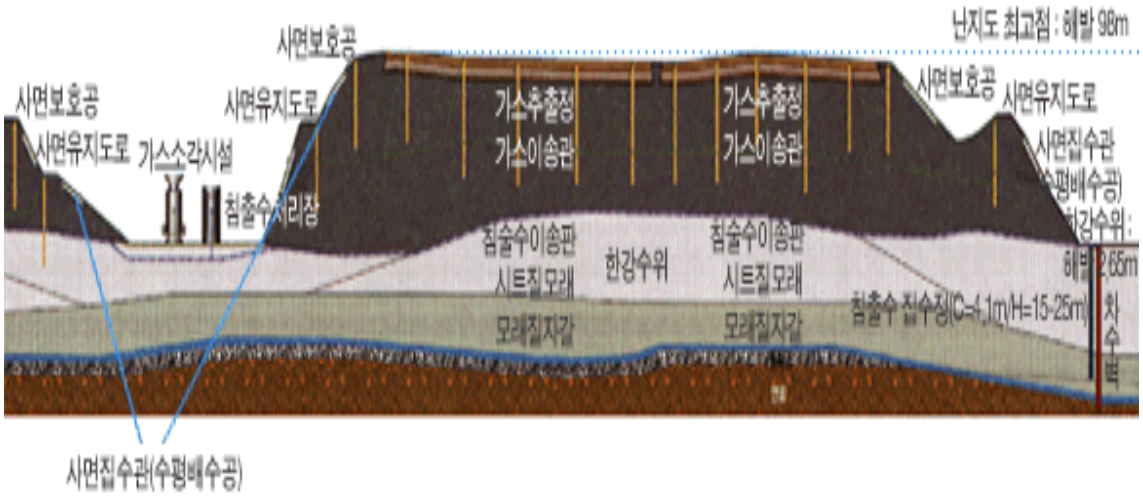


Figure 10. Resources collecting and related facilities
Source: http://worldcuppark.seoul.go.kr

7. Technical Details

The Nanjido ecology recovery project consists of landfill stabilization and ecological park development.

1) Stabilization



The stabilization aims at isolating the waste accumulated for 15 years and thus restoring the surrounding environment. The stabilization consists of barrier wall installation and leachate processing to prevent water pollution, landfill gas collection and processing, stabilization of the slope, and top molding for grass fields.

The leachate facility has intercepting and processing equipment. The intercepting equipment (barrier walls and collecting wells) isolates the leachate and keeps stable levels of leachate in the landfill to prevent collapse of the slope. 31 horizontal-drainage collecting wells were installed to 3m depth of the bottom layer with the Caisson method. This method is especially good with underground water level control and low costs. The barrier wall isolates the leachate and was installed at a depth of 19-48m at 6,235m distance by combining the S.S.P Wall and C.B.S Wall. The leachate is stored in the collecting wells; from there it is sent to the leachate treatment station and the Nanji Sewage Treatment Plan using pumps. Finally, it is discharged into the Han River.

The landfill gas produced with the biodegradation of waste is collected and then processed. The average production of Nanjido landfill gas is 432KNm³/day, which is mainly composed of methane (51%) and carbon dioxide (46%). To prevent odor diffusion and any risk of explosion of landfill gases, the top of landfill was covered with a blocking layer. The landfill gas processing collects and processes harmful gases in a safe manner and provides habitats for plants. The reflected collection of landfill gas was 300Nm³/min through 55 and 51 vertical collecting wells installed at 120m intervals on both the top and slope, respectively. The gas is collected at the landfill gas processing facility for district heating while the remaining is burnt. The landfill gas collecting and processing facilities are managed by the Korea District Heating Corporation.

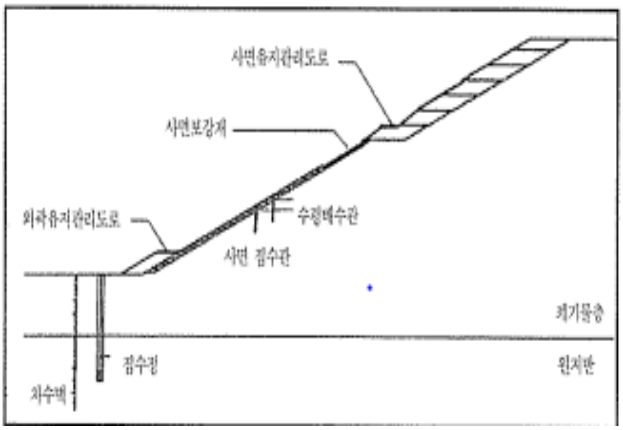


Figure 10. Design concept of slop stabilizing facility for Nanjido Landfill Stabilization
Source: Yeong Kuk Lim, 2006, Nanjido Landfill Stabilization

The slope stabilization is to prevent its collapse while minimizing rainwater penetration. Any slope with a inclination under 1:2 was maintained while those over 1:2 were adjusted with a 9m protection installed. The maintenance stage performs continuous slope inspection, waterway repairing, and maintenance to prevent slope loss. Lawn and Leafy lespedeza was planted on any

vegetation-vulnerable slope for better stability. Any potentially collapsing slope was covered with tent fabrics to prevent further damage from occurring. Additionally, regular safety inspections were performed biennially by external experts, including professional engineers.

The top arranging and molding work installed water shields (HDPE) to prevent rainwater penetration and covered the top with earth to encourage the growth of plants. The molding consists of a 50cm supporting layer, 1.5mm shield layer (HDPE), a 30cm drainage layer, filtering felt, a 30cm vegetation layer, and a 30cm surface layer in the order to create a 1.4m depth on average. The top is arranged to have an approximately 4% slope to easily avoid rainwater and encourage plant growth. The future subsidence was estimated with the hyperbolic method of the Gibson &Lo Model and Power Creep Law and then reflected on the top arranging and molding. Maximum subsidence was estimated in the center by over 3.6m for 20 years.

Table 1. Details of Nanjido Ecological Park project

Classification	Project details
A. Top arranging and molding	
1) Purpose	·Top: Minimized rainwater penetration and thus leachate production, prevention of surface gas leakage, and vegetation ·Slope: Maintenance of currently stable slopes while recovering vegetation and installing protection on surrounding sections and banking around the outskirts and slope maintenance roads
2) Arranged inclination on top	·About 4% of arranged inclination for good rainwater avoidance
3) Cross section of top molding layer	·Top molding layer (1.4m): Surface (30cm), vegetation (30cm), drainage (protection, 30cm), blocking (HDPE 1.5mm), and supporting (50cm) layers ·Dynamic compaction for landfill gas collecting well, pipelines, and roads
B. Blocking of leachate	
1) Purpose	·To prevent diffused leachate pollution in the adjacent Nanji Stream, Bulkwang Stream, Han River, and others
2)Installation section & method	·Barrier walls were fully-installed around the landfill with Coment Bentonite Slurry Wall and Steel Sheet Pile.
3)Installation depth & distance	·Depth: Penetration of 1m and 0.5m into weathered rock and soft rock, respectively ·Distance: 6,235m (S.S.P : 3,320m, C.B.S : 2,915m)
C. Intercepting and processing of leachate	
1) Purpose	·Optimized intercepting and processing of leachate from the slope and foundations
2) Slope collecting facility	·Slope collecting pipe: 6,003m, MAT type pipe: 3,622m ·Horizontal drain: 667 holes

3) Intercepting facility	·Horizontal draining type collecting well: 31 points, Horizontal strainer: 9,300m (186 holes)
4) Transfer facility	·Non-pressure flow pipe (MDPE): 5,186m, Forced flow pipe (PEM): 2,035m ·Intermediate pumping station: 3 points
5) Processing facility	· On-demand pretreatment and then transfer to Nanji Sewage Treatment Station for the separate processing ·Process: Flow Control+Collection & Precipitation+Penton Oxidation ·Capacity: 1,860 tons/day
Classification	Project details
D. Collection and processing of produced gas	
1) Purpose	·Collecting and processing of gas (375N㎥/min) produced during degradation of wastes
2) Collecting facility	·Extracting well: 106 points
3) Transfer facility	·Transfer pipe (HDPE): 13,250m
4) Processing facility	·Blower: 5 EA
E. Slope stabilization	
1) Purpose	·To prevent collapse of slopes and minimize rainwater penetration
2) Horizontal drain facility	·Length: 9m , Installation: 667 points
F. Sewage sludge processing	
1) Purpose	·To eliminate hazards by processing and disposing the landfill sludge (565,882㎥) and thus increase the recycling and land utilization
2) Method	·Banking material for landfill bottom arrangement: 202,210㎥ ·Utilization of sludge-mixed earth and sand as molding material: 16,890㎥ -Supporting layer: 91,570㎥ -Vegetation layer: 77,320㎥ (top+slope) ·Soil-like: 194,700㎥

Source: Yeong Kuk Lim, 2006, “Nanjido Landfill Stabilization”

2) Ecological park project

① Pyeonghwa Park

The Pyeonghwa Park was built on a plane surface, which had an area of 440,000㎡, between the World-up Stadium and Gangbukgangbyeon-ro, at an altitude of 10-15m altitude on a 10m-high waste pile. Its concept is the peace that is related to the Mutual Coexistence and Symbiosis theme of the World Cup Park. It was specifically designed to reflect the themes of global harmony and peace kept in mind for the World Cup. The Pyeonghwa Park was designed by the

Han River Project Planning Group, and was working-designed and constructed by the World Cup Park Project Group, Park Green Field Management Office. It consists of the UNICEF Square, Nanji Pond, Pyeonghwa Garden, Picnic Square, and Nanjido Story (Exhibited in World-cup Park). The waterside trail was developed on the water's edge using a 50cm-high wood deck. Water was brought from the Han River to the Nanji Pond in the center with cattails, baby lotuses, water lilies, scouring rush, and Russian irises planted for water purification.

Figure 13. Framework plan for Pyeonghwa Park
Source: http://www.lafent.com

② Haneul Park

This grass field park consists of a 190,000㎡ area on Landfill No.2. It has the poorest soil quality of the entire Nanjido Landfill site so it was designed to show how nature can still be reborn on poor land.

The master plan was established by the Master Plan Commission for Millennium Park; the landscaping and working design was performed by Yooshin Corporation Co., Ltd. and Pyeonghwa Engineering Co., Ltd.; the construction was performed by Bando Environment Development Co., Ltd., Imwon Development Co., Ltd., and Dongil Construction Co., Ltd. A total of 25.6 billion KRW was spent on the Haneul Park development. It was built with to a concept of a vast grass field and separated into 4 zones – with the ridge formed for drainage and the high grass field developed in the South-North section and low one in the East-West section. The South-North section had silver grass and the equivalent perennial grass field while the East-West section had mainly wild grass and some naturalized grass fields to demonstrate the stages of succession between them later. The entire area has drainage gradient of 4-8% with the cross management roads. For stabilization, the available vegetation depth was only 60cm on top of the water blocking layer and the ground was unstable so the planting of trees and installation of structures was prevented. Haneul Park has vast grass fields and the Silver Grass Festival is held there every October.

③ Noeul Park

This site was developed with about 340,000㎡ area at the location of Landfill No.1. Initially, there were plans to develop a public golf course with 57% of the area and civil leisure facilities and vegetation area with the rest. This initial plan was put forward but it, ultimately, did not succeed. There was serious disagreement concerning the golf course so the plan was changed to build family and sculpture parks in 2008 and 2009. Currently, it is used as a family park with cafes, playgrounds for children, park golf courses, and a family camping area.

④ Nanjicheon Park

This location was built in the lowlands with a 70-250m width between the waste layer (Haneul and Noeul Parks) and Sangam Area. It had suffered from serious water pollution because of leachate from the Nanjido Landfill. Some of the waste had been buried in the center and the stream was affected severely. The plan, therefore, was to develop the Nanji Stream and park around it in order to show the ecological recovery of the polluted stream and transformation into a natural one.

The Nanjicheon Park was developed for residents in the Sangam New Millennium Town - especially the disabled, old and infirm, and youth. Thus, a lawn picnic field was built sloping down toward the pond with special and natural playgrounds using natural materials and topography. The trail and stepping stones were installed around the pond so that family visitors can have the opportunity to study the wetland ecology. Furthermore, the Nanjicheon Park has sports and game facilities for the residents. It caters especially for the disabled and old, with sports facilites arranged in small groups along the road in the forest to alleviate desolateness. Curved trails were installed between the sports facilities and stream to improve accessibility to the stream's edge and different types of wild plants.

⑤ Nanji-Han River Park

This is the second biggest park among the 13 Han River parks. The Nanji-Han River Park is a neighborhood park for the recreation of residents offering sports and game facilities, picnic places, and trails and required functions for the smooth operation of the World Cup. Considering the site conditions, the land use plan of the Nanji-Han River Park was divided into a dock, camping, central square, sports facilities, and waterside ecological park zones.

Figure 14. Pyeonghwa Park
Source: http://worldcuppark.seoul.go.kr

Figure 15. Haneul Park
Source: http://www.lafent.com

Figure 16. Noeul Park
Source: http://worldcuppark.seoul.go.kr

Figure 17. Nanjicheon Park
Source: http://worldcuppark.seoul.go.kr

Figure 18. Nanji-Han River Park
Source: http://hangang.seoul.go.kr/archives/3021

8.Policy Effects

1) Environmental effects

After the ecological park development project, the ecosystem and surroundings of Nanjido have considerably improved. Over 1 million trees and herbaceous plants have been planted. It was reported that there were 89 types of 24 families of plants in 1994, which is only 1 year after the last landfill had taken place. Within 3 years, grass and trees had covered the slopes of the waste piles and the plant species had extended to 271 types of 60 families compared to 1994. These continuously extended to 502 types of 95 families until 2010. The plant species were naturally extended with different types of naturalized plants. Naturalized plants were brought in and adapted to the poor environment during the landfilling so 50% of naturalized plants in Korea were found there. This formed a very unique and notable ecosystem. Currently, only 22% of naturalized species have survived because of succession. The inhabitation of birds, insects, amphibians, fishes, and mammals has also increased. Before the park was developed, 167 types of animals had been reported to live there; this was increased to 731 types after the Nanjido Ecological Park was developed, which is a sign of healthy ecology. A continuing increasing number of birds inhabit the Han River, Nanji Pond, Nanji Stream, and mountains. It was also found that endangered species are now living there: narrow-mouthed toads and wildcats.

Figure 19. Narrow-mouthed toads found in the Nanjido
Source: http://worldcuppark.seoul.go.kr

Figure 20. Acacia flows found in the Nanjido
Source: http://worldcuppark.seoul.go.kr

Moreover, the Nanjido Ecological Park development contributed greatly to improved biodiversity and water quality. Seoul investigates the environment around the Mapo Resources Recollection Facility at 3 year intervals. These have shown that all environmental criteria are met for the air quality, noise, water quality, and soil. There are no residents around the Mapo Resources Recollection Facility so the investigation range is extended to a 2km radius, which includes the entire Nanjido Ecological Park.

2) Economic effects

The stabilization and park development created economic effects through the landfill gas collection and housing site developments. The Nanjido Ecological Park installed landfill gas collecting wells on the top and slope of Haneul Park and Noeul Park and connected pipeline to collect it. This is then used as boiler fuel at the Korea District Heating Corporation. From 2002 to 2013, a total of 232,592,000m3 of landfill gas had been used for boilers amounting to 6.86 million KRW of annual savings. The Korea District Heating Corporation processes the landfill gas for heating the World-cup Stadium, neighboring apartments, and office buildings. The landfill gas production is decreasing as the landfill is stabilized.

The surroundings of Nanjido were left undeveloped before the World-cup Park was developed because there of odor and environmental pollution and thus the demand for housing was low. However, the surrounding ecosystem and environment were considerably improved with the ecological park development and Digital Media City plans and this resulted in increased land prices. The competition rate of subscription was very high for the Sangam Housing Site Development Zone in 1999 with a land price of 900,000 KRW per 1㎡ in 1996 increased to 1,200.000 KRW to 1,500,000 in 1999. This was aided by the announcement thatthe Sangam area would be transformed into a special housing area (21C New Seoul Town) with leisure, shopping, and cultural facilities, Nanjido Ecological Park and water park, as well as different types of amenities and sports facilities. The housing site development area was 1,450,000 ㎡, which exceeded the side of one of most popular districts, Yongin & Suji District (1,350,000 ㎡).

3) Sociocultural effects

The Nanjido Ecological Park has become a representative eco-friendly project of Seoul and been annually visited by about 9.8 million citizens and foreign visitors. The representative camping ground of Seoul, Noeul Camping Ground was visited by 52,000 people in 2013 compared to only 21,000 people in May, 2010 (the first year) and the continued annual growth is promising. Popularity has increased to the extent that first-come-first-served reservations are often finished in 5 minutes through the Internet. It is also full of visible and enjoyable delights – including park golf, the silkworm ecology experience center, natural playgrounds, the firefly eco center and habitat, and the urban farmers' garden.

Additionally, Seobu Park & Green Field Office, Green City Division, Seoul is operating monthly firefly eco center description programs, silkworm ecology tours, and different programs using natural objects for the citizens to experience the Nanjido Ecological Park. The environment programs are free for children and families, and more families are applying for the

environment experience as eco-friendly education becomes more and more popular.

Table 2. Ecology program of World-cup Park

Program name	Day	Time	Workforce	Subject	Description
Kindergarten Let's play in the forest!	Tue-Thu	10:00-12:00	20	6 to7-year-old groups	✍ To know seasonal changes ✍ To walk in the park the things that disappear in winter ✍ To share the dreams of children
Korean paper experience	Sat-Sun	10:30-11:20 14:00-14:50	20	Families	✍ Explanation of process from paper mulberry to paper ✍ To recognize the importance of Korean paper by making Korean-paper post cards by themselves
Wood handcrafts	Sat-Sun	13:30-14:50 10:30-11:50	20	Families	-To make creative pieces using waste wood ✍ Importance of natural recycling
Firefly description program	Tue-Fri	10:00-12:00 14:00-16:00	20	Anyone	✍ Description about fireflies at the eco center ✍ Description of the ecology of firefly, and observation of larva and imago

Source: http://worldcuppark.seoul.go.kr

The Nanjido Ecological Park draws high attention from other countries. It is an excellent and exemplary landfill recovery and development project. It has been benchmarked by developing countries such as Indonesia and Cambodia, and serves as a stepping stone for Korea to enter environment markets of other countries. Pleasingly, it receives high attention from municipalities of developing countries for the sustainable urban development.

9. Challenges & Solutions

One of the difficulties for the Nanjido Ecological Park project was to find new housing for the urban poor who were living in Nanjido. The waste collecting workplace of Nanjido residents was closed as the Nanjido landfill was closed in May, 1993. However, they wanted the land where they were living to be granted so that they could stay. If they had stayed at the location, the entire ecological park development – including the landfill stabilization and park development – would have been hindered and their safety continually threatened by the mountains of waste as high as 100m. Seoul, therefore, gave purchase rights for permanently rented apartments and private ones to many of about 1,000 households so that they could

populate the region. However, about 400 households refused to move until Nanjido was confirmed as the World Cup site and construction began. The roofs and walls of structures were seriously corroded and catastrophic disaster was more and more likely if the banks of the landfill were to collapse due to heavy rain. Seoul gave them jobs through job placement and job-producing projects and provided rights of residence for rented and sold apartments as well as relocation expenses support to demolish the temporary housing. Meanwhile, 400 employees of 61 waste collecting centers who were living in prefabricated housing complexes were given a chance to move to the Sihwa Industrial Complex while 3 aggregate providers in the northern part of Landfill No.2 were also relocated.

Another challenge of the Nanjido Ecological Park development was the purpose issue of Noeul Park. Noeul Park was originally planned as the Nanji Golf Course. The Korea Sports Promotion Foundation was eventually selected as an investor in March, 2000 so it invested 14.6 billion KRW to develop a 9-hole golf course in Noeul Park and open it in October, 2005. However, the land owner, Seoul City Government and Korea Sports Promotion Foundation had conflicting ideas concerning the operation method and management rights so they undertook legal proceedings. Furthermore, Seoul amended the ordinance to transform the golf course into a park and the Korea Sports Promotion Foundation opened the golf course for free. Finally, Noeul Park was turned into a real park and Seoul compensated the Korea Sports Promotion Foundation with 18.5 billion KRW, including the Nanji Golf Course development expenses. The Korea Sports Promotion Foundation transferred the ownership of the golf course to Seoul. Seoul then spent an additional 4 billion KRW installing new trails, water supplies, drinking fountains, toilets, shade canopies, and benches while trying to retain as much of the lawn field of 9-hole golf course as possible so as to renovate it as a family park and thus invite more visitors.

References

- Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"
- 2002 FIFA World Cup – Details Plan for Environment Improvement Project –Seoul Policy Archive, 2014, "Framework Plan for Millennium Park"
- Environment Preservation Department, World-cup Park Management Office, Seoul; 2006; "Nanjido recovers the scent."
- Yeong Kuk Lim, 2006, "Nanjido Landfill Stabilization"
- Deok Hyeon Cho (2005) Comparative analysis of Namsan Park and World-cup Park: Focusing on construction process and use state, Master's Degree paper of University of Seoul
- Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"
- Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"
- Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"
- Seoul Development Institute, "Framework Plan for Sangam New Millennium New City," 2000
- Seoul City Government, "Framework Plan for Millennium Park," 2000
- Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"
- Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"
- Ministry of Environment (2010) Guideline for Terminated Landfill
- Seoul Institute, 2014, "2014 Economic Development Experience Modularization Project: Recovery of Nanjido Ecological Park"
- Environment Preservation Department, World-cup Park Management Office, Seoul; "Nanjido recovers the scent"; 2006
- Yeong Kuk Lim, 2006, "Nanjido Landfill Stabilization"
- Mapo Resources Recollection Facility, Seoul meets the environment criteria for surrounding, air, noise, water, and soil
- Home page of Seoul Policy Archive, Nanjido Ecological Park Development
- Sang Wook Cho, Maeil Economy, March 19, 1999
- [Our Neighbors] Backwaters of Waste Mountains, Nanjido People Feb.1, 1993
- Nanji Golf Course will be transformed into a family park.

Energy Generating WWTP: From Treatment to Energy Production

Young Jun Choi, Water Research Institute[29]

1. Time of Policy Implementation

New and renewable energy production from WWTPs' of Seoul had been planned and carried out since 2007 based on the treatment conditions and characteristics of each WWTP.

When the new and comprehensive energy policy of Seoul, aka 'One Less Nuclear Power Plant' was launched in 2012, the projects on the energy production in WWTP were incorporated into the new energy policy of Seoul, and carried out more actively using the resources and conditions of the WWTPs.

Project 'One Less Nuclear Power Plant'

The city of Seoul announced that the city will implement the project of 'One Less Nuclear Power Plant' as one of the local energy policies in April 2012. The main purpose of the 'One Less Nuclear Power Plant' project was that the city would have effective and preemptive measurements to mitigate and adopt the impact of climate change and energy crisis such as Fukushima nuclear disaster on March 11, 2011 and national blackout on September 15, 2011 (Yu et al., 2015). Conserving energy and producing new and renewable energy, the city of Seoul can save the energy of 2 million TOE, which is the same amount of energy for a nuclear power plant generate. The goal was achieved 6 month before the end of the project, in June 2014 (Yu et al., 2015).

2nd Phase of 'One Less Nuclear Power Plant' Project

The city of Seoul started the 2nd phase of 'One Less Nuclear Power Plant' project after

[29] Translation by ESL®

successful completion of the 1st phase of the project in 2014. The goal of the 2nd phase of the project is to realize the value of the project by changing the related institutions and structures of energy production and consumption for eco-friendly energy projects. The essential goal of the 2nd phase project of 'One Less Nuclear Power Plant' is energy self-sufficiency of 20% (Figure 1). The energy self-sufficiency which was 4.2% in 2013 will be increased up to 20% in 2020 by 1) new and renewable energy and combined heat and power generation (46%), and improvement of energy efficiency and conservation (54%).

It is required for the city of Seoul to have a fundamental base of self-sufficient energy supply to make a city of 'no-blackout' to be prepared for energy crisis such as the national blackout occurred on September 15, 2011.

The three important approaches are conservation of energy including fossil fuel, distributed production of new and renewable energy, and efficient use of energy.

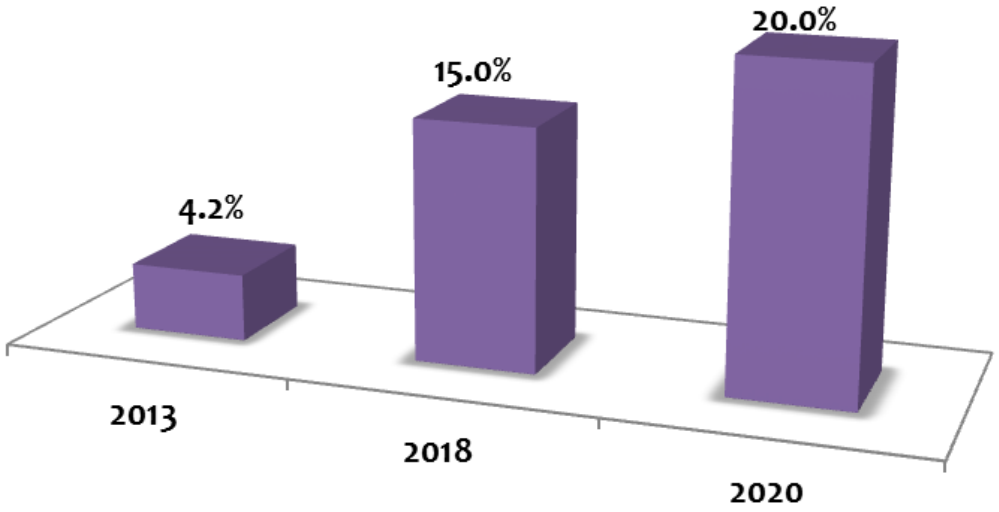


Figure 1. Energy self-sufficiency goal of Seoul (Lee, 2015)

Seoul made a plan to increase energy self-sufficiency of the city. The plan has strategies to change Seoul from energy consuming city to energy producing city. The strategy includes project to transform the structure of the energy producing and supplying system of Seoul, i.e., from large scale centralized system to distributed system. With decreasing power demand of 9,553 GWh, producing new and renewable energy of 2,711 GWh, and producing thermal power generation and combined heat and power generation of 5,444 GWh, the city of Seoul will save and produce energy of total 8,155 GWh by 2020 to achieve the goal of energy self-sufficiency of 20% (Figure 2).

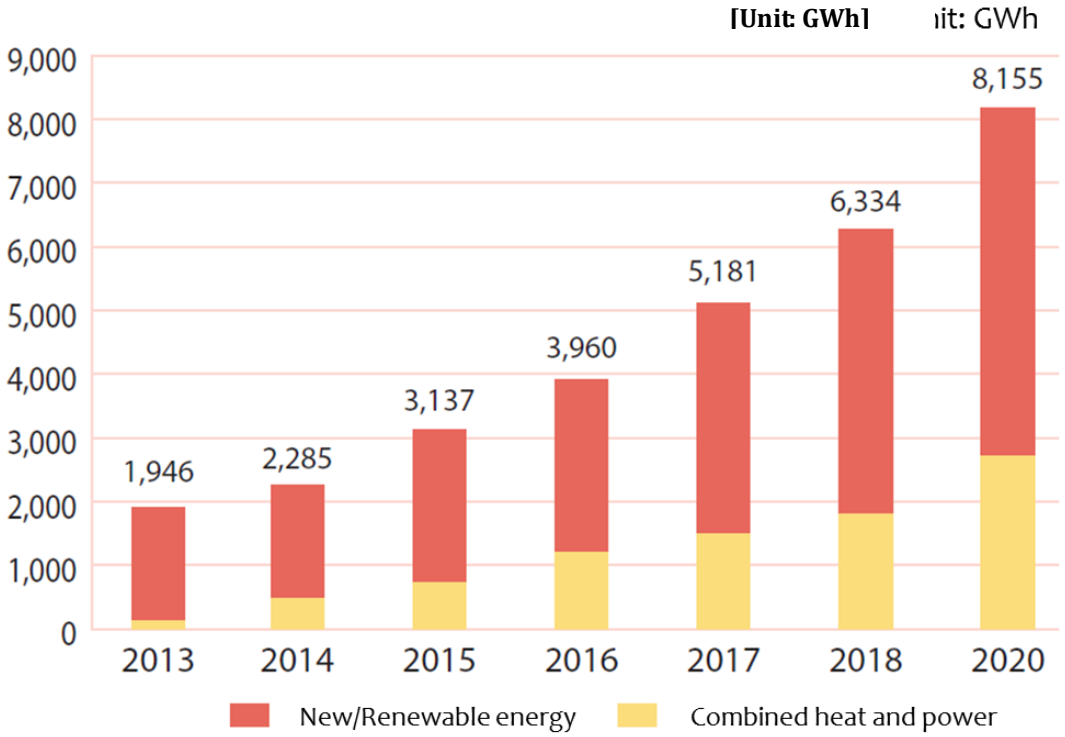


Figure 2. Energy saving and producing in Seoul through the 2nd phase project of 'One Less Nuclear Power Plant' (Lee, 2015)

The WWTPs can contribute much to successful results of the project by producing new and renewable energy such as biogas, small hydropower plant, geothermal, and photovoltaic power generating facilities.

2. Situational Background for Policy Implementation

Sewerage System of Seoul

In the Chosun dynasty (1392 – 1897), wastewater from individual house was collected naturally in the lower land area and on the road, and discharged to streams or infiltrated into underground via ditches. Only the Chung Gye Chun (or Chung Gye stream), the largest stream in Seoul except for the Han river, was dredged and managed periodically (Figure 3). According to history, there was massive dredging and repairing in Chung Gye Chun and Ok Chun to be prepared for flood from the streams in 1412 (Bureau of Water Management, 2009a). There was a record on structures used for basic sewerage system30 in the Shilla dynasty (57 BC – 935 AD). Modern

[30] Remains of the drainage systems and ditches were found in the investigation and excavation of the l ocation of the Yellow Dragon Temple in 1983. It was the evidence to tell that there was a system for w

sewerage system was constructed and operated after 1921. 225 km of sewer lines including the main and the branch sewer were constructed, improved, and maintained until 1943.

The purposes of the sewer system construction and operation at that time were, prevention of urban flood, accumulation of and contamination by wastewater, and treatment of human waste discharged from houses.

Storm water drainage had been added as one of the main functions of the sewer system.

The disposal of human waste was changed from being taken away by hands to being flushed with water due to improvement in life standard and rapid economic growth with urbanization and industrialization. Construction and maintenance of WWTP and sewer system got more interests as the contaminants loads were increased and more of the streams were polluted.

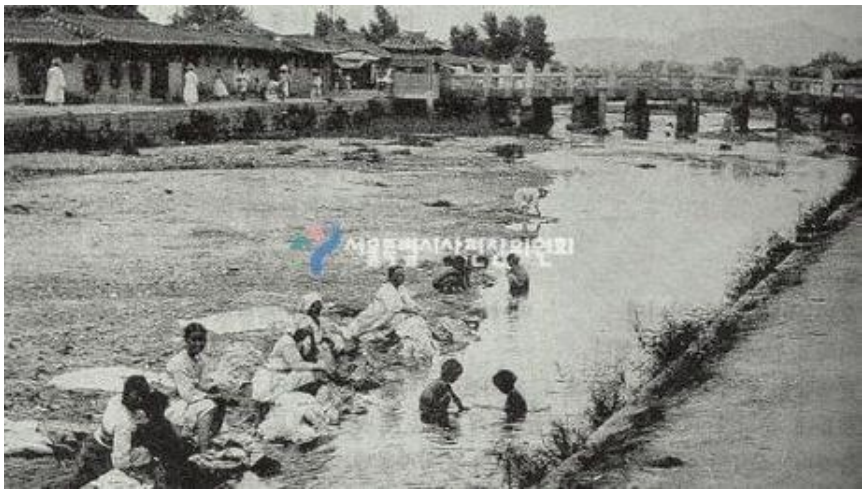


Figure 3. Old Chung Gye Chun31

Ending the Korean War in 1953, massive construction and maintenance of sewer systems had been carried out in order to rehabilitate the city of Seoul since 1954 with various financial aides from international organizations. Huge amount of budget was invested and the 1st phase of the project to cover the top of the Chung Gye Chun in 1959.

An administrative organization to manage the sewerage system of Seoul, Department of Sewerage, Bureau of Water and Wastewater, on March 17, 1959. Laws on sewerage system were enacted in 1966, which is an institutional system for sewerage management.

The city of Seoul made a plan to construct the 1st WWTP in Seoul, Chung Gye Chun WWTP in 1965. The project was carried out with the loan of 350,000 US dollars from AID and the construction of the Chung Gye Chun WWTP with the treatment capacity of 150,000 m3/day was completed in 1976.

Sewerage service was late to drinking water service. The sewerage service rate32 was 27.9% in

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astewater in the Shilla dynasty (BC 47 ~ AD 935) (Bureau of Water Management, 2009a)

31 https://goo.gl/30I2cR

1970 while that of drinking water service was 85.6%. Most of wastewater and storm water flew through the top of the road not the sewer lines. The sanitation condition in Seoul at that time was very poor. Not many people could think that WWTP was essential to improve the sanitation conditions for the citizens. The poor people gathered to Seoul after the Korean War lived in a shantytown along the Chung Gye Chun. The Chung Gye Chun or the Chung Gye stream itself functioned as a WWTP. The other small streams in Seoul were in the same conditions as the Chung Gye Chun. The sewerage service rate exceeded 50% after 1977 and the sewerage system had been expanded rapidly through 1980's. The rate increased from 68.8% in 1982 to 85.9% in 1983, after only one year. The rate exceeded 90% in the mid 1980's and got to 100% in 1997 (Seoul Development Institute, 2010).

Seoul held the Asian Games in 1986 and the Olympic Games in 1988 consecutively. The city had to improve all of the urban environments and WWTPs and sewerage system were constructed massively and actively. Due to the efforts of the city, the service rate of Seoul reached 90% in the mid 1980's. As the Joong Rang WWTP which was the Chung Gye Chun WWTP was expanded, and the Tan Chun WWTP, the Seo Nam WWTP, and the Na Ji WWTP were constructed in 1986, the service rate got to 100% in 1997 (Table 1).

The name of WWTP was renamed as 'Water Reclamation Center', which meant that the 'Water Reclamation Center' was not only a plant to treat wastewater but also a center to recycle wastewater and produce useful and necessary water resource (Figure 4).

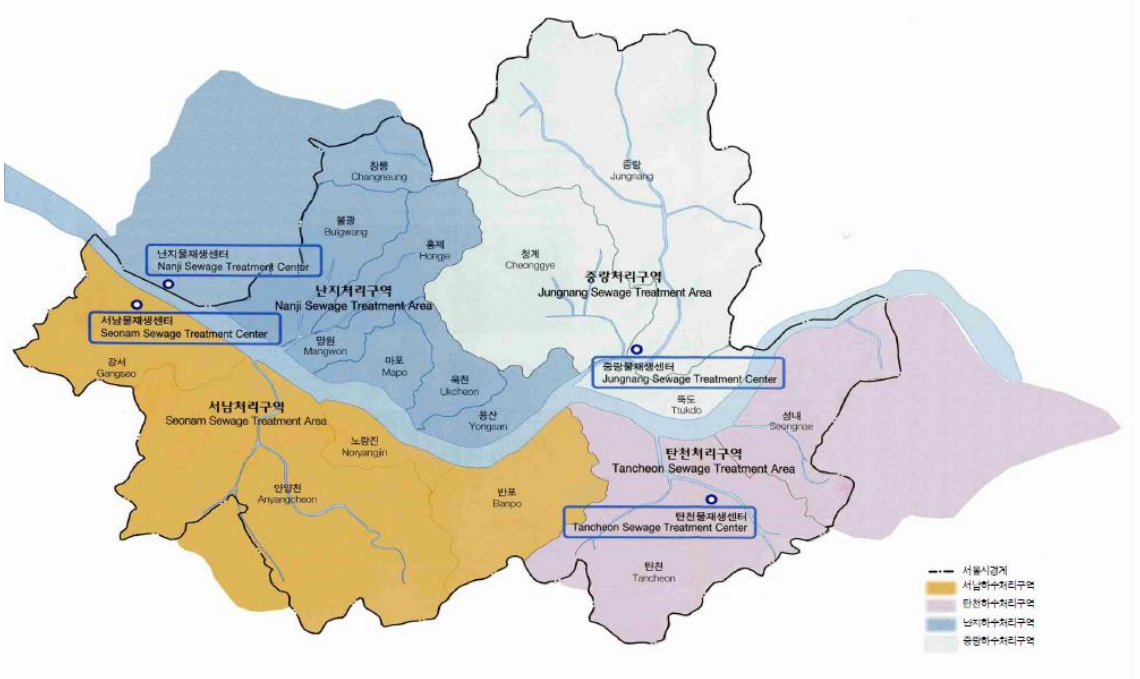

Figure 4. The 4 WWTPs of Seoul (Bureau of Water Management, 2009b)

[32] The ratio of the population living in the area of sewerage and wastewater treatment service. Sewerage service rate = (population within the area of sewerage service/total population)×100 (Kwak, 2007]

Table 1. WWTPs in Seoul

	Joong Rang	Nan Ji	Tan Chun (outsource to private)	Seo Nam (outsource to private)	Total
Treatment Capacity [M m^3/day]	159	86	90	163	498
Service area	10 boroughs	7 boroughs, 1 city	4 boroughs, 2 cities	9 boroughs, 1 city	All the 25 boroughs of Seoul, 4 cities of Kyung Ki Province

Energy Policy of Seoul

The total power consumption in Seoul in 2011 was 46,903 GWh, 10.9% of the total national consumption and energy self-sufficiency was only 2.8%. Due to the low electric power reserve rate, there was a massive black out in Korea including Seoul on September 15, 2011. As it was very possible to have another blackout in the future, it was necessary to improve energy (power) self-sufficiency to cope with power disaster (Yu et al., 2015). The city of Seoul has been carrying out the 2nd phase of the project 'One Less Nuclear Power Plant' (aka, Energy Producing City) to increase the energy self-sufficiency to 20% in 2020 after successful completion of the 1st phase of the project since August 2014.

The city made a plan to achieve the goal of the energy self-sufficiency of WWTP of 50% by 2030 through energy conservation and new and renewable energy production, according to the 'Master plan for energy self-sufficiency' of the Minister of Environment (January 2010). As of 2016, the energy self-sufficiency of WWTP of Seoul is 51%. The next goal of Seoul for the energy self-sufficiency of WWTP is 100% by 2020.

Sustainable Development Goals

UN has announced the new goal of 'Sustainable Development Goals (SDGs)' for the next 15 years from 2016 to 2030 after successful completion of the project of 'Millennium Development Goals'. The projects for SDGs were launched on December 5, 2015 with selection of the post-2015 SDG agenda at the UN General Assembly.

Sustainable development can be defined in many ways, but according to IISD (International Institute for Sustainable Development), the most frequently quoted definition is from 'Our Common Future', also known as the Brundtland Report.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: 1) the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and 2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. (http://www.iisd.org/topic/sustainable-development)" UN SDGs include 17 goals and 169 targets (Figure 5).

Figure 5. UN Sustainable Development Goals [https://sustainabledevelopment.un.org/sdgs]

Although all the UN member countries of 193 agreed to make every effort to achieve the SDGs, the main body of SDGs fulfillment has to be city. In this respect, the city of Seoul held 'International Forum on Urban Policy for the Sustainable Development Goals' on June 8, 2016, and announced that Seoul will lead the projects to achieve the SDGs.

One of the prerequisites for SDGs is sustainable production or efficient use and reuse of resources. The energy production from WWTP is an indispensable policy for Seoul to achieve the SDGs.

Water-Energy NEXUS

In all cases with water production and use including water treatment using source water from ground water or surface water, supply the customers with treated water, collecting[33] and treating wastewater, discharging the treated effluent to stream, reuse the wastewater, and

[33] No energy is required to transfer, collect, and discharge the wastewater in Seoul as the system used gravitation.

desalinating brine and sea water, energy is inevitable.

For instance, energy used for water systems in 2011 was 12.6% of total energy consumed (http://goo.gl/2pFxgQ). The energy used for wastewater treatment is about 0.1~0.3% of total energy used in the US (Stillwell et al., 2010). In Korea, the public sector uses 4.6% of total energy and 1.02% of the energy is used for drinking and wastewater systems (Choi, 2015). Drinking water system uses 0.8% of total energy used in Seoul while wastewater and sewerage system uses 0.9% (Choi, 2015).

Water is also required for energy production. Cooling water for thermal power generation, water for hydropower generation and mining, and water for fuel processing are the water resources used for energy production. The water used for cooling thermal power generation system takes 48.7% of the total water used for energy production in the US. This is 52% of freshwater withdrawal34 and 10% freshwater consumption (Figure 6).

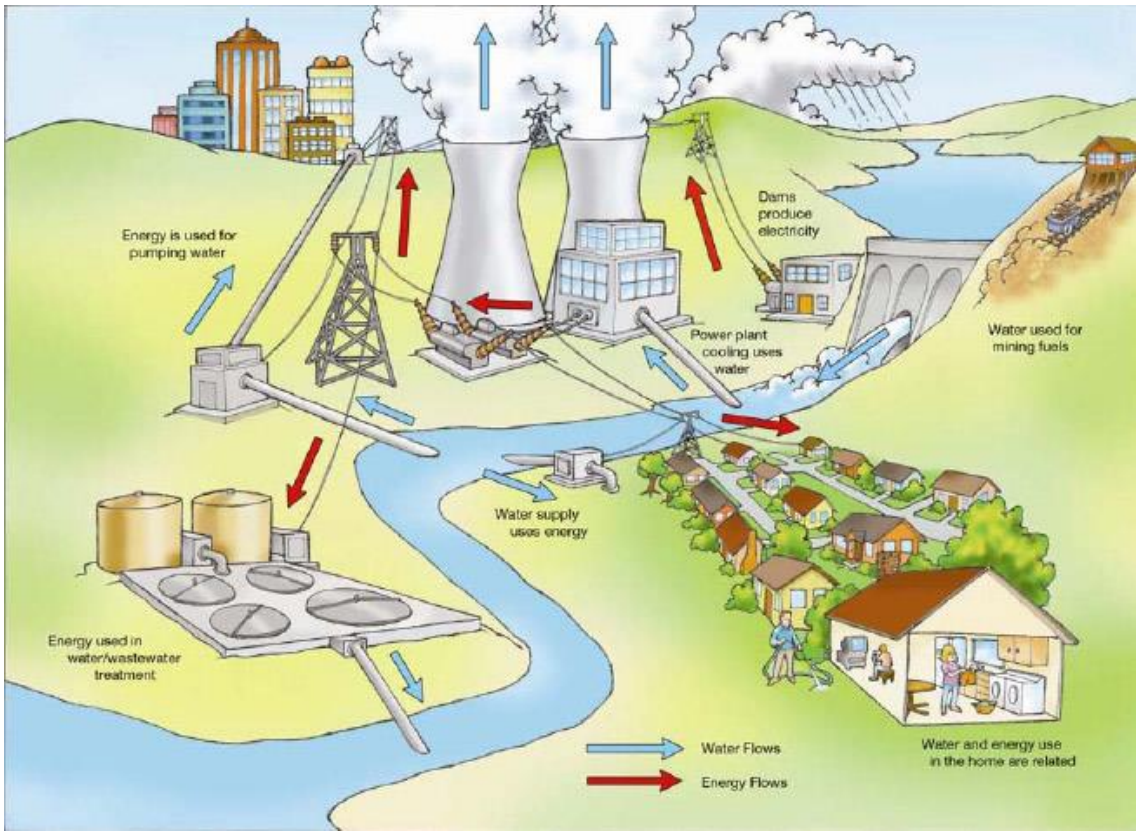

Figure 6. Schematic illustration on Water-Energy NEXUS [http://goo.gl/UCozax]

The approaches recommended building a virtuous cycle of water-energy NEXU in wastewater treatment and sewerage system are as follows; 1) energy conservation, 2) efficient system, 3)

[34] Most of the water resource used to produce energy is water of 'withdrawal'. The water will be backe d to the water body without any significant changes in its original conditions.

Best Management Practice (BMP), and 4) new and renewable energy production (Choi, 2015).

According to the scenarios made by National Renewable Energy Laboratory of Department of Energy (DOE), 50% of water resource used for power generation can be saved if new and renewable energy use can be increased to 80% by 2050 (NREL, 2012).

UN reported that 9.2 billion people will live together on earth and energy consumption is expected to increase by 80% (Le Blanc, 2012). Although new and renewable energy take only 10% of total energy produced, the new and renewable energy produced from WWTP has a lot of meanings and significance as it is the only sustainable energy.

About 30% of energy can be saved in most of WWTPs through efficiency improvement and changes in treatment processes (Means, 2004). 3~6% of total energy used in a WWTP can be saved only with efficient operation of aeration process and pumps (Hoppock and Webber, 2008).

New and renewable energy production along with efficient operation of wastewater treatment plant is one of the critical factors for sustainable Water-Energy NEXUS.

Climate Change and Water-Energy NEXUS

In general, climate change reduces the availability of water resources and more energy has to be consumed to increase the availability. Increased energy demand and financial burden will magnify the Water-Energy Conflict. The conflict by the severe drought in 2015 could be moderated by cheaper oil price, did not rise to the surface. As the water-energy conflict can be escalated any time in the future with climate change, the policy for energy self-sufficiency of water system is always very important.

3. Importance of the Policy

There are about 20 communities in Germany to supply the 100% of energy for the comminity with new and renewable energy. Schleswig-Holstein has 15 communities and became the 1st state using 100% new and renewable energy. The communities with 100% new and renewable energy has limits of geographical characteristics (i.e., very windy mountainous area) and small population less than 10,000.

According to the ‘master plan for climate protection’ for Frankfurt reported by Fraunhofer Gesellschaft in June 2013, the city will reduce carbon emission by more than 95% by 2050 compared with that of 1990 and all the energy demand will be met with new and renewable energy (Shin, 2016).

It was urgent for Seoul to get prepared for accident like the massive blackout in 2011 through energy conservation and production capacity expansion for new and renewable energy, not only as the long-term and strategic plan to mitigate and adopt to climate change. It became the prior energy policy for Seoul to increase power self-sufficiency to operate the urban infrastructure in any case including the massive blackout (Yu, 2015). The WWTP is one of the best fitted urban

infrastructures to increase system efficiency and produce new and renewable energy.

Improvement of system efficiency and energy production are the most important factors for the water processes to secure the virtuous cycle of Water-Energy NEXUS. In addition, as the wastewater flows into a WWTP has high concentration of organic materials which can be converted into various types of energy. In this respect, the identity of WWTP of Seoul has to be changed from 'treatment' of wastewater to 'production' of resources and energy.

Wastewater treatment and sewerage system are composed of the processes with concentrated investment and energy. Therefore, the tightened water quality standards for the effluent from WWTP will definitely be connected to expansion of treatment facilities which will increase financial burden of a local government. Energy self-sufficiency of WWTP will contribute to reducing the financial load of the local government by increasing system efficiency and energy production.

4. Relationship with Other Policies

Adoption of Paris Agreement

The Paris Agreement was adopted at the 21st Conference of Parties (COP21), Paris in December 2015. The agreement was about the new climate corresponding mechanism to replace the Kyoto protocol after 2020. The agreement had meanings and significance as it made all the countries, regardless of developed and developing countries, work together to mitigate and adopt the impact by climate change (Kim, 2016).

The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework (UNFCCC, 2016).

In addition, the agreement requested each country to make and report strategies for long-term low greenhouse gas (GHG) emission development by 2020 (Kim, 2016). Korea proposed 37% reduction by 2030 BAU in June 2015. The countries also agreed on establishment of international carbon market to achieve reduction of greenhouse gas emission.

Low Carbon Economy and Sustainable Development

One of the important meanings of the Paris Agreement is, the Post-2020 will be the platform to

implement low carbon economy. As Korea depends its energy mainly on fossil fuel, it will be necessary to have projects to improve energy efficiency and policies on active production and use of new and renewable energy.

The technical bases for reduction of carbon emission include energy efficiency improvement, CCS35, new and renewable energy. The domestic market size of related industries is expected to be 47.2 trillion KW in 2030 (Won, 2016). The GHG emission from Seoul in 2011 was 49 million ton CO2eq and took 9.8% of total emission in Korea. It was relatively low comparing with its population and size of economy. But, the structure of emission does not look desirable as the relative importance of energy consumption moved from the direct emission source such as gasoline and coal to indirect one including heat and electricity (Yu et al., 2015). The city of Seoul announced that it would reduce 10 million tons of GHG by 2020 after the 2nd phase of the project 'One Less Nuclear Power Plant', i.e., 79.5% reduction from the GHG emission in 2011. The goal will be achieved by improvement of energy efficiency of buildings (28%), new and renewable energy production (21%), energy conservation (21%), LED(21%), savings in transportation (6%), and heat energy production (2%)36 (Figure 7).

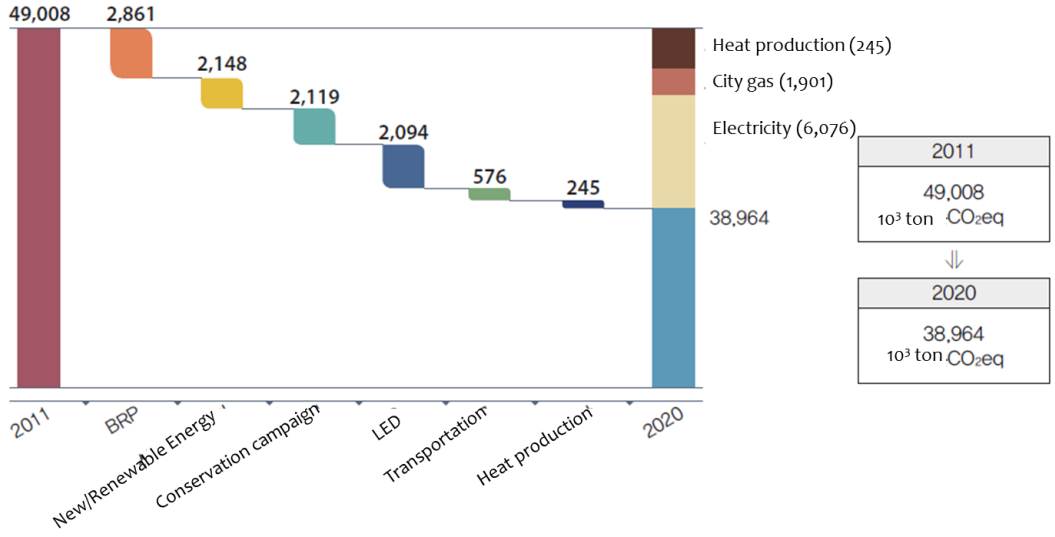

Figure 7. GHG reduction goal by the 2nd phase 'One Less Nuclear Power Plant' (Yu et al., 2015)

As the city of Seoul declared the leadership in 'initiative of local government for sustainable development' at the 1st International Forum on Urban Policy for the Sustainable Development Goals in 2016, it is very important for the city to secure technical and political fundamentals to

[35] CCS: Carbon capture and storage

[36] Energy efficiency improvement of buildings: 2.9 million ton CO_2eq, new and renewable energy production: 2.1 million ton CO_2eq, energy conservation: 2.1 million ton CO_2eq, LED: 2.1 million ton CO_2eq, transportation: 576,000 ton CO_2eq, and heat generation: 245,000 ton CO_2eq

achieve the SDGs effectively. New and renewable energy production from WWTP has significant meaning for Seoul as well as from the level of country.

5. Goal of the Policy

When transforming the wastewater with high concentration of organics into energy and resources, theoretically about 10 time more energy can be extracted than required for treatment of the wastewater. Some WWTP's in Germany and Denmark are producing more energy than required for treatment, i.e., energy self-sufficiency is over 100%.

The energy self-sufficiency of WWTP's in Seoul is 51.3% as of 2016. The goal of the project 2020 is to produce new and renewable energy from WWTP's more than 100% of energy needed for treatment by 2020 (Figure 8).

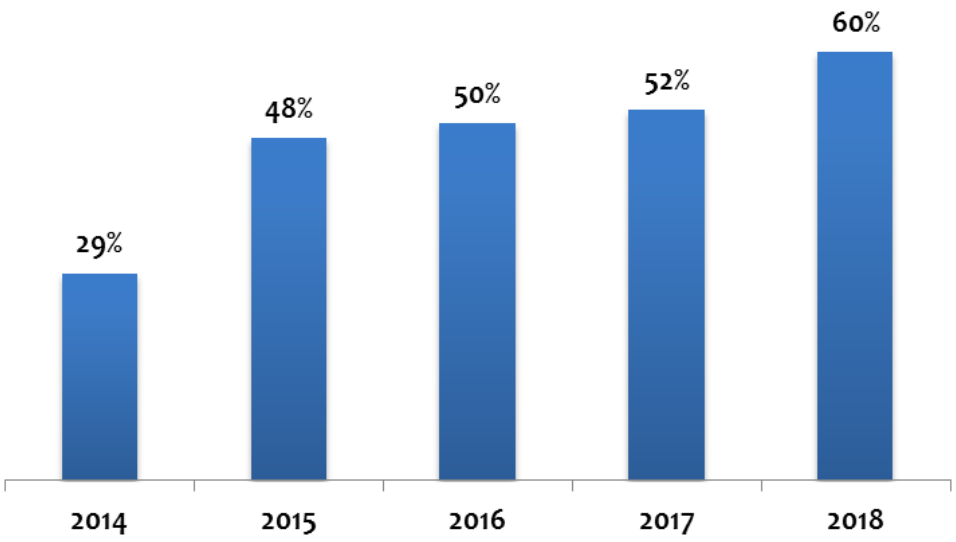

Figure 8. Energy self-sufficiency goal for WWTP's of Seoul

The city of Seoul has been preparing the comprehensive energy management plan for WWTP's since May 2016. The energy oriented management plan will be completed in January 2017 for three different time frames, i.e., short, mid, and long-term plans.

The plan will include 1) goal for energy self-sufficiency of the WWTP, 2) sound foundation for energy oriented management of WWTP, 3) expansion of energy production and promotion of energy business, and 4) projects for energy conservation and efficiency improvement.

6. Main Contents of the Policy

Mast Plan for Energy Self-sufficiency of WWTP, MOE

The Ministry of Environment of the central government of Korea announced the 'Master Plan for Energy Self-sufficiency of WWTP' to save energy and produce new and renewable energy using green environmental technologies in 2010. According to the report for the plan, the electricity used in WWTP's was about 0.5% of the total power used in Korea but the energy self-sufficiency of WWTP's was only 0.8% (MOE, 2010). The plan had three step-wise goals; 18% of energy self-sufficiency in the 1st stage (2010~2015), 30% in the 2nd stage (2016~2020), and the 3rd stage (2012~2030) 50%.

The goals will be achieved through 1) energy conservation, 2) building fundamentals for energy self-sufficiency, 3) Utilization of unused energy37, 4) production of natural energy38 (MOE, 2010).

[Energy Policy of Seoul] Seoul has just completed the 1st phase of the energy project, 'One Less Nuclear Power Plant' (2012~2014). The goal of the 1st phase of the project was to reduce consumption of energy and produce new and renewable energy of 2 million TOE, which is the power generating capacity of a nuclear power plant. The city of Seoul has been carrying out the 2nd phase of the project, known as 'Energy producing city', to increase the energy self-sufficiency of Seoul to 20% in 2020 (SMG, 2014).

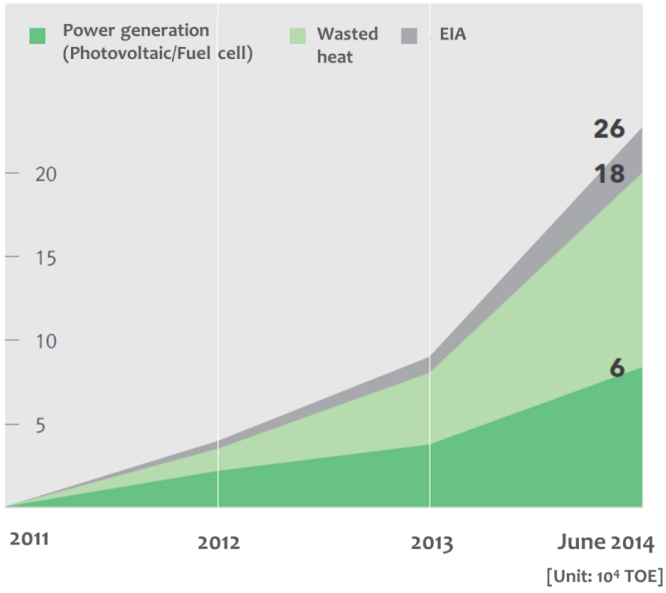

Figure 9. Energy production in Seoul (SMG, 2014)

[37] Biogas from digestion process, small hydropower generation, wastewater heat

[38] Photovoltaic power generation, wind power generation

The largest part of energy production comes from the energy produced from the wasted heat such as wastewater heat and it takes 46% of all the energy produced and saved in Seoul (Table 2, Figure 9).

Table 2 Energy production in Seoul (SMG, 2014)

Energy Producing Process	Energy Production [104 TOE]		Remark
Power Generation	57,403	22.1%	Photovoltaic, fuel cell
Wasted heat and geothermal heat	119,218	45.9%	Wastewater heat, burning heat, geothermal heat
EIA	82,912	31.9%	
Total	259,533	10.0%	

Energy Saving and Production in WWT and Sewerage Systems

As discussed above, the main approaches of the 'Comprehensive Energy Management Plan for WWTPs' can be categorized as follows; The first category is on building the foundation for energy self-sufficiency. The detailed projects for this approach are replacement and rehabilitation of the old facilities and renewable energy production from anaerobic fermentation of organic sludge. The second approach is capacity increase to save more energy and produce new and renewable energy. The projects to achieve the second category of the project are, energy saving by management of electric power demand, expanding utilization of biogas from digester, increasing capacity of sludge drying facilities, and active discovery of unused energy. The last category is about energy efficiency and process optimization. Streamlining process management of WWT system and energy saving from wastewater treatment processes are the projects for the third approach.

7. Technical Contents

The Water-Energy NEXUS in wastewater treatment systems, can be built from two approaches. One is energy saving by improvement of system efficiency and the other is producing new and renewable energy from WWT systems.

Considering the structural characteristics, the processes from which system efficiency can be expected include sewage collection, wastewater treatment, water reuse, and discharge of the

treated wastewater.

568,000 kWh of energy is required to collect 1 m3 of wastewater in the US (Klein, 2005). The problem with wastewater collection through old pipe system is costs for old system improvement and decreased system efficiency by I/I (Inflow and Infiltration). Fortunately, the city of Seoul doesn't need to use energy to transfer wastewater as wastewater is collected by gravitation in Seoul. But the city has to deal with increased treatment cost due to old pipe systems.

The improvement of system efficiency in wastewater treatment process has limit due to regulatory rigidity on water quality standards of the effluent and structural characteristics of financial operation and support for wastewater treatment system. For example, 13~29 billion US dollars of financial investment is required to improve the aged and deteriorated wastewater treatment system for the next two decades (CBO, 2002).

The process that uses most energy in wastewater treatment is aeration, which uses about 54.1% of the total energy used in whole wastewater treatment process in the US while the energy for pumping is 14.3% and digestion is 14.2%. In Seoul, wastewater treatment process takes 64% of the total energy used in a WWT, while 15% and 21% of energy is consumed for sludge treatment and common facilities, respectively (Choi, 2015).

Water reuse39 has advantage in energy savings not in wastewater treatment system itself but in transferring through pipe system as water does not need to be pumped from source to treatment process and distribution for use as water reuse is done at the point of use.

Only the new and renewable energy production among the whole Water-Energy NEXUS is discussed in the report as energy production is much larger than energy saving.

The city of Seoul has to treat 4.1 million m3 of wastewater every day as of 2014 and a part of biogas generated in the treatment process was burned out in the incinerator. The Nan Ji WWTP covering the northwestern part of Seoul has built and operated the 1st combined heat and power plant with the capacity of 3.1 MW using biogas since March 2013. Another biogas of 26,000 m3 is supplied every day to Korea District Heating Corporation. The corporation generates about 20,000 MWh of power every year and 24,000 GCal of heat supplied to 8,000 households. The Joong Rang WWTP covering the northeastern part of Seoul produces 6 million m3 of biogas every year and sells them as the city gas. 7.8 billion KW of the capital cost including the gas purification facilities was invested from the private sector.

Total energy used in the WWTPs in Seoul as of 2016 is 64,944 TOE (

[39] 7~8% of the effluent from the WWTPs were reused in the US (EPA, 2012) while only about 3% of wa stewater was reused in Seoul in 2010. The city of Seoul will increase the percentage of water reuse to 14.4% by 2020.

Table **3)**. Electricity takes 78% (50,781 TOE) of the total energy for the WWTPs.

Table 3. Energy consumption in the WWTPs in Seoul by energy source

Energy Source	Electricity	Heat recovery	Oil	LNG	Biogas	Total
Consumption [TOE, %]	50,781 78.2%	5,391 8.3%	41 0.1%	22 0.03%	8,709 13.4%	64,944

The process which uses the largest portion of electric power energy is blower for aeration process. The energy for blower takes 49% (24,811 TOE) of the total energy used in WWTP (Figure 10).

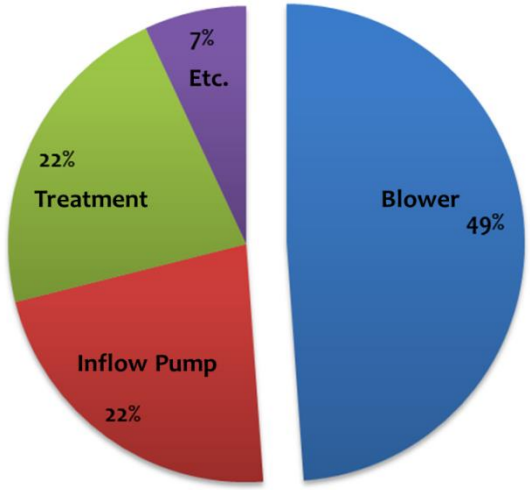

Figure 10. Electric power consumption in WWTP of Seoul (Lee, 2016)

Considering the conditions discussed above, the ‘Comprehensive Energy Management Plan for WWTPs’ includes 1) building the foundation for energy self-sufficiency, 2) energy saving and new and renewable energy production, and 3) enhancing system efficiency and optimization.

Building the foundation for energy self-sufficiency

As blowers consume about 50% of electric energy of a WWTP, the city is carrying out projects to replace the aged and deteriorated facilities including blowers with new and efficient ones. In addition, sludge drying facilities are constructed to make the sludge into fuel[40]. The energy produced from the dried sludge is estimated to be about 392 TOE.

[40] Projects of construction of sludge dryers: energy production 392TOE, project period : January 2016 ~ December 2019, capacity : 1,175 m^3/day (Joong Rang 350, Nan Ji 130, Tan Chun 140, Seo Nam 555)
※ Existing drying facilities: 950 m^3/day (Lee, 2016)

Energy saving and new and renewable energy production

Electric power demand control project is carried out to reduce electric power consumption. As discussed before, the aged blowers will be replaced with new blowers with higher efficiency and energy saving functions. Power consumption during the peak season will be managed much more tightly.

The biogas from digester is the most tangible energy source among the new and renewable energies produced in a WWTP. The quality of biogas will be improved by tight maintenance of the desulfurizing facilities. The amount of biogas can be increased by adding chemicals to increase the yield. The capacity of the sludge dryer will be increased by 1,175 m3 by 2019 and the dried sludge will be sold as fuel for thermal power plants.

The city will actively search for unused energy such as small hydropower generation using hight difference of the effluent[41] and heat supply to households in the area using wastewater heat[42].

Enhancing system efficiency and optimization

The operation of process in a WWTP will be optimized with advanced monitoring system. Energy consumption will be managed by plant and process to improve efficiency of treatment system. Optimization of the inflow pumps and efficient blower operation system corresponding to load fluctuation will be implemented to enhance system efficiency. In addition, highly efficient oil pressure motors for dehydrator and concentrator will be installed as one of the energy saving wastewater treatment processes.

The operation manual and incentive system to motivate energy saving is being prepared with replacement and improvement of processes and devices for higher system efficiency.

New and renewable energy production

The energy self-sufficiency goal for the project ‘Energy Producing City’, the 2nd phase of the project ‘One Less Nuclear Power Plant’, is 20% by 2020. The ongoing projects as of 2015 are as follows (Figure 11).

Project to use the biogas as fuel is a project to supply with the biogas from digestion process as the city gas. The annual energy saving estimated from the project is about 25,000 TOE from the 4 WWTPs in Seoul.

Photovoltaic power generation project is a project that makes use of the large space of WWTP to generate electric power using photovoltaic panels. Private sector as well as the city of Seoul

[41] Projects of small hydropower generation: Joong Rang 60kW, Tan Chun 60kW

[42] Heat supply to the area using wastewater heat (Seo Nam) : 150,000 Gcal of heat supplied to the Ma Gok community annually (plan to be completed in October 2017)

invested together for the project. Photovoltaic power plants with total capacity of 5,545 kW are operated in the 4 WWTPs of Seoul and the annual energy saving from the project is estimated to be about 1,586 TOE.

Projects of combined heat and power plant based on biogas use biogas from digester, produce heat and power at the same time, and supply the customers with the heat and power. The heat from biogas combustion is supplied for digester heating first and the remaining gas is supplied to the heating company in the area. The electricity is sold to power trade market with higher price. The projects are based on private investment projects. The plant in the Nan ji WWTP has the capacity of 3.06 MW while that of the Seo Nam WWTP is 5.8 MW.

Projects on natural lighting for the underground utility tunnel use the sun light to light up the underground utility tunnel. The underground utility tunnel is improved into place with clean and pleasant conditions. Although the contribution of the project to energy saving is not big, the annual energy saving by the project is estimated to be about 20 TOE. The systems are installed and operated in the 245 utility tunnels in the Joong Rang WWTP and the Seo Nam WWTP.

Projects to recover heat from the effluent is a project to recover heat from the effluent using heat pump and use the energy for heating and cooling the offices and buildings in the WWTP. The Nan Ji WWTP and the Seo Nam WWTP use the energy for cooling and heating buildings and save about 12 TOE annually.

The most tangible project is the project to supply biogas as the city gas. The projects were also based on private investment. The wasted biogas is purified and supplied to the households as the city gas. The Joong Rang WWTP supplies with 26,000 m3 of gas every day. 5.3 million m3 of biogas is supplied to about 7,000 house holes every year through the project.

Figure 11. New and renewable energy producing facilities in WWTPs in Seoul [Clockwise from the top left, combined heat and power plant (Seo Nam), recovered heat supplying unit (Tan Chun), Photovoltaic power plant (Seo Nam), small hydropower plant (Seo Nam), Power plant using biogas (Seo Nam), natural lighting for underground utility tunnel (Joong Rang)]

Heat supply to the area using wastewater heat is carried out with private investment. New projects for new and renewable energy in 2016 include small hydropower generation and heat supply to the area using wastewater heat. More than 200,000 Gcal of heat is generated annually in the Tan Chun WWTP and supplied to 20,000 households for heating. The heat recovered in the Seo Nam WWTP will be supplied to the community of Ma Gok with private investment. The community of Ma Gok will be supplied with 150,000 Gcal of heat annually (Figure 12).

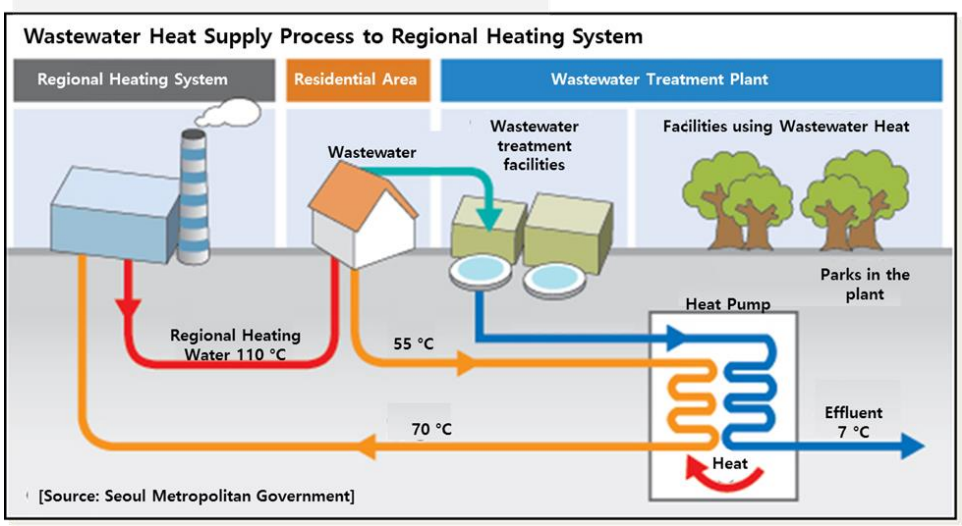

Figure 12 Schematic illustration of heat supply to the district using wastewater heat

Projects of small hydropower plant using the effluent use the difference in height of the effluent for small hydropower generation. The Seo Nam WWTP started to operate the plant with the capacity of 100 kW in April 2015 while a plant with capacity of 60 kW has been built in the Joong Rang WWTP since November 2015. The wasted potential energy of the effluent can be used as a good source of new and renewable energy.

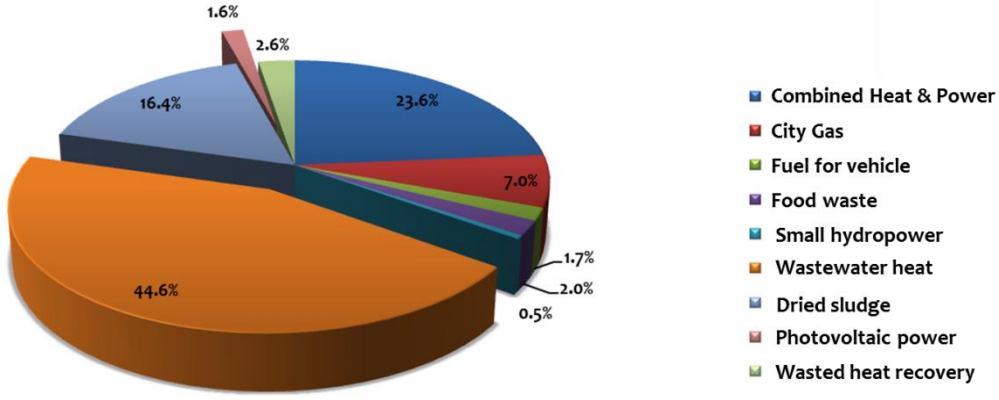

Figure 13. New and renewable energy production in the WWTPs in Seoul

8. Effect of the Policy

Functional change of WWTP and improved energy self-sufficiency

The only function of WWTP in Seoul was treatment of wastewater. The modern WWTP is not a treatment plant any more but a power plant producing various types of energy as well as water resources from wastewater (Figure 14). The main function of WWTP is changing from treatment to energy generation and resources recovery.

The city of Seoul can achieve the goal of the 2nd phase project of ‘One Less Nuclear Power Plat’ successfully and contribute to UN’s SDGs achievement. Seoul can be evaluated to have technical and political foundations through energy self-sufficiency projects to move to low carbon economy.

Business model based on PPP(Public-Private Partnership)

Huge amount of budget is required to construct and maintain urban infrastructure including energy related facilities. The size of the structures in Seoul is the largest in Korea and the projects cannot be carried out only by public sector in terms of technical capability as well as financial capacity. The city of Seoul carried out the projects to produce and supply the new and renewable energy from WWTP based on multilateral cooperation business model for the city, private sector, and energy companies in the area to invest, construct and operate the systems together. The project to supply heat to the area recovered from wastewater heat was taken as a successful project with business model based on the largest PPP in Korea. The similar business model was applied for the project of small hydropower generation, i.e., the WWTP provided with space for power generation facilities and carried out the administrative process while the private sector invested finance to design, construction, and operation of the facilities and would make earnings by sales of the energy produced from the facilities.

The project was also taken as a model of ‘new growth engine for green industry’, i.e. the local energy company could use the wastewater heat with lower price instead of supplying heat produced with higher priced LNG. The company could lower the unit price for supply, correspond to new heat demand, and secure reserve of heat (Choi, 2016).

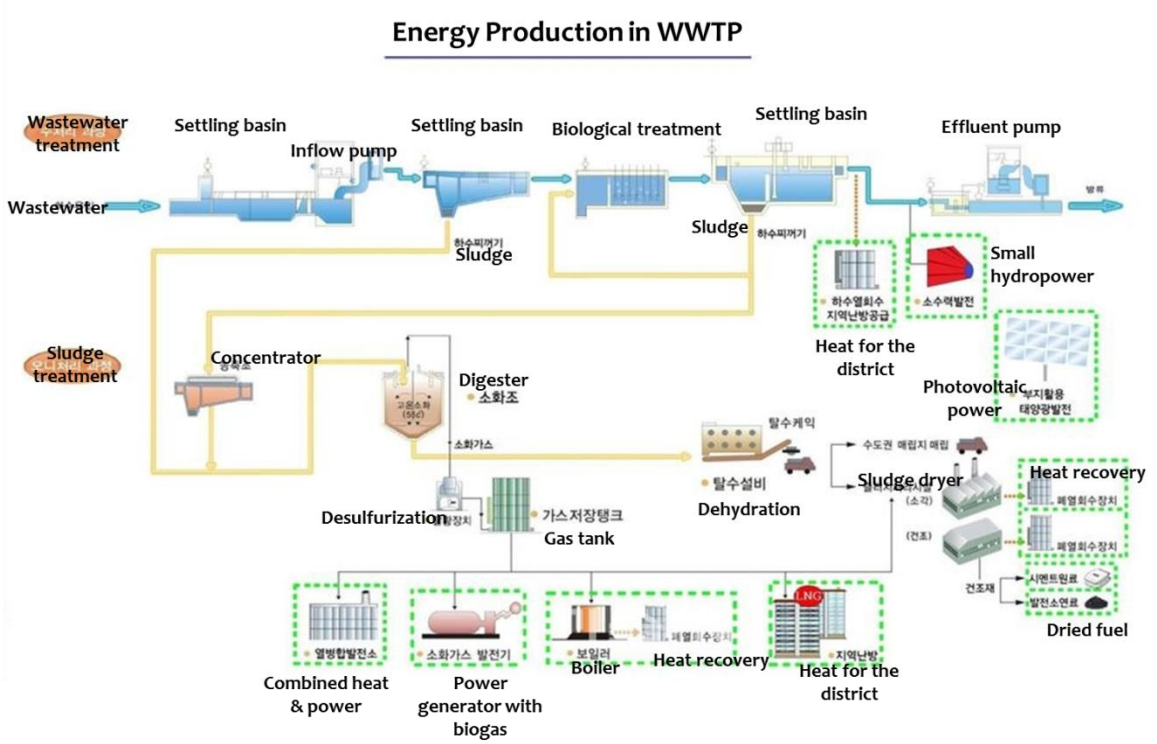

Figure 14. Schematic illustration of new and renewable energy production in WWTP of Seoul (https://goo.gl/v5bxpe)

Overcoming technical adversities and expanding new technologies

For the project of small hydropower generation using head difference of the effluent to generate power, the effective head has to be larger than 2 m. The city of Seoul developed new technology, 'power generating system with small head and flow', to use small head effectively by using water flow and velocity.

(Baek, 2014). As the system can use water flow and velocity under small head condition, the technology can be applied to other WWTP with the similar conditions. Operated successfully, the project can be a new growth engine and contribute for job creation.

Reduction of GHG and transformation to low carbon economy

Seoul already achieved energy self-sufficiency goal of 51.6% proposed by the 'Master Plan for Energy Self-sufficiency of WWTP' of the Ministry of Environment, 15 years prior to the target year. The total energy required for all the 4 WWTP's in Seoul is similar to those needed for the 70,000 households in the Ha Nam city. The amount of energy saved and utilized from the processes of WWTP of Seoul including unused energy is the same as the energy consumed by the 37,000 households in the Sok Cho city. The financial effect can be calculated to be about 35.4 billion KW and the city could reduce about 3,5000 tons of CO2 emission with the project.

9. Difficulties and Overcome

The main adversities in producing new and renewable energy are financial and technical difficulties. As in the cases of other urban infrastructures, it takes huge amount of financial investment and high level of technical capacity for construction and operation of the facilities to recover resources and produce energy.

One of best way to overcome the difficulties is to adopt private investment and technologies based on the PPP (Public-Private Partnership) business model. For instance, the city provides with space for the business and the private sector constructs and operates the systems to generate electric power and sell the electricity to make profits.

The successful operation of the system for new and renewable energy generation and resource recovery in Seoul, can be a good model for public-private cooperation.

References

- Baek, Y.D., 2014, Small hydropower generation using effluent in WWTP, Daily Country, https://goo.gl/8nMNBS
- Bureau of Water Management, 2009a, Sewerage System of Seoul, Seoul Metropolitan Government
- Bureau of Water Management, 2009b, Master plan for Sewage System Maintenance 2020, Seoul Metropolitan Government
- CBO, 2002, Future Investment in Drinking Water and Wastewater Infrastructure, Congressional Budget Office
- Choi, I.S., 2016, WWTPs in Seoul changed into the outposts for new and renewable energy production, Khan, https://goo.gl/KS0dzK
- Choi, Y.J., 2015, Now and future of urban water reuse, SMG-Korean Society on Water Environment Joint Forum
- EPA, 2012, 2012 Guidelines for Water Reuse
- Headquarter for Climate and Environment, 2014, Seoul will be 'Energy producing city' following the success of the project, 'One Less Nuclear Power Plant', Seoul Archive (http://env.seoul.go.kr/archives/43330), SMG
- Hoppock, D.C., Webber, M.E., 2008, Energy needs and opportunities at POTWs in the United States, In Proceedings of the American Society of Mechanical Engineers (ASME) 2nd International Conference on Energy Sustainability, Jacksonville, FL, USA
- Kim, K.H., 2016, Adoption of the Paris Agreement and Our Strategies, Science and Technology Policy Institute (STEPI)
- Klein, G., Krebs, M., Hall, V., O'Brien, T., Blevins, B., 2005, California's Water-Energy Relationship, California Energy Commission
- Kwok, D.H., 2007, Terminology of drinking water and wastewater system
- Le Blanc, D., 2012, Back to our common future: Sustainable Development in the 21st century (SD21) project, UN DESA
- Lee, C.H., 2016, Energy self-sufficiency of WWTP in Seoul, Proceeding of the seminar on the New Technologies for Wastewater Treatment and Energy, Seoul Water Institute.
- Lee, Y.J., 2015, Governance and stakeholder participation: Key to policy making – Regional and urban case studies from Germany and Korea, Seoul International Energy Conference 2015
- Means, E.G., 2004, Water and wastewater industry energy efficiency: A research roadmap, Water Research Foundation, Denver, CO, USA
- MOE, 2010, Master Plan for Energy Self-sufficiency, Department of Wastewater, Ministry of Environment (MOE)
- NREL (National Renewable Energy Laboratory), 2012, Renewable Electricity Futures

Study: Exploration of High-Penetration Renewable Electricity Futures, vol.1

- Seoul Development Institute, 2010, Seoul Research Database – Sewerage system
- Shin, H.S., 2016, German cities competing for the future, Shi Sa IN (November 10, 2016; http://www.sisain.co.kr/?mod=news&act=articleView&idxno=27460)
- SMG, 2014, One Less Nuclear Power Plant Project, the message of hope for the energy policy of Seoul, Seoul Metropolitan Government (SMG), OLNPP Citizens' Action Committee
- Stillwell, A.S., Hoppock, D.C., Webber, M.E., 2010, Energy recovery from wastewater treatment plants in the United State: A case study of the Energy-Water Nexus, Sustainability 2, 945 – 962
- UNFCCC, 2016, The Paris Agreement, http://unfccc.int/paris_agreement/items/9485.php (last surfed on Dec. 15, 2016)
- US GAO (Government Accountability Office), 2012, Energy-Water NEXUS. Coordinated federal approach needed to better manage energy and water tradeoffs, GAO-12-880
- Won, D.K., 2016, Main contents of the Paris Agreement and issues related with power industry, KEMRI REVIEW
- Yu, J.R., et al., 2015, One Less Nuclear Power Plant 2: Energy Producing City, Seoul, Seoul Metropolitan Government

Efficient Drinking Water Supply System: Revenue Water Ratio(RWR) Improvement Project

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1. Time of Policy Implementation

The Revenue Water Ratio (RWR) Improvement Project has begun with the start of the special organization focused on drinking water, i.e., Seoul Water Authority, in 1998. Although there were projects to increase the system efficiency before, it can be said that the real plans and projects to improve RWR have been carried out by Seoul Water Authority since 1998.

In 1990's, the first priority of drinking water policy was still on qualitative issues. As the drinking water quality of Seoul was improved to the world-best level, the city of Seoul made plans to increase the efficiency of water system, i.e., RWR improvement, and started new projects.

Improvement of RWR can be directly related with streamlining the management in water business.

2. Situational Background for Policy Implementation

The beginning of water system can go back to the earliest history of human being as we need water to live. The archeological evidence told us that the history of water system in Korea goes back to the 7th century43. The system was very fundamental one to supply the citizens with groundwater and clean surface water through pipe system made of wood and/or clay.

[43] "It was known that drinking water was supplied through clay pipes in the period of the United Shilla Dynasty in the 7th – 10th century after aqueduct and water ways with clay pipes were found in the An Ap fond in Ku Hwang Dong, Kyung Ju city, Kyung Sang Book Do in 1974" – A Centennial History of Seoul Waterworks System, 2008

Modern Waterworks System

The modern waterworks system of Seoul started to be operated in 1908 with construction of Tukdo WTP and supply the citizens with the treated water from the Tukdo WTP44. During the Japanese occupation starting in 1910, the capacity of drinking water production and supply system was not increased with population growth during the period as the treated water was supplied to only few restricted citizens. Although Korea won its independence in 1945 with the end of the 2nd World War, political turmoil and social instability continued. Due to the chaotic conditions, few people concerned about urban development and operation/maintenance of social infrastructures.

The Korean War

The political turmoil grew to the tragedy of the Korean War in 1950. During the war, the total number of the dead, missing, and wounded soldiers was 973,000 while that of civilians was 2.1 million, i.e., One of five-membered family was dead, missing or wounded. This was not only enormous damage for individual and for society but also national tragedy. The damage on industrial facilities was so huge that about 35~90% of urban infrastructure was destroyed by the war45. It took years for Korea to recover the damage by the war.

Economic Growth

Water demand grew rapidly with expansion of urban area and explosive increase of population by economic development in 1960's. The population of Seoul increased by about 3.3 times from 2.5 million in 1960 to 8.1 million in 1979. The population growth rate was same as the rate to build a city with population of 300,000 every year [ ]. The city of Seoul spurred urban development to accommodate the rapidly increasing population. The 25% of the current urban area of Seoul was developed in 1960's and 1970's [ ].

Expansion of Tap Water Production and Supply

Seoul made every effort to correspond to the changes in 1960's and 1970's by increasing drinking water production capacity and expanding the network system for treated water supply. It could not be enough to cope with the explosively increasing water demand with rapid

44 September 1, 1908 is known to be the beginning of drinking water supplied in Seoul from the modern style water treatment plant, the Tukdo WTP.

45 "In terms of the infrastructure for waterworks system, 30~90% of water treatment plants, 5~10% of pipe network system, 60~80% of booster stations, and 90% of communication systems were destroyed by the war." [ ]

population growth.

310,000 m3 of drinking water was produced every day but about 57% of the treated water was lost due to the dilapidated waterworks facilities (i.e., RWR of 43%) [ ].

Seoul had extended the waterworks system with the 3-year plan since 1965 even with the difficulties mentioned above. The goal of the plan was old pipe replacement and scientific leak management. The financial problems could be solved by the international funds and issuing national bonds.

Although some of the plan had problems in coping with the population increase, the water supply condition of Seoul had been improved gradually (Figure 15).

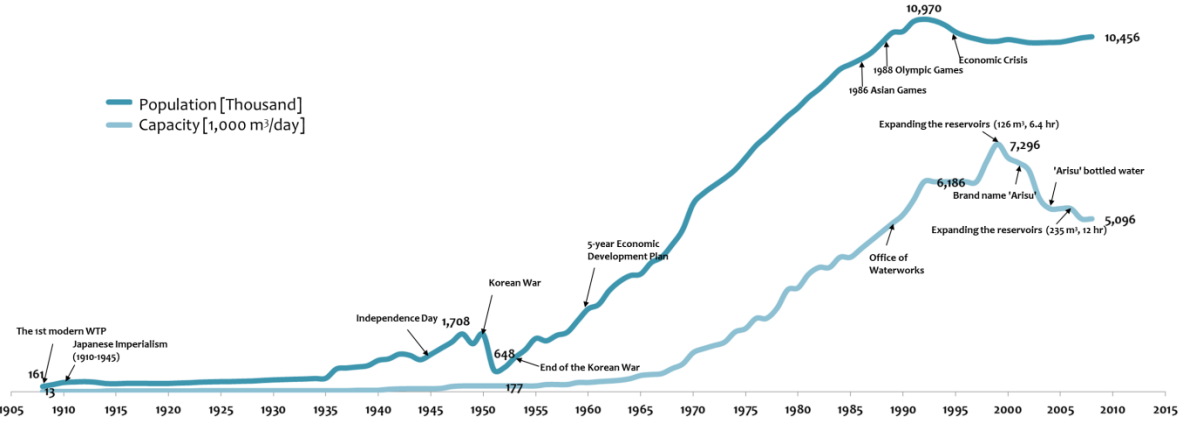

Figure 15. Time line of population and drinking water production capacity of Seoul

Over 90% of the citizens could get water service in 1980's from 60% in 1960's46. As the water demand could be met by increasing the production capacity, the city increased the storage capacity of water reservoirs, built booster stations, and decreased leakage by replacing old pipes.

As discussed above, there were rapid industrialization and urbanization with the implementation of the national economic development plans, and rapid increase in water demand with population growth, in Seoul in 1960's. The city focused on increasing drinking water production capacity and improving supply systems in 1970's and 1980's. As the results, the waterworks system of Seoul could provide the citizens with sufficient drinking water, in terms of quantity.

Quality Improvement of the Tap Water

The source water, i.e., the Han river, was polluted with incomplete treatment of waste water in the early 1980's. The city had difficulties to treat the dirty source water such as using too much chemicals.

46 The percentage of population connected to drinking water service was increased from 92.7% in 1980 to 99.9% in 1992 by expansion of drinking water production capacity from 3.1 to 6.2 million m³/day [ ]

With the Asian Games in 1986 and the Olympic Games in 1988, the city made many efforts to set the Han river in good condition including building and expanding the waste water treatment plants.

There were many accidents of water pollution including increase of ammonia nitrogen concentration in local waterworks system and phenol flowing in to the Nakdong river located in south-eastern part of Korean peninsula. The tap water quality became a national issue as more of the citizens did not trust the quality of tap water [ ]. The central government of Korea made the 'Comprehensive Plan for Clean Water Supply' and launched innovation projects including aggressive protection of water sources, prevention of water pollution, and improvement of drinking water treatment system.

The city of Seoul made the waterworks service highly specialized47; 1) Launching a research institute for research and development on water treatment technologies, scientific water quality management, and increase in system efficiency, 2) streamlining monitoring and management of source water protection areas and active correspondence, 3) improvement and replacement of the old facilities in the water treatment plants, and 4) massive replacement, cleaning, and rehabilitation of old pipes in the supply network [ ].

The drinking water quality as well as the source water quality could be maintained in world-class level with the launch of Seoul Water Authority and the efforts made by the city (Figure 16).

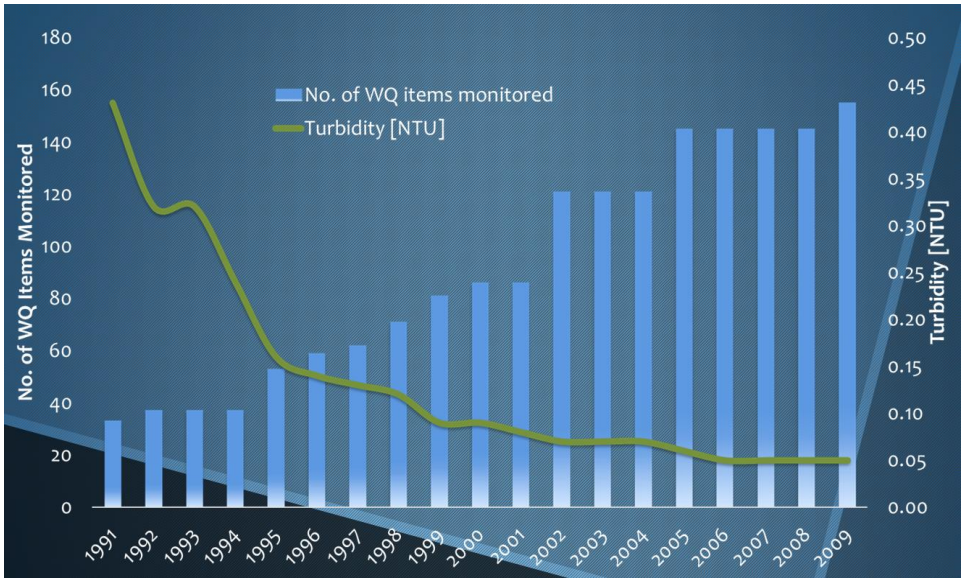

Figure 16. The number of water quality monitoring items and the turbidity of the treated water [ ]

Improving Efficiency of the Water Business

The goal of drinking water policy changed from quality and quantity to efficiency of the system

[47] The Seoul Water Authority only for drinking water production and supply for Seoul was launched in 11/1989

as the city secured enough capacity of the waterworks system for qualitative and quantitative goals. The city could produce enough drinking water by increasing the capacity of water treatment plants and supply the citizens consistently with enough of high quality drinking water.

Water reservoir is a water storage facility in the middle of water supply system and can secure consistent supply of the drinking water to the citizens by controlling the amount of water supplied directly to the citizens. The capacity of water reservoir is critical for consistent supply of drinking water to the citizens, as well as the capacity of water treatment.

Expansion and improvement of water reservoirs were not in the main project list as the priority of the policy was on capacity building for drinking water production.

More resources could be invested in the early 1990's after the city had enough production capacity. The total capacity of the water reservoirs reached to 1.3 million m3 in 1999, which could guarantee continuous supply of drinking water of 6.4 hours in any case.

As discussed above, the city could increase the RWR dramatically through installation of indirect water supply system using water reservoirs, and detailed leakage management by block system[48].

The 'Revenue Water Ratio (RWR)' is defined as the ratio of the volume of water paid by the customers to that supplied (Figure 17). The higher RWR means water loss in supply system is minimized. The water system with higher RWR can increase the managerial efficiency as the water demand and supply can be controlled precisely.

<table>
<tr><td rowspan="8">System Input Volume (corrected for known errors)</td><td rowspan="3">Authorized consumption</td><td rowspan="2">Billed authorized consumption</td><td>Billed metered consumption (including water exported)</td><td rowspan="2">Revenue water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled authorized consumption</td><td>Unbilled metered consumption</td><td rowspan="6">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Commercial (apparent) Losses</td><td>Unauthorized consumption</td></tr>
<tr><td>Customer Metering Inaccura-cies and Data Handling Errors</td></tr>
<tr><td rowspan="3">Physical (real) Losses</td><td>Leakage on transmission and/or distribution Mains</td></tr>
<tr><td>Leakage and overflows at util-ity's storage tanks</td></tr>
<tr><td>Leakage on service connections up to point of customer metering</td></tr>
</table>

Figure 17. International standard terms on water balance by IWA [ ]

[48] A block system can be defined as a pipe network system composed of "blocks" considering the characteristics of the area (i.e., elevation, road, streams, and rail ways) in order for efficient network management and easiness of water demand control [ ]. It is also called as District Metered Area (DMA).

3. Importance of the Policy

The water business of Seoul is quite different from other public organizations in its organizational, managerial, and financial characteristics. The water business of Seoul is one of the public services provided by the local government of Seoul. At the same time, it is operated as a local public company, i.e., the finance of the Seoul Water Authority is controlled as a special budget system depending only on the water tariff from the customers based on a self-supporting accounting system.

The Seoul Water Authority has the mission to provide the citizens with clean and safe drinking water as one of the public services. At the same time, the Authority has to achieve the goal of rationalization of administration and management as a company.

It is very important to reduce the prime cost and the operational cost through increasing the RWR and to collect the water tariff correctly for rationalization of water business management. It is critical to maintain the finance sound by increasing the RWR which is the ratio of the volume of water secured as tariff income to that of total produced and supplied [ ].

Although it's not easy to increase the RWR, the goal can be achieved through long-term plan for reducing non-revenue water by cause and consistent implementation of the plan. The main goal of water business is, generally, improvement of the system in terms of quantity and quality. Cost reduction and improvement of the lives of the citizens by increasing the system efficiency, can be the goal for the next step project. The city of Seoul could build an efficient water system through RWR increasing project.

As the results of the efforts, the Seoul Water Authority could increase the financial self-sufficiency and achieve rationalization of administration including replacement of old pipes, renovation of water treatment plants, outsourcing of a part of operation to private sector, and advanced redemption of debt with higher interest rate

The financial self-sufficiency of the Seoul Water Authority increased from 95.4% in 2002 to 100% in2004. The debt decreased by 75% between 2002 and 2007, i.e., 600 billion KW in 2002, 540 billion KW in 2003, 396 billion KW in 2004, 325 billion KW in 2005, 203 billion KW in 2006, and 150 billion KW in 2007. The city of Seoul could have frozen the water tariff for 12 years[49] since 2001 and return the benefits to the customers [ ].

High RWR is a base for safe and sustainable water system as it can rationalize management of water business and make the finance sound. RWR is one of the most important factors to continue the virtuous cycle of water business [ ]. A system, financially and technically stable, can achieve the essential goal of water business, i.e., to maintain water safe in quality and secure water enough to supply, and also have direct advantages in water tariff. The real meaning of the policy related with higher RWR is to provide the citizens with happy lives by supplying clean and safe drinking water.

The RWR of Seoul was 55.2% in 1989 when the Seoul Water Authority started its business. It

[49] The water tariff of Seoul was raised by 9.6% only once in 2012 since 2001. The increased production cost could be covered by rationalization of management.

reached to 95.2% in 2015 after continuous efforts to increase the RWR. The results of the project between 1990 and 2013 can be summarized as reduction of drinking water of 7.5 billion m3 (which can be used by 10 million citizens of Seoul for 6 – 7 years) and calculated as 4.2 trillion KW of financial benefit. The number of leak cases was reduced by 82.5%, by which the city could save about 1.8 trillion KW of budget. As the production could be reduced by the increased RWR, the 4 of the 10 WTP's (total capacity of 7.3 million m3/day) could be closed, i.e., 6 WTP's with the capacity of 4.4 million m3/day was enough to meet the water demand.

The WTP's closed were renovated to parks and recreational spaces for the citizens to increase the standard of life [ ].

4. Relationship with Other Policies

Although the policies for water demand and supply is related with other policies of the city, it is not affected much by other policies as the impact by changes of other policies is not that large to the water policies. Therefore, the policies related with the RWR may not directly relate with other policies than water.

Regeneration and Rehabilitation of Urban Areas

Regeneration and rehabilitation project for old residential areas are closely related with the RWR project. As the projects for urban rehabilitation may take more than 10 years from plan to completion, it may be hard to replace old pipes and manage pipe network efficiently. The project for higher RWR can be hindered by inadequate maintenance and remaining old pipes and abandoned pipes. Inadequate post-project measurement after demolition of buildings and treatment of abandoned pipes, can increase the possibility of leakage. It can also increase the amount of water leaked as it takes long to repair the supply system when it has a leak.

It is necessary to have measurement for facilities management including preventing leak, and closing abandoned and forked water posts, at the early stage of the urban rehabilitation project. A systematic management using O/M card can be a good example. Detailed water demand management by installing water meters on the main pipes in the area where the rehabilitation project is carried on. Control on water supply and pressure is also required to meet the decreased water demand by closed water posts and household move.

Upgrading GIS

It is necessary to update the GIS for systematic management of the facilities as well as for urban rehabilitation project. Although the projects related with upgrading GIS can be performed separately from the project to increase RWR, it is recommended to design the two projects together as GIS is a very useful tool to increase RWR. The project to increase RWR can be

managed efficiently by registering and managing the information related with urban regeneration project and data related with pipe network.

Facilities to Control Electrolytic Corrosion

The most important technical target for the project to increasing RWR is the pipe network and corrosion is related with leakage in the pipe network. Installation of the facilities to control electrolytic corrosion can affect the RWR directly in the conditions with lots of underground facilities. As the corrosion control facilities installed on the water pipes can promote corrosion on other facilities, the corrosion control facilities need to be installed and operated considering the effect on other facilities in underground.

Urban Safety

Leak from water main can cause safety problems such as road sink. The RWR project has to be designed to help other projects for the safety of the citizens.

Other Water Policies

Other water policies related with the RWR improvement project are, water demand and supply management [50], pipe network improvement projects (replacement, rehabilitation, and management of old pipes), and investment and budget operation strategies.

5. Target of the Policy

The RWR of Seoul is world-top-level of 95.7% as of August 2016. After thorough evaluation on capacity of each local service office including conditions of mid-size block management, field conditions such as regeneration/rehabilitation, and water supply management by flow monitoring systems, the city decided that 0.2 – 0.3% of increase every year could be achieved and set the goal of 97% in 2022. This level of RWR may be the maximum level that a waterworks system can achieve. As investment may be more than profit by increasing RWR above this level of RWR, the goal of a RWR project needs to be set systematically and scientifically.

The ultimate goals of RWR project are, 1) improvement of efficiency of water system by

[50] Water Demand Management (WDM) is a managerial approach of developing and implementing strategies to affect water demand to consume the restricted water resources fairly, efficiently, and sustainably [,]

management of RWR at higher but appropriate level, 2) steady supply of drinking water with higher quality, and 3) improvement in productivity of water system through balanced demand/supply management.

6. Main Contents of the Policy

The main contents of the policy include;

- Launching and operating a dedicated organization for drinking water
- Projects to reduce leakage using scientific and systematic leak detection based on ICT
- Projects to measure night minimum flow
- Projects to replace and rehabilitate old pipes
- Installation of water reservoir system using gravity
- Scientific water management based on water flow monitoring system
- Knowledge sharing programs to improve RWR

The project to improve RWR was carried out by phase as follows.

[1st Phase] was the initial stage of RWR increase project. It started from 1989 when the Seoul Water Authority was launched and until 1995. One of the largest advancements at that time was launching of the drinking water dedicated organization. It is necessary to have a dedicated organization to carry out projects related with increasing RWR through the strategy of ‘selection and concentration’.

Another goal in this time of period was to construct fundamental basis to increase RWR, i.e., installation of monitoring systems. Zonal flow meters were installed to monitor water flow by unit area. Each local service office could complete the monitoring system to estimate precise water flow in and out of the system. The projects carried out between 1991 and 1993 for replacement and rehabilitation of old pipes could be another basis for the RWR improvement project.

[2nd Phase] was the stage of full-scale project promotion between 1996 and 1999.

The Seoul Water Authority made a task-force-team for RWR improvement on October 12, 1998. The TFT was one of actions for the strategies for field operation of the project based on ‘selection and concentration’ concept. More detailed data and information were collected from the monitoring systems installed in the 1st phase. The project to manage RWR started with analyses on the accumulated data and information.

Precise amount of water supplied was measured and the RWR was estimated and managed.

Inadequate water meter was replaced for more systematic and scientific flow monitoring. The whole distribution area in Seoul was re-organized into 2,037 small blocks and minimum night flow was measured. The RWR could be increased based on the strategy of 'divide and conquer'.

Another important policy related with the improvement of RWR was one about urban regeneration. As discussed above, urban regeneration projects takes long time from plan to completion and the waterworks systems within the project area might be managed poorly. It is required more concentrated and detailed management on the waterworks system. As the city had more of urban regeneration projects, the management on the waterworks system within the project area was managed systematically and intensively since 1999.

[3rd Phase] was focused on making the results of the previous projects sustainable. In other word, the project of RWR increase was settled in this phase starting in 2000 until now.

The main goal of the policy in this phase was to maintain the high RWR consistently by constructing production and supply system for RWR increase.

The TFT for RWR increase was reformed into a permanent organization, the department of RWR, and the department became an organizational base to increase the RWR continuously and systematically.

The city had changed the water supply system into the 'indirect water supply' system by expanding water reservoirs between 2000 and 2003. With the 'indirect water supply' system with operation of booster stations, the authority could manage water pressure within appropriate level. Water meter reading was outsourced to private sector in 2001 as it had little to do with RWR increase although meter reading was very important business of the authority.

The management of pipe network was carried out in two approaches; the abandoned pipes were managed systematically and the RWR was managed by mid-size block unit. In the water supply management, the city started supply analysis and flow control based on the information from the flow monitoring system. The city could detect leaks in the pipe network successfully by introducing technology called 'multipoint leak noise correlator'. As the results of the project, the RWR of Seoul has reached to world-class of 95.2% in 2015 (Figure 18).

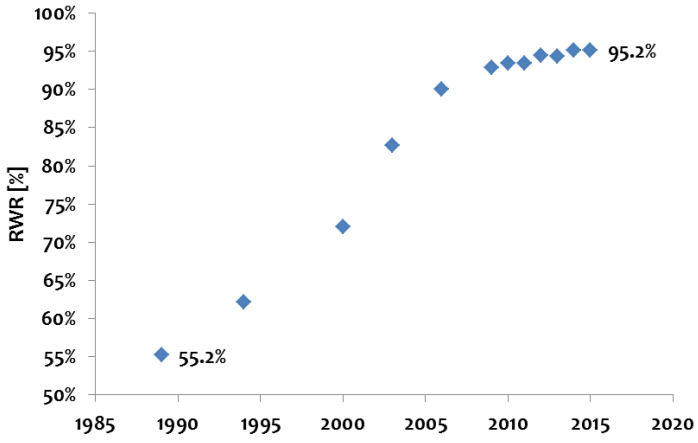

Figure 18. The RWR of Seoul

Economic feasibility is one of the most important factors to be considered to design an RWR improvement project. Economic loss by leaked water must be compared with the project cost to increase RWR (Figure 19). The cost by water loss is originated from physical loss and commercial loss. Physical loss is calculated with operational costs such as labor cost, chemical cost, energy cost. Commercial loss is estimated from water tariff. The cost for RWR management is defined as the costs used for RWR improvement including costs for labor, equipment, and transportation. The cost for RWR management definitely increases with RWR increased [ ]. Although it depends on the financial and technical conditions of the water business in the area, the RWR over 95% is close to the break-even point of investment and revenue. The focus of policy for future RWR needs to be more on managing and maintaining the RWR efficiently while increasing RWR is still important.

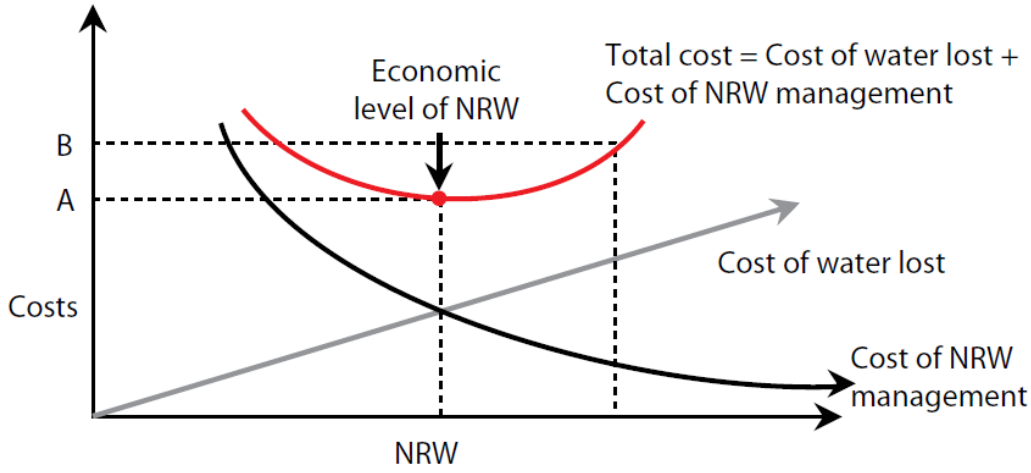

Figure 19. Determination of NRW considering economic feasibility [ ] (As RWR is the opposite concept of NRW, the graph can be understood as upside down relationship of RWR and economic feasibility)

7. Technical Contents

Replacement of Old Pipes

As of 2015, the total length of the pipe network of Seoul is 13,697 km, i.e., about 1.1 times longer than the diameter of the earth (12,756 km). The most effective way to increase the RWR is to replace the old pipes in the supply network system. The Seoul Water Authority invested budget of 1.7 trillion KW between 1984 and 2013 to replace the 87% (11,221 km) of the old pipes. The authority has replaced 97% (13,292 km) of the old pipes in 2016 with total budget of 3.3 trillion KW. Remaining 405 km of the old pipes will be replaced until 2018.

Although it differs by pipe material and diameter, the life of the pipe asset is generally 30

years51. The replacement of the old pipes has to be a continuous project based on technical and financial consideration. Criteria to determine the old pipe has to be established for the project to be effective. Studies on asset management are required to secure the efficiency of financial investment for RWR increase.

Measuring Minimum Night Flow (MNF)

Minimum Night Flow is defined as the measured rate of flow into any distribution network or district meter area during the minimum demand period on a given night. Usually it is between midnight and 4 AM. Although the conclusion of measurement depends on type of water supply, when the result of the flow measurement is between the minimum allowable leak of 0.5 m3/hr-km and 1.0 m3/hr-km, leak detection is carried out intensively and measurements to manage leakage is taken. The city of Seoul had measured the MNF at the 2,037 small-size blocks between 1998 and 2005. Currently, the MNF is measure for selected blocks. It takes overnight for 5 staffs to measure MNF of a block. After the valve installed at the boundary of blocks is fully closed to separate the block, the water flow and the water pressure into the block are measured (Figure 20). The remaining staffs check water meter with noise detecting poles. The water flows in all of the manholes in the block are also checked by naked eyes. If the staffs find any suspicious observation, they get into the manhole by themselves to check any leakage.

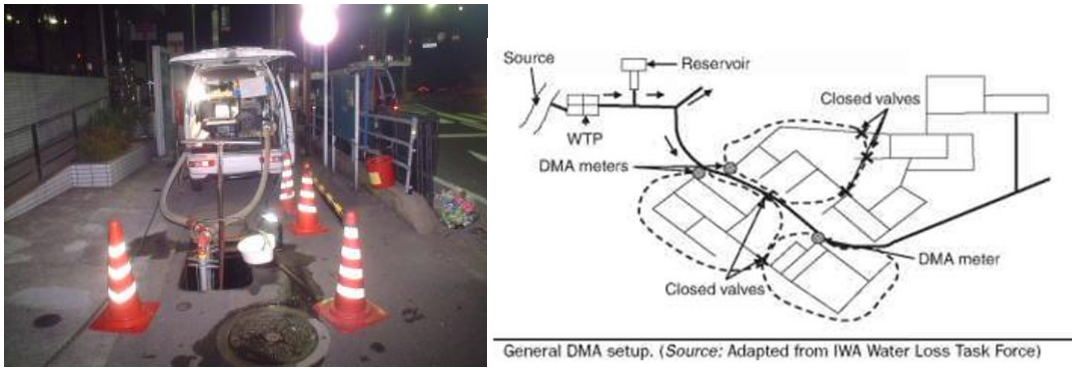

Figure 20. Minimum Night Flow and District Metered Area [http://goo.gl/gjnMI1(Left), http://goo.gl/Ju0azi(Right)]

[51] Life time: Literally, it means time to use a device or a facility with original condition. In waterworks system, it means time to maintain the facility in conditions acceptable by the city or the national standards even after contamination and physical deformation and changes in water supply. Life time of a pipe is hard to be specified as it can be affected by various factors including pipe material, age of pipe, underground condition where the pipe is buried, soil corrosiveness, traffic condition, population served, population density, water pressure, and water flow. Currently, the life time of pipe system is decided considering financial depreciation.

Systematic Leakage Management based on the Block System

A ‘block system’ is defined as a system of water supply network consisted of separated areas considering the characteristics of the area (altitude, roads, streams, railroads etc.) for efficient management of the water supply network and control on water demand and supply [ ]. Similar concept of District Metered Area (DMA) is also used internationally. It is very effective to analyze the changes in water demand and supply and leakage when the area for water supply is divided into small unit areas based on the hydraulic conditions. The water supply (flow, pressure, and quality of water supplied) in a block can be managed efficiently based on the more detailed data and information, and it helps increase the RWR.

As of the end of 2014, there are 2,037 small-size blocks, 100 mid-size blocks, and 29 large-size blocks in Seoul. The water supply network of blocks was constructed based on the unit block, the small-size block. Old pipes replacement, leak detection, and facilities check are carried out by the small-size block. The MNF measurement for all the 2,037 small-size blocks had been completed between 1999 and 2005. The RWR management by the small-size block is very efficient but requires too much of time, cost, and labor (Table 4). Currently, the city of Seoul manages the RWR by the mid-size block. If the RWR of the mid-size block is low, the RWR is managed by the small-size block.

Table 4. Process of RWR management by the small-size block [ ]

Step	Goal	Contents
1st step	Fundamental investigation of the block	To make list of current condition of the block including separation of the block, characteristics of the block, and current conditions of facilities for water supply
2nd step	Selection of block	To select relatively weak block with many leak cases among the blocks separable
3rd step	Measuring water supply and consumption	To measure water supply and consumption in the small-size block three times
4th step	Estimation of the RWR; Plans and strategies for the RWR goal	To make strategies and plans to increase the RWR considering changes in water supply and consumption

Geographic Information System (GIS)

The essential point in the RWR improvement project is to reduce water loss in the water supply system. The most fundamental and effective approach is ‘leak detection’ and ‘replacement of the old pipes’. For the RWR improvement project, it is essential procedure to diagnose the conditions of pipes buried underground, prevent leaks, and reduce loss by aged pipes.

Precise information of location and attributes of water pipes are quintessential to increase the RWR. GIS is a database and computerized management system to accumulate and manage

graphic and attribute data for common facilities, water pipes and attached facilities. A user can search for spatial information using waterworks GIS, manage construction, analyze and predict leakage. This can be a preemptive management method for the RWR improvement.

The city of Seoul built waterworks GIS between 1998 and 2001 for efficient management of the pipe network for water supply (Table 5).

Table 5. History of GIS building in Seoul [ ]

Goal	Contents
Building the waterworks GIS	1998: Plan for the waterworks GIS of Seoul 1999: Launching the project to build the GIS 2001: Completion of the GIS
Stabilization of the GIS	2002~2004: Maintenance of the GIS
Advancement of the GIS	2005: Improvement of the GIS 2007~present: Improving the accuracy of the GIS DB

The number of leak cases has been decreased continuously by the precise spatial information after the waterworks GIS was installed in the Seoul Water Authority. The cost for repairing leaked pipes could be saved big as precise drilling on the leaking point was possible. The quick and precise repair could reduce time to cut off water supply and increase the citizens' satisfaction on water service of Seoul. The waterworks GIS will evolved into a decision making support system with scientific analysis and prediction as well as support field work efficiently.

Water Pressure Control using Water Reservoir System

A water reservoir is water storing facility to supply the citizens in the area with water supplied from water treatment plant. The drinking water supply system in a city has to maintain consistent water flow and pressure even in the case of black out or leakage. Without water reservoirs, the function of continuous water supply cannot be secured. As the city of Seoul has many hills and mountains, the city makes use of the water reservoir system based on elevation difference for effective water pressure management as well as effective water quality and energy management.

The city of Seoul had constructed the local, the 1st and the 2nd water reservoirs since 2000. As of 2015, there are total 120 water reservoirs in Seoul with the total capacity of 2.4 million m3. The elevation difference between the reservoirs is about 30 m. A community is supplied with the drinking water from the upper water reservoir (Figure 21). With this system, any excessive water pressure can be controlled at appropriate level. It is very effective system for reducing leakage. In addition, as the water from WTP can be pumped to water reservoirs using relatively cheap power at night time and supplied to the citizens by gravity at day time, the cost for energy to pump can be saved a lot.

The total retention time in the water reservoirs is about 17 hours, which is much longer than 12 hours required by the waterworks system standards of the Ministry of Environment.

5% of all the water reservoirs in Seoul have shorter retention time than 12 hours. The authority has plans to increase the capacity of water reservoirs and build new reservoirs.

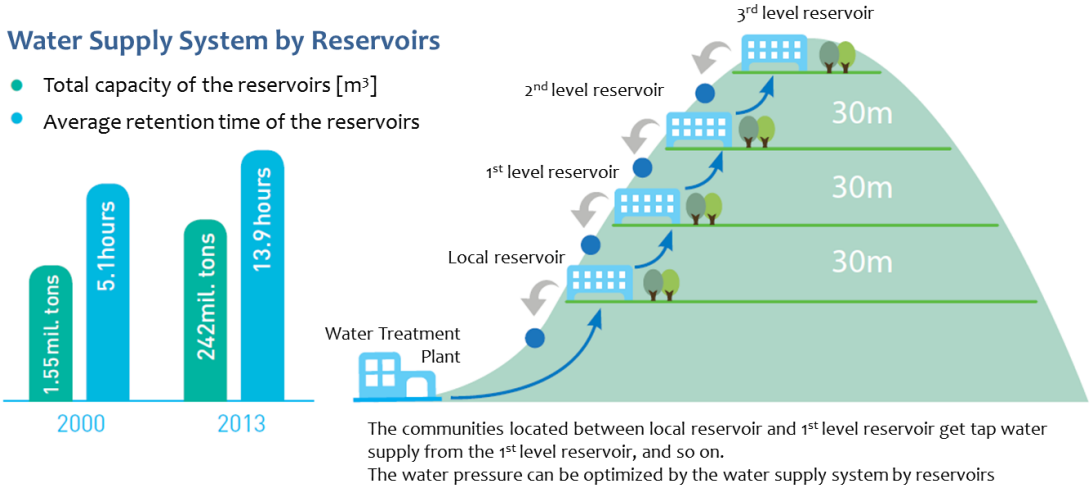

Figure 21. Water supply system of Seoul based on water reservoirs [ ]

[Multipoint Leak Noise Correlator] is a device or a system fining leaking point by detecting, collecting and analyzing acoustic data by leakage from water pipe. The device is very effective to determine leakage by the accuracy of 80%. When there are many pipes buried in relatively narrow space or the water supply and consumption is fluctuated much in the area, or there is big noise by structural characteristics, it may be very hard to analyze the data as the ratio of signal to noise (S/N) is too small. Therefore, it is recommended to collect data at night time when the water consumption and noise from surroundings is smallest, and increase the number of data collection.

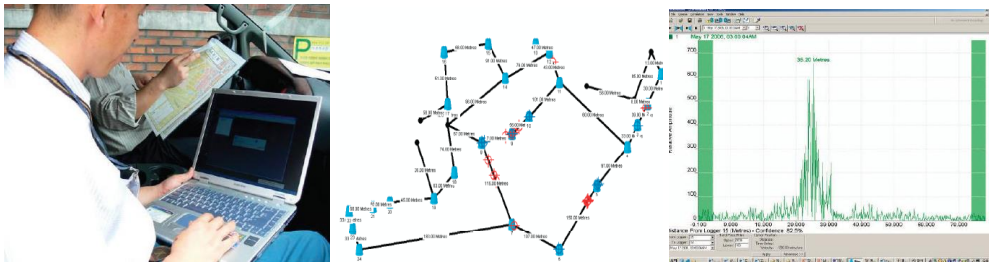

Figure 22. Leak detection using multipoint leak noise correlator [ ] (Upper left: leak detection device, upper middle: installing data logger in the valve room, upper right: data collection from the logger, lower left: data analysis, lower middle: symptom of leak (red dots), lower right: leak confirmation through data analysis)

8. Effect of the Policy

As mentioned above, the effects of the project to improve the RWR is evident and direct for water policy. Higher RWR means that water loss in drinking water production and supply is less. It could reduce drinking water production, cost for water source, and costs for materials and energy for treatment and supply processes.

As the result, the managerial efficiency of the waterworks business becomes higher and the citizens can have financial benefits and trust the public service of Seoul including the drinking water service. The social benefit from the citizens' satisfaction is priceless.

As the RWR of Seoul was over 80% in 2000, the city could supply the citizens with enough drinking water from the WTP's with the total production capacity of 3.4 million m3/day. The rate of the WTP operation was about 60% lower than the recommended 75%. As the results, the part of Gui WTP in 2002, the part of Tukdo WTP in 2003, and the Shin Wall WTP in 2003, and Bo Kwang WTP in 2004 were closed. Extra water due to increased RWR could be supplied to the nearby cities with rapid population growth and increased water demand and the city of Seoul could make additional profits52.

Increased benefit of the citizens due to the improved RWR resulted in frozen water tariff. The city of Seoul could freeze the water tariff for 10 years between 2001 and 2011 with increased financial capacity through the RWR improvement project.

The increased production costs could be compensated by the RWR increase and organizational

[52] After investigation of water supply conditions in nearby cities within water supply area of Seoul in 2001, the city decided to supply the cities of Kwang Myung, Han Nam, Ku Ri, Nam Yang Joo, Kwa Chun, and Sung Nam with drinking water of 75,000 m^3 every day. The Seoul Water Authority has a plan to supply other cities of Eui Jung Boo and Dong Doo Chun as a long-term project and makes every effort for 'tap water sales' [ ].

reform, and the city could reduce financial burden of the citizens. In 2012, the water tariff of Seoul was raised by 9.6% to make budget for financial investment on the advanced water treatment process. The water tariff has been frozen again since 2013 through continuous RWR improvement and efficient management.

The closed WTP's were transformed into parks and recreational facilities for the citizens and contributed to increasing the quality of public service for the citizens.

The successful project of RWR increase improved the citizens' satisfaction on various public services of Seoul including drinking water service by the Seoul Water Authority.

9. Difficulties and Overcome

One of the largest difficulties for the project to improve the RWR was the underground facilities buried with the urbanization of Seoul, as the complicated conditions did not allow effective replacement or rehabilitation of old pipes. Through the project to improve the precision of the waterworks GIS, the city could understand accurate location and structure of underground waterworks facilities including pipe network. The GIS has improved continuously.

More systematic and scientific separation and management on block unit has been carried out for more detailed management on leakage.

The urban infrastructure for waterworks system in Seoul has been stabilized decades ago. Another aspect of stabilization of system is that the system gets old. Although 97% of old and corrosive pipes were replaced and all of them will be replaced with new pipes by 2018, the pipe replaced in 1984 when the replacement project started became old pipe to be replaced. That is to say, consistent financial investment and preemptive old pipe replacement are required to maintain the performance of the waterworks system in outstanding level. The problems can be solved with long-term financial investment plan and asset management system.

Although the water reservoir system is also stabilized, support from the citizens in the area and the borough office is inevitable for increasing the capacity of water reservoirs and building new reservoirs. To make parks and recreational facilities on top of the water reservoirs can be a good approach to solve civil complaints related with water reservoir construction. The city needs to communicate with the stakeholders at the beginning of the project to build water reservoirs.

References

- Arntzen, J., 2003, Incorporation of water demand management in national and region water policies and strategies, IUCN
- Choi, Y.J., 2016, Time to share! A centennial journey of Seoul Waterworks System, Addis Ababa-Seoul Urban Planning Capacity Building Program I
- Desalege, W.B., 2005, Water Supply Coverage and Water Loss in Distribution Systems, International Institute for GIS & Earth Observation, Enschede, The Netherlands
- Farley, M., et al., 2008, The manager's Non-Revenue Water Handbook, USAID
- Simbeye, I., 2010, Managing Non-Revenue Water – NRW Sourcebook for Trainers WAVE Pool, ImWEnt
- Kang, SJ, et al., 2015, White paper on the RWR of the waterworks system of Seoul
- Seoul Water Authority, 2008, A centennial history of the waterworks system of Seoul
- Seoul Water Authority, 2014, Management of RWR and leakage, Seoul Policy Archive (https://goo.gl/NT0uJo)

New Renewable Energy
(One Less Nuclear Power Plant)

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1. New Renewable Energy System and Policy

Based on the official effect of the Tokyo Protocol in 2005, it is predicted that the obligation of reducing greenhouse gases will need to be performed during 2008 to 2012, and Seoul, as a biggest energy consumer in Korea,is required to support the government's new renewable energy and renewable energy policies as well as make concerted efforts to promote the reduction of atmospheric contamination and the relief of global warming.

Through the Seoul Energy Declaration in Seoul in 2007, the goal of the nation's first low carbon society vision and the obligation to reduce greenhouse gases were established. Furthermore, the '5 year Green Growth Plan (2009-2013)' was proposed to apply low carbon technologies and develop green cities. Along with this plan, demonstrative cities with respect to the low carbon urban restoration project and low carbon energy saving new city developments were selected and supported. From this, the specialized new renewable energy supply project was initiated for residential housing, buildings, and regions.

Seoul reflected the regional properties and the flow of the international society in order to establish the 'Energy Master Plan' in 2008. This plan proposed the vision of 'the realization of sustainable energy' and, in the following year, Seoul city reinforced its relativity with the Energy Master Plan to announce the '2030 Seoul Energy Master Plan' including the vision of 'low carbon green growth'. To realize this plan, Seoul city proposed three initiation strategies of the low energy consumption city, energy recycling city, and energy welfare city. To initiate the three strategies, specific plans were established, such as guarantees of basic energy rights, in addition to long and short term energy saving, increases in efficiency, and low carbon energy supply plans in the home, commercial buildings, transportation, and public fields. In 2011, Seoul city set the goal to reduce the emission of greenhouse gases, reduced energy usage, and increased use of new renewable energy as part of the 'Seoul Energy Declaration'. In addition, the '2030 Seoul Green Design Masterplan' was established to conform to the vision of the basis

[53] Translation by ESL®

of the government's policy of low carbon green growth, and to propose an initiation plan that emphasizes the properties of the metropolis of Seoul, and includes integrated and long term plans.

As an integrated means of the 「One Less Nuclear Power Plant Plan」 through reduced energy consumption and increased generation of new renewable energy, the goal of reducing 2 million TOE of energy by producing 410 thousand TOE of new renewable energy (including solar power and hydrogen cell), and reducing 1.59 million TOE through low energy consumption and the efficient use of building transportation energy, was established in 2012.

In 2014, the goal of Phase 1 of the One Less Nuclear Power Plant Plan was achieved, and Phase 1 initiation projects were effectively reinforced and expanded to new fields in order to initiate Phase 2 of the One Less Nuclear Power Plant Plan. It aims to reduce 40 million TOE of energy, gain 20% of energyby 2020, and to reducet of 10 million tons of CO2 of greenhouse gases.

Table 1. Comparison of Phases 1 and 2 of Seoul City's 「One Less Nuclear Power Plant Plan」

	Phase 1	Phase 2
Vision	▪ Energy self-reliant construction	▪ Energy self-reliant city, Seoul - Three values of energy: independence, sharing, participation
Goal	▪ Reduction of 20 million TOE of energy	▪ 20% power independence rate (2020) - Reduction of 40 million TOE of energy, reduction of 100 million ton of greenhouse gases
Strategy	▪ Production, efficient use and saving of new renewable energy	▪ Change of the social structure through institutionalization - Dispersive energy generating city - Efficient low consumption social structure - Innovative energy employments - Warm energy sharing community
Task	▪ 71 projects in three fields	▪ 88 projects of 23 tasks in 4 fields

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

One Less Nuclear Power Plant Plan

Seoul city predicted that the reduction of 2 million TOE in Phase 1 of the One Less Nuclear Power Plant Plan would be completed in the first half of 2014, six months earlier than planned,

and so discussed the methods of establishing the succeeding plan from January 2014.

Phase 2 of the One Less Nuclear Power Plant Plan comprised various means of professional meetings, citizen discussions, and the analysis of overseas cases to realize the values of energy self-reliant programs, sharing and participation as pursued by Seoul. These were based on improved policies and the innovation of the energy consumption structure achieved by Phase 1.

Discussions of Phase 2 of the One Less Nuclear Power Plant Plan were conducted around private and governmental governance organizations, 'One Less Nuclear Power Plant Plan executive committee' and the executive committee discussed the values and visions of Phase 2 of the One Less Nuclear Power Plant Plan. In order to establish an efficient executive plan, the existing four divisional committees were reformed into five divisions of general affairs division, energy generation division, energy efficiency and saving division, energy industry and employment division, and energy welfare and the community division. Through many meetings, the tasks required to achieve the visions and values were devised. Furthermore, an initiation plan was discussed, and a forum was held to discuss policy he energy industry to collectbroad opinions of professionals and citizens.54

Table 2. Phase 2 Executive Plan of One Less Nuclear Power Plant

General Affairs Division	Production Division	Efficiency and Saving Division	Industry and Employment Division	Community and Welfare Division
* Organization of plans * Reformation of policies and regulations	* Renewable energy * Dispersive energy, etc.	* Building and transportation sectors * Eco mileage, etc.	* Industry and employment support * Social corporation support	* Low income class support * Donations and sharing projects

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

To devise projects in Phase 2 of the One Less Nuclear Power Plant Plan, the opinions of citizens were actively collected through discussions and internet forums. The name was selected as 'Phase 2 of the One Less Nuclear Power Plant Plan' through a public naming competition in February 2014. In March, a survey was conducted on 2,000 citizens on the awareness and willingness to participate in the One Less Nuclear Power Plant Plan. Furthermore, the 'Social Fiction Festival for One Less Nuclear Power Plant Plan Phase 2 was held at Seoul City Hall under the theme of '10 million citizen's Sunlight Imagination Fair for Energy Self-reliant City of Seoul' attended by 400 citizens to voice their opinions.

Phase 2 of the One Less Nuclear Power Plant Plan was planned to effectively reinforce the projects of Phase 1 and to manifest the energy value through a progressive change of the production and consumption structure of energy and eco-friendly policy. Furthermore, efforts

[54] Combined Plan of the 「Seoul Sustainable Energy Action Plan」, Seoul City (2014)

were made to supplement the problems including lack of governance and integratedexecutive, which were found in phase 1. Moreover, the committee focused on application of newly developed technologies, introduction of previously implemented policies and exploration of new tasks.

2. Policy Goal

The management of quantitative goals in Phase 1 of the One Less Nuclear Power Plant Plan evolved to energy value goals in Phase 2, deducing the three values of energy self-reliance, energy sharing, and energy participation.

Energy Self-Reliance	* Decreased dependency on external energy to facilitate conversion into a responsible energy consumption city * Generation of safe and sustainable energy in preparation for an energy supply crisis * Expansion of energy industry and employments through the process of energy self-reliance
Energy Sharing	* Citizens who enjoy energy services share their resources to energy minority classes and sharing with the future generation - Coexistence through energy welfare in minority classes and fair distribution of energy generation and consumption
Energy Participation	* Construction of energy governance for the establishment and execution of energy policies * Publication of energy information and policies, and provision of education and training opportunities

Figure 1. Three Values of Phase 2 of the One Less Nuclear Power Plant Plan

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

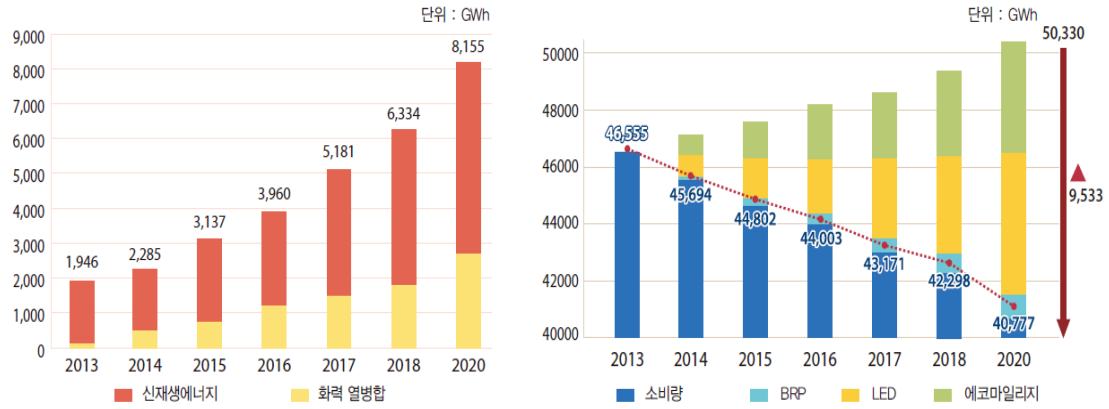
Seoul city has set the goal of expanding energy self-reliance from 4.2% in 2013 to 20% by 2020. 46% of this rate is to be achieved through new renewable energy and thermal convergence development, and 54% is to be achieved through improved energy efficiency and energy saving.

As a core index, energy self-reliance pursues the energy justice from an energy consumption city to a generation city, and reflects regional energy policies that supplement the government's policies on mass production and mass transmission. Furthermore, it is also an index for ascertaining the initiation achievements of the increased efficiency policy and the generation of dispersive energy. The goal energy self-reliance rate is an index that represents the generation of new renewable energy and dispersive energy, efficient usage and saving, and can be considered as the goal achieved by increasing generation and reducing consumption. There are difficulties,

however, in reflecting the effort and achievement of reducing other energy sources, such as fossil fuels, and thus, the reduction of greenhouse gases and the amount of generation and reduction of the total amount of energy (TOE) are concurrently managed.

The amount of energy consumption in Seoul in 2020 is prospected to be 50,330GWh, which applies the 1.2% increase rate of the average energy usage in Seoul over five years from 2009 to 2013. Energy consumption is planned to be reduced to 40,777GWh by 2020, by reducing 9,553GWh through Phase 2 of the One Less Nuclear Power Plant Plan. 5,639 GWh will be reduced through increased efficiency of energy by introducing BRP and LED, and 3,914 GWh will be reduced through energy saving using methods such as eco mileage.

In addition, 8,155 GWh of energy is to be generated through the expansion of new renewable energy and thermal power generation, as well as heat convergence generation, in order to achieve an energy self-reliance of 20%. Through the generation of new renewable energy, including 256GWh of solar power and 2,365GWh of fossil fuel, a total of 2,711GWh of energy will be generated, and 1,195GWh of group energy, 803GWh of self-heat convergence energy and 3,446GWh thermal energy will be generated to equate to 5,444GWh of energy.



Prospects of Energy Generation	Prospects of Energy Consumption & Reduction Rate
□ New Renewable Energy	□ Consumption
□ Thermal Heat Convergence	□ Eco mileage

Figure 2. Core Index: Prospects of Achieving an Energy Self-Reliance of 20%

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

Seoul city has proposed the goal of reducing 10 million tons of greenhouse gases by 2020, a 20.5% reduction compared to 49,008,000 ton CO2eq of emission in 2011. To achieve this, there are plans to improve energy efficiency by 2,861,000 tons CO2eq, generate 2,148,000 tons CO2eq of new renewable energy, save 2,119,000 tons CO2eq, supply 2,094,000 tons CO2eq of LED, transport 576,000 tons CO2eq, and generate 245,000 tons CO2eq of thermal energy.

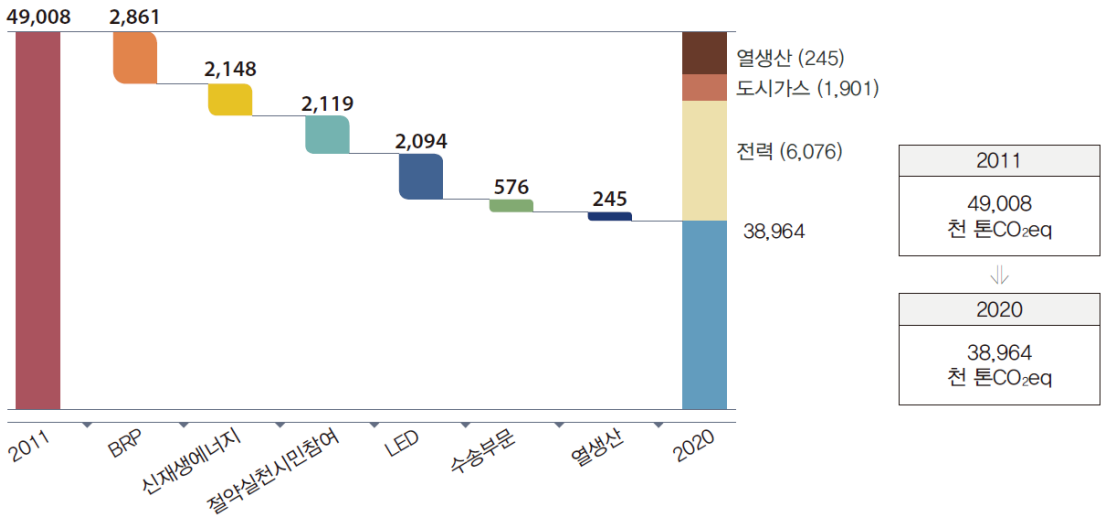


Figure 3. Reduction of 1 million tons of Greenhouse Gases

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

3. Necessity of Plan

Seoul's energy self-reliance rate is remarkably low compared to energy consumption, and the generation of new renewable energy is a mere 1.5% of the energy consumption. Thus, there is a need for a new paradigm regarding energy policy.

Although nuclear power is a cheap and efficient source of energy, significant sacrifices and costs arise if a problem occurs, demonstrated by the Fukushima nuclear accident in Japan. Seoul city is reducing the need for the nuclear power plants through the generation of environmentally friendly energy sources. As much as 90% of greenhouse gases, which increase the earth's temperature, are caused by the generation and consumption of energy; thus, Seoul has made efforts to decrease the rising temperature of the earth and to make Seoul healthy and safe for future generations.

Due to possible depletion of fossil fuel and climate change, new renewable energy is noted as the future's sustainable energy source. However, the new renewable energy sources that have been developed so far encounter problems of low energy sufficiency or costs. There is a need, therefore, to introduce better research and development and policies for new renewable energy. Seoul is making an effort to further expand new energy and renewable energy sources that can be introduced.

Low energy supply rate (3.0%) Rapid increase in power consumption	Need for energy self-reliance in preparation of an energy crisis	Reduction of 2 million TOE of energy through the reduction of energy consumption and expanded generation of energy
Increased anxiety of the citizens after the Fukushima nuclear accident	Obtainment of safe and sustainable energy	
Intensified climate change, such as global warming	Need for reduced greenhouse gases	

Figure 4. The Need for the 「One Less Nuclear Power Plant」 Plan

Source: One Less Nuclear Power Plant Plan Guidelines, Seoul City

4. Main Policy Contents

One Less Nuclear Power Plant Plan Phase 2 primarily initiates 10 core projects divided into 88 unit projects and 23 tasks. It has four basic guidelines of the dispersive energy generation city, social structure with energy efficiency, good energy work sites through innovation, and the warm energy sharing community.

4 Guidelines of Energy Policy			
Expansion of Dispersed Generation 5 Tasks, 19 Projects	Energy Efficient City 9 Tasks, 34 Projects	Good Energy Work Site 4 Tasks, 17 Projects	Realization of Welfare through Sharing 5 Tasks, 18 Projects
1. Seoul City of Sunlight! Project 2. Opening of the dispersion energy generation era in buildings 3. Expansion of group energy to 60,000 units by saving 20% of heating cost 4. Finding unused energy within the city 5. Active support for energy self-reliance with innovative policies	1. Proclamation of zero energy in new buildings 2. Healthy and comfortable architectural city through energy diagnosis and increased efficiency 3. Reinforced responsibility of increasing efficiency in energy in the public sector 4. LED light city Seoul! 5. Reformation to low energy consumption urban space structure 6. Expansion of green car supply 7. Energy saving traffic environment city 8. Settlement of an energy saving citizen life culture 9. Creation of the world's best recycling city	1. Creating green energy work places with the citizens 2. Customized support for each phase of the life cycle of green energy corporations 3. Construction of the green energy industry and green technology infrastructure 4. Fostering green IT-based green energy innovative technologies	1. Construction of citizen participating energy welfare fund (platform) 2. Guarantee of basic energy rights 3. Conversion and increased efficiency of reducing energy costs 4. Special means for the energy minority class 5. Energy community project

Figure 5. 4 Energy Orientation Points in of the One Less Nuclear Power Plant Plan Phase 2

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

Dispersive energy generation city

Next is a focus on the initiation of the 4 projects of citizen participation, dispersed power, new renewable generation, and regional specialize energy. The initiation goal is to expand small scale dispersive power through new renewable energy and thermal convergence generation.

Citizen Participation	Dispersive Power	New Renewable Generation	Regional Specialized Energy
40,000 mini solar power	61 MW self-thermal convergence	300MW solar power and fuel cell	1.65 million Gcal cooling heat and burning heat

Figure 6. Initiation Goal of Dispersive Energy Generation City

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

More support is offered to expand the supply of new renewable energy led by the public sector to include the small scale generation of private buildings as well as the initiation of policies joined by citizens, including mini solar power, sunlight generation citizen funds, and mini power plants.

Along with the obligatory implementation of dispersive power, policies to increase power generation are implemented. To achieve this, Seoul will introduce stricter criteria forthe environmental impact assessment, and lower the city gas cost for fuel cells and thermal convergence generation.

1) Production of ‘Healthy and Clean Electricity’ with Citizen Sunlight Generation

- For the conversion of citizens from energy consumers to energy generators, interest in environmentally friendly energy is induced by supplying 40,000 250W ‘mini solar power generation facilities’, which then allow easy installation in apartments and housing verandas.

- 10MW solar power generation facilities will be installed on urban roads and streets by 2018 to compose a ‘sunlight generation citizen fund’, which is directly invested and profited by citizens.

- The installation of solar light is continually expanded using unused spaces (such as school roofs and corporate buildings), and the locations for the installation of solar power generation facilities using public sites are then diversified.

- The improvement of policies for the expansion of installing solar power generation facilities is continually carried out while the reintroduction of the FIT policy is proposed to the central government topreserveprofits of small scale generation businesses.

Figure 7. Solar Power Generation Facility Building

(Source: Seoul Remarkable Environment Policy (Energy City Seoul) One Less Nuclear Power Plant Plan, Seoul City)

구 분	합계(MW)	공공시설	민간시설	학교시설
2012~2014	63.9	33.3	26	4.6
2003~2011	20.4	6.3	12.2	1.9
계	84.3(100%)	39.6(47%)	38.2(45.3%)	6.5(7.7%)

*2014년 말 기준

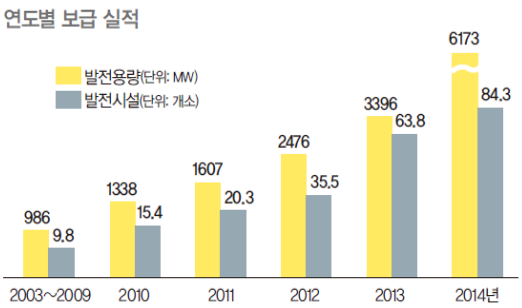


Figure 8. Current Status of Solar Power Generation Facilities

(Source: Seoul Remarkable Environment Policy (Energy City Seoul) One Less Nuclear Power Plant Plan, Seoul City)

2) Safe City with Dispersed Electricity Generation

- As of 2013, there were 46 units of 89MW self-thermal convergence generation facilities, such as apartments and buildings, in Seoul. Thermal convergence generation facilities, which generate electricity and heat in large buildings, are to be expanded from 90MW in 2014 to 150MW in 2018.

Figure 9. Rooftop Solar Panel in Gangseo Agricultural Market

Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City

- In order to increase the power independence rate of housing, old boilers are replaced with extra small heat convergence boilers. These generate electricity and 10,000 sterling engine boilers are scheduled to be supplied to individual homes, such as apartments and villas, by 2020.

- The stability of the operation of city based facilities is maintained through an emergency power supply by installing 174MW fuel cell plants. These have the effect of a high attraction of private investment and power independence by 2018, and installing 20MW fuel cell in city based facilities, such as rail bases (Shinnae, Suseo, Jichuk) and the Seonam water regeneration center.

- Group energy supply facilities are to be constructed for the stable supply of heat sources in the Magok region. The expected heat demand will be responded in connection to the Mokdong thermal convergence plant and GS Power's Bucheon power plant, A 280MW combined gas power plant facility is to be constructed in 2017 for use as a stable heat source after 2020.

- Efforts are extended to improve policies on expansion of dispersive power. In order to increase the installation of new renewable energy facilities over the newly constructed large buildings with surface areas of above 100 thousand m², Seoul will have higher score on the obligatory installation of new renewable energy facilities as one of the deliberation criteria of EIA.

Figure 10. Case Study of Solar Light installed on a Roof

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

3) The maximum use of energy in adjacent cities and wasted energy

- Wasted thermal energy is collected for regional floor heating. Hydro energy sources are actively extracted from Jamsil reservoir, water regeneration centers, and purification centers, based on substantive projects to install a 3,160㎾ scale hydro power plant by 2018.

- Wasted heat sources from adjacent local governments and private corporations are collected to supply the heat source for 10 thousand units, and 35 thousand Gcal is to be supplied per year in connection with the metropolitan heat pipe networks in 2018.

- Through the participation of citizens, the creation of resources is promoted by enhancing recycled waste of vinyl and fabric. Waste vinyl bins will be used in all regions of Seoul to recycle 243,000 tons by 2018, and separated disposal of fabric will be enforced to recycle 168,000 tons of waste fabric by 2018.

Energy efficient social structure

Buildings consume 56% of energy, 87% of electricity, and vehicles release20% of greenhouse gas emissions, which cause atmospheric contamination. There shows an urgent need for special means to combat this - including the efficient use of buildings, LED supplies, environmentally friendly traffic, and urban planning.

Efficient Use of Buildings	Supply of LED	Environmentally friendly Traffic	Urban Plan
Energy diagnosis systematization (2015) Publication of energy efficiency (2015)	Public 100% (2018), Private 25% > 65% (2018)	Increased charge for greenhouse gas emission	Production of energy map, reinforced inspection of environmental efficiency

Figure 11. Initiation Goal of an Energy Efficient Low Consumption Social Structure

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

Support, such as facility improvement cost loans are continually expanded for the efficient use of energy, while the introduction of the obligatory efficient use policy is supplemented in consideration of the fact that the policy is still in a nascent stage. To achieve this, policies related to the environmental effect evaluation deliberation standards, green architecture planning standards, and public architecture planning standards are reinforced. Moreover, the concurrent application of institutional regulations and the efficient use of energy are reflected to the market value of buildings to compose a basis for the efficient buildings project to be initiated by market principles. Furthermore, the obligation of diagnosis, substantive application of architecture energy consumption verification policy, and the publication of energy grades will be initiated.

1) Introduction of improved energy efficiency and market principles for buildings through policies

- Seoul will have have stricter deliberation criteria for environmental impact assessment(EIA), obligate the installation of the building energy management system (BEMS), and replace all lighting in buildings to LED lights by 2018 in order to improve the efficient use of energy in large buildings and large scale development projects. This will reinforce the construction of buildings with the level 1 energy efficient.

- Policies are to be improved to have stricter energy audit program on large buildings that consume 2,000 TOE of energy, and an energy reduction model for each application (including hospitals, schools, professional facilities, and hotels), is to be developed and supplied through research.

- A financial basis is to be composed, such as loans for the efficient use of energy in buildings and housing; the scale of these loans and the beneficiaries of this support for efficient buildings are to be expanded, and energy audit is required upon applying for any BRP projects, in order to encourage the reinforcement of the BRP project.

- The beneficiaries of the loans are to be expanded to include energy audit, eco-friendly boilers, and air conditioning devices, in addition to windows and insulation, as well as installation and replacement, operation systems, and monitoring costs. Furthermore, up to 15% of asset tax is exempt upon obtaining the new green architecture certificate or architecture energy efficiency level, and the same benefits are applied to existing building efficiency projects.

- The verification system of the energy efficiency level evaluation report is to be enforced for the value of efficiency projects applied to buildings to be reflected in the trading price of buildings.

2) LED light in all public facilities

- 100% of lighting in public buildings, subway stations, and security lights are to be replaced with LED lighting by 2018, and 65% of lighting in private sectors, which accounts for 30 million units, is to be replaced with LED lighting.

Figure 12. Solar panels installed at Yangcheon River

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

Figure 13. LED installation at Dongdaemun History and Culture Park

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

3) Human-oriented, energy saving traffic environment city

The car sharing project, which saves energy through the reduction of traffic consumption, achieves the effects equivalent to the reduction of 3.4 vehicles per one participating vehicle a year, and equivalent to the reduction of over 10,000 personal vehicles for 3,000 shared cars a year. Furthermore, the system is to be reformed to focus on consumers in apartments, public organizations, and corporations, to expand from 1,500 vehicles in 2014 with 1.68 million users, to 3,000 vehicles in 2018 with 2.5 million users.

- Electric vehicles are estimated to achieve the effect of reducing 25% of greenhouse gases including the generation phase compared to standard vehicles. Thus, the emission of fine dust and the consumption of energy are to be reduced through the supply of electric vehicles (green cars).

4) Settlement of public culture of saving resources and energy

- The citizens' representative energy saving program of the eco mileage system is to be continued. 1.68 million eco mileage members in 2014 is to be expanded to 2.8 members by 2018, and 850 thousand TOE of energy, such as electricity and city gas, is to be reduced. To achieve this, members will be obtained through connection with various new renewable energy sources, BRP, LED, and consulting projects, while optimizing energy reduction through monitoring, effect analysis and feedback of the participants.

- Discarded garbage is recycled and changed to energy, while various projects are initiated in order to connect such processes to employments and industries. First, recycling stations will be installed in housing units to increase the recycling rate and to provide employment. About 1,128 stations in 73 quarters in 2014 will be expanded to 3,500 stations by 2016, and the effect of employment creation will be increased through the efficient management of recycling stations by appointing a total of 10,000 station managers with 15 to 30 managers per quarter.

5) Reflecting energy concerns in city policies including climate energy map and urban plans

- An energy map is to be produced to be used as basic data upon establishing main urban plans and climate environmental plans - including city plans, and site usage plans. The energy map is to reflect the researched properties of each region and building with respect to the distribution of use, climate, and the current usage of energy source.

- In order to compose living zones for minimizing the loss of energy consumed during commute and rush hours, the '2030 Basic Urban Plan' will be established. The specific plan includes the composition of pedestrian friendly living zones adjacent to work and housing, the reformation of spatial structures within metropolitan areas in connection with public transportation in order to suppress the use of personal vehicles, and the prevention of the energy-inefficient expansion of urban regions.

6) Reduction of greenhouse gases through the ‘One Less Nuclear Power Plant Plan Phase 2’

- The ‘emission tradingscheme’ delegates a permissible amount of annual emissions to businesses that release a lot of greenhouse gases. It also allows the trading of leftover amounts or insufficient amounts among businesses. The scheme is for corporations that have released more than an average of 125,000 tons CO2eq and businesses that have released more than 25,000 tons CO2eq onaverage over the past three years. 25 facilities in Seoul are included within these scopes, such as waste processing facilities, including the Nowon Resource Recovery Facility, and water regeneration centers that process water.

- Seoul city prepares greenhouse gas inventories by apprehending the greenhouse gas emissions and the current status in each sector. It then uses the inventories as basic data for the greenhouse gas reduction plan and the institutional direction. A greenhouse gas inventory organization is selected to initiate composition and verification, and an efficient reduction plan is to be carried out in connection to the greenhouse gas emission right trading system.

Good energy work sites through innovation

Seoul’s basis for the green energy industry is very weak. Among the approximately 10,000 businesses, 99% are small-and-medium businesses and 59.1% small scale corporations with 5 or less employees. Although investment in new renewable energy, such as solar power, increased with Phase 1 projects of the One Less Nuclear Power Plant Plan, the main products, such as solar power modules, are mostly produced in district areas. Thus the effect of direct contribution to employment creation was relatively small.

Structuralization of green industry	Citizens’ energy project	Regional energy service	Support of green corporations
6 green clusters	70 social corporations and cooperatives	25 energy hub centers	234 enterprise supporting corporations

Figure 14. Initiation goals of good energy work sites through innovation

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

With continual investment in new renewable energy and LED industry fields, new facilities are to be installed, and service industries for post-management will be nurtured. Furthermore, the pioneering introduction of new technologies suitable for Seoul, such as BEMS and the smart grid will be supported. The customized support for each life cycle is reinforced by considering many small-and-medium corporations with poor management skills and that the formation of industrial market in its initial stage.

Employment in the service industry is based on region, and thus, this project is to be initiated to allow the participation of regional residents and in connection with the energy welfare of the community.

1) Green Metropolitan Seoul, Nurture of Seoul's green energy industry

- G-Valley, located in Guro-gu of Seoul, is the largest cluster of new renewable energy corporations (including 60 new renewable energy corporations, 117 green IT corporations, and 44 LED corporations), and there is a high possibility of connection with the ICT corporations in G-Valley. Furthermore, green industries, such as IT integration, urban resource circulation, and green architectural service, are to be expanded to six regions within Seoul, and the focal industries will be appointed based on the experience of G-Valley, with various services supported for nurturing of the industries.

Pilot Operation	Expansion	Creation of Achievement
Creation of Pilot Cluster	Creation ofRegional Cluster	Combination of Regional Clusters
* Demonstrative new renewable energy cluster project in G-Valley	* Initiation as a contest targeting the concentrated areas of green industries * Consortium of local governments, universities, research institutes and regional groups	* Joint research and production of fused products that include solar power and LED * Nurturing of independent and global cluster

Figure 15. Initiation Direction of the Seoul Green Industry Cluster Nurturing Project

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

- Seoul city is initiating the pilot smart grid (intellectual power network) project for the establishment of a demand management market and to improve energy efficiency by fusing IT to the existing power network. Various types of projects are to be initiated according to the regional situation and properties of Seoul. Specifically, the project will be initiated in Sadang-dong region in connection with the community energy supply system (CES). The urban industrial complex efficient energy project is to be initiated in Guro Digital Industrial Complex, increased efficiency of energy will be initiated in city railway by Seoul Metro, and the intellectual wiring power network is to be initiated in unit-divided apartments. Together with these projects, the electric gauge, which allows automatic power consumption and demand management, will be supplied to a rate of 50% in 2016 and 100% by 2020. Furthermore, the electricity usage information alarm system, which alerts electricity usage and gradual increase in real time, is to be developed and demonstratively applied to apartments in Seodaemun-gu.

2) One-stop customized support for green corporation for each lifecycle

- To support the foundation of green corporations in Seoul, the 'Green Corporation Enterprise Fund' is operated. A total of 8 types of funds are composed equating to 126 billion won - including 46 billion won in 3 funds during Phase 1 and 80 billion won in 5 funds during Phase 2. The fund will be used to support corporations that have green technologies, but lack financial

strength, for 4 to 5 years. Prospective venture corporations are prioritized to annually provide financial support from the 25 to 30 billion won small-and-medium business nurturing fund.

- To create jobs in the green industry, the development of green technologies has been actively supported. First of all, financial support will be granted on the 7 major R&D for green technologies including green cars, green IT, new renewable energy, green architecture, and LED lighting by 2018. GT research and development tasks that suit corporate demand are to be selected to support new technologies in connection with corporation affiliated research institutes and university research institutes.

3) Creation of jobs in the green energy indutry

- Seoul will select 70 social enterprises and cooperatives in the energy field by 2018. Intensive support will be made during the initial stage to develop them into grade corporations with remarkable self-sufficiency. First, up to KRW 300 million is to be supported as pilot operation costs, and a consulting education program will be operated to nurture socioeconomic bodies in the green energy field through the ‘socioecnomic support center’ and ‘cooperative consultation center’.

- Seoul will establish as many as 25 ‘regional energy hub centers’ by 2017, which provide energy-related services to the citizensThis center provides combined services, such as the installation of energy equipment, monitoring, and post-management, as well as other services, including installation of LED lighting, installation of solar lighting, provision of price information, group purchasing, and product exhibition. The hub center uses the offices of citizen groups, and leases public organizations when needed. It also plans to expand to a service sales network and energy cooperative service business.

Realization of welfare through sharing

Having an energy expense of 10% of the income, it is estimated that 10.3% of the households in Seoul are energy poor homes. Low income classes consume relatively high priced energy (LPG, kerosene), and low efficient home appliances to spend 4.7 times the average cost of all homes. The government has thus far failed to construct sufficient legal policies in this regard.

Responsibility of energy welfare	Citizen participation	Conversion, increased efficiency	Community
Energy welfare ordinance The country’s only enactment	100,000 participants in the welfare fund	1,100 units in the low income insulation project	200 energy self-reliant villages

Figure 16. Goal of initiating warm energy sharing communities

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

A regional energy welfare policy suitable for local government is to be realized. To this end, institutional consideration is supplemented in regions that are not benefited from the central government's welfare policies by reflecting the regional properties of Seoul. These include rented homes and lower class accommodation in the cities through such institutionalizations as the enactment of the energy welfare ordinance and basic energy rights.

Fundamentally, energy conversion projects are to be initiated, including increased energy efficiency in homes and the reinforcement of solar light. Furthermore, direct support of vouchers and energy costs are concurrently enforced in preparation of energy crises. Moreover, the capacity for carrying out specialized policies regarding energy welfare is reinforced by nurturing and conducting research on energy welfare officers, and reinforcing energy functions in residential welfare support centers.

1) Guarantee of energy welfare rights through policy

- Seoul is coming up withan institutional basis that guarantees the use of energy as universaland basic rights. Various opinions were collected to prepare the energy welfare ordinance plan, and the preparation of the ordinance plan is to be announced in order to declare energy welfare. The main content of the ordinance includes the preparation of specific standards, such as the selection of the eligible applicants, as well as specifying Seoul city's responsibility toward the energy poor class. This will be part of the preparation of the basis for the presentation of an energy welfare platform (fund).

- Seoul will raise energy welfare fund for citizens that is created, operated, and distributed by the people themselves. The fund is to be composed through profitable donations generated by the production and saving of energy (including solar power, LED, increased efficiency of housing, and eco mileage systems), and is to be used for the objective of supporting the energy poor class.

Citizen participation	Citizen management	Sustainable fund
> Participants in solar power, LED, and eco mileage projects	> 100 citizen committee members (fund, management, delegation)	> Preparation of a basis with the energy welfare ordinance > Connection with professional fund groups

Figure 17. Participation of citizens through the policy

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

2) Building basis for the regional energy community

- An energy self-reliant village plan is to convert a village from a consumer to a village that creates profit through efficient use and generation of energy, and shares energy in connection with energy welfare. 15 villages in 2014 will be increased to 200 villages by 2018, and specialized projects suitable for each village will be branded.

- A virtuous cycle of an energy ecology system is to be createdin the village community by expanding the citizen's energy saving project. After analyzing the effect of two demonstrative power saving stations in 2014, 10 stations will be installed in 2015, and consecutively expanded from 2016. A citizen power saving station is initiated with the direction of promoting value by reinvesting and sharing the incentive given to eco mileage members. The main fundamental group of the region will be selected, and a power saving station director performing the role of a coordinator is to be nurtured. An 『Energy Station』 for energy recharging services is operated in each village, and the investment basis of energy projects is composed by reforming the eco mileage system and reducing energy points.

Eco mileage reduction point system	Power saving stations in villages	Energy project investment and consumption	Village corporation
> Citizen power saving station	> Coordinator groups, power saving station director > Network, promotion, etc.	> Energy station > Energy supermarket, BRP, solar light, etc.	Citizen fund

Figure 18. Energy project through the citizen participation system

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

5. Policy Effect

1) Proposal of vision and successful model of the regional energy policy

The One Less Nuclear Power Plant Plan is an energy policy that expands the former energy saving policy to the generation of new renewable energy and BRP, which has reduced the total consumption of energy - such as electricity, gas, and fuel. Furthermore, regardless of the restriction of a local government group, it is evaluated that a successful model of a regional energy policy is proposed through creative policy improvements and projects. Seoul's good policies, such as the Feed in Tariff (FIT) policy, improved rental of solar power generation facility sites, and the supply of mini solar power in particular, have been expanded to other district groups.

2) Improvement of public awareness of and revitalized public participation in energy policies

The One Less Nuclear Power Plant Plan can be considered a citizen-led energy policy. As many as 1.68 million Seoul citizens have participated in the eco mileage policy, and around 20,000 students in the energy guardian angel group to partake in energy saving in the home and at school.

Such citizen participation is estimated to be based on the active support from the citizens toward the One Less Nuclear Power Plant Plan. According to the survey conducted onthe One Less Nuclear Power Plant Plan in March 2014, as many as 71% of the respondents said they knew about the One Less Nuclear Power Plant Plan at Furthermore, since 59% of the respondents stated that the Plan is 'good', it is believed that the One Less Nuclear Power Plant Plan is seen as a plan that is highly supported and necessary in Seoul at the current stage.

3) Formation of initial basis for energy related industry and employment

The One Less Nuclear Power Plant Plan has revitalized the Korean LED market through the LED supply project in large scale public facilities, including the entire replacement of lighting in subway stations to LED lighting and required the installation of LED in newly constructed public offices, and has attracted 600 billion won of private capital to contribute to the preparation of employment in new renewable energy production and installation fields, such as solar power and fuel cells. Furthermore, energy planners have obtained new employment in the establishment of three cooperatives based on the experience of energy diagnosis in commercial buildings.

6. Policy outcome

Outcome of One Less Nuclear Power Plant Plan Phase 2

1) Initiation of the core index of Phase 2, such as increasing power independence rate

The bases of most projects were constructed by initiating Phase 1 of the One Less Nuclear Power Plant Plan, which accumulated experience to enable the achievement of exceeding the goal of the first year.

Index	Goal (Jul 2014 – Dec 2015)	Outcome(Jul 2014 – Sep 2015)
Energy self-reliance rate	7.0% (2014 Goal: 5.0%)	4.7% (based on the capacity of facilities at the end of 2014)
Increased efficiency in generating energy and energy saving	902,000 TOE	910,000 TOE

Figure 19. Energy self-reliance initiation achievement

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)*as of 2014

(Unit: 1,000 TOE)

Generation (64,000 TOE)	Increased efficiency (495,000 TOE)	Saved (351,000 TOE)
* Solar power 8.3 * Fuel cell, etc.: 55.6	* Green architecture planning: 225 * Efficiency of building energy: 86.4 * LED supply: 176.2 * Traffic: 7.3	* Eco mileage: 351

Figure 20. Reduction and generation of energy in main projects

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)*as of 2014

2) Main achievements

The initiation of the 'Seoul City of Sunlight Project' as a core project in the One Less Nuclear Power Plant Plan Phase 2 has led to the installation of 30MW solar power plants by September 2015. Thereby, Seoul city has a total of 101MW solar power generation facilities, to allow 34,000 homes in Seoul to only use power generated by sunlight.

In order to expand the supply of mini solar power plants, which was actively pursued from the One Less Nuclear Power Plant Plan Phase 2, the support that was provided only to housings installing the mini plants was then expanded to all areas (including public sectors) by increased contact with citizens and sales at large supermarket stores and other locations. Furthermore, a pilot project of installing solar panels on sale booths was initiated to install 2,528㎾ in 3,469 areas by September 2015.

Seoul has established Special Purpose Company (SPC) which is exclusively in charge of replacing lighting with low-energy high-efficiency LED lighting and has implemented the public lighting replacement project using private capital to replace 93,000 lighting fixtures in 48 business sites in Seoul and 13 other district areas. The project initiated to replace approximately 210,000 lighting fixtures in offices and control rooms of the subway station (Seoul Metro, Urban Railway Cooperation) was enforced by SPC and to be completed in October 2015. With the addition of 430 thousand lighting fixtures exchanged in Phase 1, a total of 640 thousand lightings, excluding the interior lighting of subway trains, were exchanged.

A fund of 1.6 million won in cash and gifts (LED, etc.) had been raised and in January 2015, the 'Seoul Social Welfare Association' was selected as the administrative fund operating group, and an agreement was then concluded. In July 2015, the 'Seoul Citizens' Energy Welfare Fund' council was established, and a volunteer university group was created. Since it is important to bring about a warm social atmosphere for energy welfare, in addition to physical support, an energy welfare fund website was constructed to create a cordial living environment based on the participation of many citizens, and promotion has been conducted for the donations and participation of the citizens.

2015	2016	2017	2020
200 million won	600 million won	1.7 billion won	3 billion won

Figure 21. Goal of composing annual energy welfare funds

(Source: One Less Nuclear Power Plant 2 Seoul Sustainable Energy Action Plan, Seoul City)

8. Main challenges and solutions

After 2015, when the One Less Nuclear Power Plant Plan Phase 2 officially began, there were some obstacles caused by the changes in the external conditions and the deterioration of the social environment, including the outbreak of MERS case. Accordingly, there was a need to modify the strategies and goals of initiating the project. There was also a need to adjust the excessively high goals of certain projects that need to be initiated in cooperation with other organizations.

The 'home energy clinic service' project, under which energy planners visit homes or stores, thereby checking the energy usage pattern and providing information on how to save energy. However, it was difficult to continue the project in the first half of 2015 due to widespread outbreak of MERS and people's tendency not to meet others for fear of possible contagion. It was difficult to secure space for the 'wooden pallet usage boiler' project causing reduction of demand, and thus it was necessary to modify the project target to public facilities.

Although these disadvantages were eventually overcome and the goal reached, , it is predicted that there is a need to come up with strategies in order to achieve the goal of the One Less Nuclear Power Plant Plan Phase 2.

Accordingly, the cooperative system between the One Less Nuclear Power Plant Executive Committee and related organizations has been reinforced and the opinions of professionals of the Seoul International Energy Advisory Group will be collected to devise an efficient strategic system in order to achieve the core goals by 2020.

The solar power project among the core projects of Seoul' One Less Nuclear Power Plant Plan focuses only on power generation. However, as a project that has been initiated to attract private investment, it is important to attract public attention. For instance, instead of installing solar panels only on school roofs, the installation of solar light in streetlamps near schools will allow citizens to personally experience and benefit from the results.

Although fuel cells, which occupy the largest proportion of new renewable energy sources, are used in large buildings or are supplied for power generation, the policy has not been properly pushed for. Fuel cells can be considered devices that create electricity using hydrogen or natural gas, and not a form of pure renewable energy. . After all, fuel cell has limitations as it consumes more gas to generate energy. There is a need consider subsidiary support system for the fuel cell as is in the solar panel project. Overcoming these problems is predicted to contribute to the reduction of greenhouse gases and the generation of new renewable energy in Seoul. If Seoul overcomes such challenges, there will be a great leap forward in the reduction of green house gas emissions and the development new renewable energy.

Seoul's Illumination Management Policy

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1. Background Information

1) The need of the policy

① Specialized Nightscape

'Urban Light Management Project', includes nightscape projects for bridges, cultural assets and facilities in order to provide attractions to tourists who visited Seoul during Seoul Olympic held in 1988. Seoul Metropolitan Government has made a sustained effort to manage lighting so as to create a beautiful and pleasant environment.

② Prevention of Light Pollution

Light pollution caused by excessively bright artificial lighting or night lights has emerged as a recent environmental issue for Seoul. Light pollution has caused lots of problems such as the deterioration of human biorhythms and destruction of the ecosystem. Experts are highlighting light pollution as one of the most rapidly expanding pollutions throughout the world.

Having recognized serious light pollution, Seoul Metropolitan Government has publicized the harmful effects of light pollution and been modifying the system since 2009. Seoul Metropolitan Government persuaded members of the National Assembly and pushed ahead with projects closely cooperating with the Ministry of Environment and made forty presentations on light pollution at public hearings, seminars and conferences by visiting local governments all over the country. Seoul Metropolitan Government enacted "Seoul Special City's Ordinance of Prevention of Light Pollution and Urban Lighting" in 2011 before the Korean Government established Act on the Prevention of Light Pollution by Artificial Lighting to protect citizens from light pollution resulting from excessive lighting and improve the quality of life. In a survey conducted by the Ministry of Environment in October 2010, 64.1 percent of respondents said that 'excessive artificial lighting may be considered environmental pollution' and 64.9 percent of respondents said that 'it is necessary to prepare laws and systems for controlling light

[55] Translation by ESL®

pollution'. Accordingly, the "Act on the Prevention of Light Pollution by Artificial Lighting' was enacted in 2012 to meet the desire for improvement in quality of life and to prevent traffic accidents, bad effects on the ecosystem caused by excessive light and the deterioration of the urban landscape created by messy advertisements.

"Criteria for Calculation of Acceptable Limit on Light Pollution Caused by Artificial Lighting and Amount of Damages" was established by the Korean Government in February 2014.

Accordingly, the Seoul Metropolitan Government prepared "Comprehensive Measures for 『Solving Light Pollution 』in Seoul " in February 2012. There were about 700 complaints of light pollution in Seoul in 2013 compared with 330 complaints in 2009 which suggests that it was necessary to prepare measures for preventing light pollution.

③ Electric Energy Saving

"Basic Plan on Energy Use Rationalization" (2008.12) made by the Korean Government aims to improve energy efficiency by 11.3% in 2020 compared with energy efficiency in 2007. As the need for energy saving has increased, the Ministry of Knowledge Economy established "Guideline on the Operation of Streetlight" and made public it in January 2012.

The main contents of "Guideline on the Operation of Streetlight" were related to 'switching on or off lights depending on the brightness in surroundings and adjusting brightness considering traffic' and 'installing integrated intelligent control systems and dimming systems'.

Seoul Metropolitan Government set up overall measure called 『One Less Nuclear Plant』in May 2012. One of the ten goals of 『One Less Nuclear Plant』is a "remarkable increase in smart lighting and supply of LED". Seoul Metropolitan Government plans to replace 7800 thousand lights with LEDs and create a smart lighting city by building an "IT based outdoor lights control system".

Seoul Metropolitan Government made "Mid and Long Term Plan on Improving LED Roadway Lighting" (2012) which aims to replace all roadway lights with LEDs passing through two stages.

Table 1. Mid and long term plan on replacing roadway lights with LEDs

Classification	Total	Stage 1(5 years)	Stage 2(5 years)	Remark
Period	10 years	2011-2015	2016-2020	
Goal	100%	50%	50%	
Quantity	177,180 lights	88,590 lights	88,590 lights	Lights that were already installed excluded
Necessary budget	139,5 billion won	86,4 billion won	53,1 billion won	

The above mentioned plans are closely related to electric energy saving. Replacing streetlights, security lights and signboards lights with LEDs made dimming possible which leads to electric energy saving.

Seoul Metropolitan Government devised a measure to save electric energy for lighting, prevent light pollution, reduce expenses required for public lights and provide improved convenience.56

2) Period during which the policy was implemented

The Act on the Prevention of Light Pollution by Artificial Lighting, which serves as the basis for a plan on preventing light pollution caused by artificial lighting, was enacted on February 1, 2012 to prevent light pollution arising from artificial lighting. The Act on the Prevention of Light Pollution by Artificial Lighting and Enforcement Decree of the same Act were then later implemented on February 2, 2013.

The purpose of the Act on the Prevention of Light Pollution by Artificial Lighting is to prevent harm to health or the environment caused by excessive emission of artificial lights and to provide a basis so that all people can live in a healthy and pleasant environment by managing artificial lights in an environmentally friendly way.

The Seoul Metropolitan Government enacted the「Ordinance of Prevention of Light Pollution and Management of Urban Lighting」on July 15,2010 and implemented it before establishing the Act on the Prevention of Light Pollution by Artificial Lighting. After enacting the Act on the Prevention of Light Pollution by Artificial Lighting in 2012, Seoul Metropolitan Government made a complete revision to the「Ordinance of Prevention of Light Pollution and Management of Urban Lighting」and enacted the「Ordinance of Prevention of Light Pollution and Creation of Good Lights」on July 17, 2014 . The Enforcement Rule of Ordinance of Prevention of Light Pollution was enacted on January 27, 2011 and ordinance of prevention of light pollution was revised on April 16, 2015

The Ministry of Environment determined matters required for standard for installation •management of lighting fixtures and made a public announcement on the matters. The Ministry of Environment established standards for installation •management of lights according to uses so that the standard can be used as a criteria to help prevent energy inefficiency and visual inconveniences arising from excessive light.

Standards for the installation •management of streetlights, security lights, lights for parks and lights for advertisements was established to present technical criteria for installation and maintenance.57

[56] 2014, 『Smart Lighting City Seoul』a summary report on the construction feasibility study and establishment of basic plan

[57] 2015, Plan on preventing light pollution in Seoul

Table 2. Recommended standard for installation •management of lighting fixtures for preventing domestic light pollution

Notification	Implementation	Objective
Recommended standard for installation •management of lights for advertisements to prevent light pollution (Notification No. 2014-212 of the Ministry of Environment)	2014.11.28	To specify matters about efficient installation •management of lights for advertisements so that this standard can be used as criteria which help prevent energy inefficiency and visual inconvenience arising from excessive light
Recommended standard for installation •management of streetlights to prevent light pollution (Notification No. 2014-211 of the Ministry of Environment)	2014.11.28	To be used as a criteria that helps secure the safety of those who use roadways at night and prevent energy inefficiency and visual inconveniences arising from excessive light by installing and managing streetlights efficiently
Recommended standard for installation •management of security lights and lights for parks to prevent light pollution (Notification No. 2013-606 of the Ministry of Environment)	2013.12.31	To be used as a criteria that helps prevent energy inefficiency and visual inconveniences arising from excessive light by establishing standards for installation •management of security lights and lights for parks
Recommended standard for installation •management of decorative lights to prevent light pollution	Under way	To solve light pollution problems by presenting improvements according to types and applications of decorative lights and the limit in brightness considering surroundings

Table 3. Classification of artificial lighting to be managed

Classification	Legal basis	Target
Space lighting	Road under Article 2, Paragraph 1, Subparagraph 1 of「Road Act」	Streetlights
	Pedestrian walkway under Article 2, Paragraph 1 of「Pedestrian Safety and Convenience Enhancement Act」	Security lights
	Parks and greenbelts under Article 2, Paragraph 1 of 「Act on Urban Parks, Greenbelts, Etc.」	Lights for parks
Decorative lighting	Article 2, Paragraph 1, Subparagraph 2 of Building Act. Article 3-5 of Enforcement Decree of the same Act. Seoul Metropolitan Government's Ordinance of Prevention of Light Pollution and Creation of Good Lights [schedule] facilities to be reviewed by Good Light Committee	Decorative lights
Lighting for advertisements	Article 4(Advertisement and Billboards subject to permission) of Enforcement Decree of the Outdoor Advertisements, etc. Control Act	Lights for advertisements

3) The Importance of the Policy

Remote surveillance and the control of lights are considered important in urban light policy because they can help save electric power and prevent light pollution by switching on or off lights and adjusting illumination as needed. Details of the surveillance and control of lights are as follows:

Table 4. Details of monitoring and controlling lights

Classification		Monitoring •control			Remark
		Switching on off lights	Dimming	Condition monitoring	
Lights for public use	streetlights	O	O	O	
	Security lights	O	O	O	Considering safety of citizens
	Lights for parks	O	O	O	
	Lights for tunnels	O	O	O	Lights are kept on around the clock
	Lights for underground roadways	O	O	O	Lights are kept on around the clock
	Landscape lighting	O	O	O	Special lights considering aesthetics
Lights for private use	Lights for signboards	O	O	×	Scheduled to be decided in the future

Conditions of all lights for public use are monitored, which means that functions such as dimming control are available. Considering the fact that a smart lighting system can be used for dozens of years, functions can be controlled depending on changes in circumstances.

It is reported that regulations for remote switching and dimming control of signboards for private use are being prepared. It is advisable to apply remote control to save electricity and prevent light pollution after relevant regulations are supplemented and lights are replaced with LEDs.

According to " review of plan to reduce the period required to construct 『smart lighting city Seoul』", policies on lights in cities require "replacing existing discharge lamps with LEDs and equipping dimming functions" because it is possible to monitor •control LEDs remotely.58

2. Policy Objectives

1) Establishment of basic plans for preventing light pollution

There are about 225,000 security lights all over Seoul. It is reported that there were a total of 3,141 light pollution related complaints in Seoul from 2009 to June 2013. There were 720 light pollution related complaints in Seoul in 2013 compared with 337 complaints in 2009 which shows that light pollution related complaints increased by 213%.

Lights for public use (streetlights, security lights, lights for landscape and so on) are required to be approved by the Seoul Metropolitan Government's "Light Pollution Review". 66.8% of signboards for private use have not been reported or approved. Messy advertising signboards spoil the beauty of the city and cause light pollution.

How to best control and manage light pollution caused by lights for public use or lights for private use in order to reduce light pollution should be considered in policies.59

① Proposal of the comprehensive basic direction for preventing light pollution

The Act on Prevention of Light Pollution by Artificial Lighting provides standards for managing light and therefore a plan on the prevention of light pollution should propose basic principles and directions for targets and the application of standards. "A plan on managing light environment' to be established by reflecting the basic direction for standards proposed in a plan on the prevention of light pollution proposes detailed guidelines for management.

② Preparation of measures for the prevention of light pollution by fields •stages

Measures are to be prepared for preventing light pollution and plans built on managing light pollution according to use and area based on legal management standards and provide a basis for Seoul Metropolitan Government's pushing ahead with policies on light pollution.

3) 2014, 『smart lighting city Seoul』summary report on construction feasibility study and establishment of basic plan

[59] 2014, 『smart lighting city Seoul』summary report on construction feasibility study and establishment of basic plan

③ Preparation of measures for education •promotion of light pollution

Article 2 of the Enforcement Regulation of Act on Prevention of Light Pollution by Artificial Lighting provides that local governments should prepare measures for education and publication of light pollution so as to prevent light pollution. Accordingly, those in charge of light recognized the importance of light pollution and prepared manuals so that they can implement such policies. Having recognized that light pollution affects the health of citizens, the people in charge of light pollution made a plan concerning the increased publication of light pollution.[60]

2) Comprehensive plan for the prevention of light pollution

A plan for the prevention of light pollution is based on the Act on Prevention of Light Pollution enacted in February 2012 and has legal executive force on targets and standards determined by the Act on Prevention of Light Pollution and Enforcement Ordinance of the same Act.

The Act on Prevention of Light Pollution divided a plan on light into three stages; evaluation of present conditions, preparation of a basic plan and the preparation of a management plan. A plan for the prevention of light pollution is a basic plan that comes under stage 2. A plan for the prevention of light pollution aims to establish measures for preventing light pollution by reflecting standards for light emission according to use and area.

"Technical Service of Environmental Impact Assessment and Measurement • Survey of Light Pollution in Seoul" (hereinafter referred to as environmental impact assessment of light pollution) conducted in 2014 carried out a preliminary investigation for designating lighting environment management area in accordance with Article 16 of the Act on Prevention of Light Pollution.

Article 5 of the Enforcement Ordinance of Act on Prevention of Light Pollution provides that local governments should make plans for managing lights in an environmentally friendly way. A plan for managing the lighting environment should include goals and the basic direction of lighting management, management plans and a plan on technical •financial support .

Seoul Metropolitan Government established 「Ordinance of Prevention of Light Pollution and Creation of Good Lights」 in July 2014 and provided that a plan for the prevention of light pollution determined by the Enforcement Regulation of Act on Prevention of Light Pollution, urban lighting energy saving, carbon dioxide reduction, a plan on nightscape and preparation of guidelines for nightscape should be applied.[61]

「Enforcement Regulation of Act on Prevention of Light Pollution by Artificial Lighting」

Article 2(Planning on Prevention of Light Pollution by city •province)

② A plan on the prevention of light pollution by the city •province shall include.

[60] 2015, A plan on the prevention of light pollution in Seoul

[61] 2015, A plan on the prevention of light pollution in Seoul

1. Matters on present conditions of light pollution and prospects

2. Goals and the basic direction of the plan on the prevention of light pollution in the city •province

3. Measures for preventing light pollution by field •stage

4. Education •promotion of light pollution

5. A plan on taking measures for preventing light pollution in city•gun•gu (refer to autonomous district. The rest is the same as above)

6. Calculation of expenses required for implementing a plan on the prevention of light pollution by city•province and a plan on financing

7. Matters required to prevent light pollution

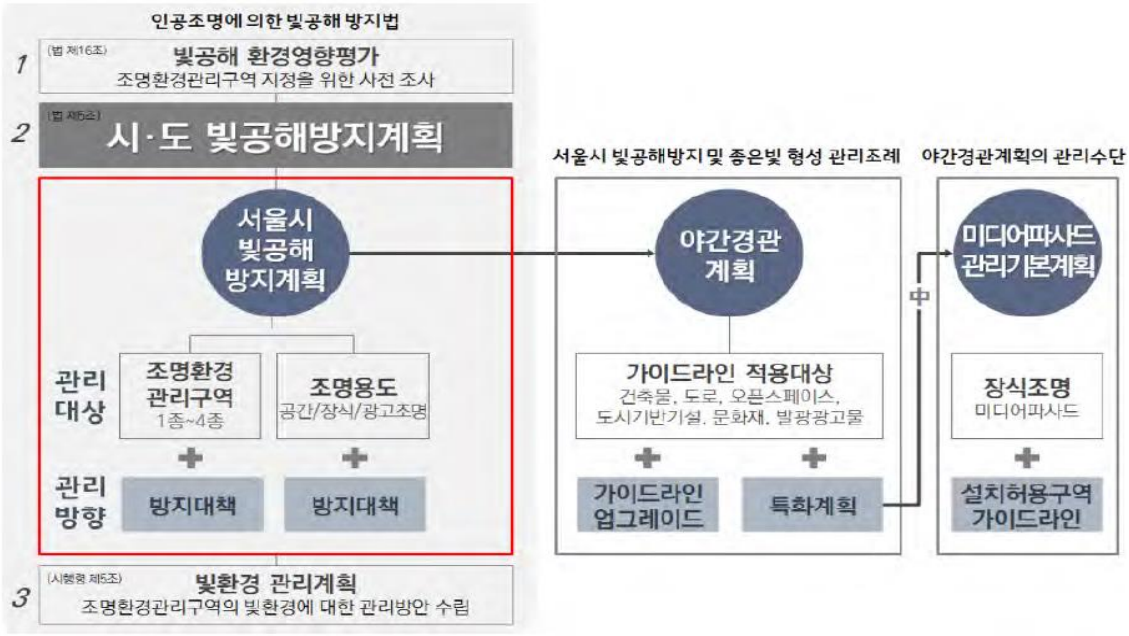


Figure 1. A plan on prevention of light pollution in Seoul

A plan on the prevention of light pollution was made based on the Act on Prevention of Light Pollution by Artificial Lighting and Ordinance of Prevention of Light Pollution. A plan on nightscape should be made as a part of a plan for the prevention of light pollution and guidelines on nightscape should be prepared so as to create good light. A plan on nightscape can include media façades as a part of specialization plan. It is advisable to make a basic plan on managing media façade lights as part of the plan on nightscape.

The Act on Prevention of Light Pollution by Artificial Lighting proposes standards for managing lights and targets. A plan on the prevention of light pollution is a ‘comprehensive plan’ for managing lights. A plan on the prevention of light pollution proposes principles and the

basic direction for the application of standards.62

Environmental impact assessments of light pollution were conducted in 2014 to better understand the present condition of targets and the result of the assessment has been used as the basis for the designation or cancellation of lighting environment areas. A plan on the prevention of light pollution proposes principles for the application of standards for legal management and secures the power of execution for the prevention of light pollution by considering the assessment of present condition of targets. It is necessary to make good use of a plan on the prevention of light pollution in various fields – such as urban planning, maintenance work and urban development. It is advisable that a plan on the prevention of light pollution should propose detailed guidelines according to lighting environment areas by applying principles suggested by a plan on the prevention of light pollution. This plan can be used as guidelines when making a plan on lighting environment areas.

Figure 2. Nature of a plan on the prevention of light pollution in Seoul

A plan on the prevention of light pollution shows a way to manage light pollution in order to prevent light pollution. It is advisable to create detailed guidelines that consider the characteristics of each region.63

3) Preparation of a plan on saving electric energy

Power usage in Seoul is 46.9 million MWh/year, which accounts for 10.3% of power usage all over the country. Power usage consumed by lights for public use (such as streetlights and

62 2016, A plan on management of light environment in Seoul

63 2015, A plan on prevention of light pollution

security lights) and signboards for private use is 1.1 million MWh/year, which accounts for 2.3 of the total power usage in Seoul and makes up 24% of the annual power produced by Kori Nuclear Power Plant 1. Streetlights and security lights are kept on with the same intensity of illumination until they switch off once they turn on regardless of traffic. It is advisable to adjust the intensity of illumination of streetlights and security lights in the middle of the night to save electricity.

It is reported that signboards for private use are on for 6.2 hours daily and for 1.3 hours during the daytime, which suggests that there is room for saving electricity by 20%.

The second goal of this policy is to work out a plan to save electricity and find ways to reduce power usage.

4) Relations with other policies

"A plan on the supply of LEDs to public organizations for 2013" prepared by the Ministry of Trade, Industry and Energy aims to improve energy efficiency of the public sector by replacing lights with LEDs by 2020. The authorities concerned support the replacement of lights with LEDs in accordance with regulations on the rationalization of energy use in public organizations and LED 20/60 supply plan. The relevant authorities offered "Guideline on Energy Saving through Efficient Management of Streetlights" for "energy saving by efficient management of streetlights" in 2012 and encouraged the introduction of integrated intelligent control systems or intelligent dimming systems.

Plans that Seoul Metropolitan Government worked out to save energy include "『One Less Nuclear Power Plant』" (2012.5), "Plan for supply of LED" (2013.2) and "Mid and long term plan on improvement of roadway lighting by replacement of lights with LED". A plan on the replacement of streetlights with LEDs is as follows.64

Table 5. A plan on the replacement of streetlights with LEDs in Seoul by year

Stage	Classification	Description					
Stage 1	Year	2011	2012	2013	2014	2015	Total
	Target lights	450		2,820	35,000	50,320	88,590
Stage 2	Year	2016	2017	2018	2019	2020	Total
	Target lights	18,000	18,000	18,000	18,000	16,590	88,590

Seoul Metropolitan Government made a complete revision to the ordinance of the prevention of light pollution in July 2014 so that it can better manage light pollution more comprehensively. Article 5 of the ordinance provides that matters on nightscape should be applied when making a

64 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

plan on the prevention of light pollution.

Seoul Metropolitan Government has endeavored to create beautiful and pleasant nightscapes. Seoul Metropolitan Government made basic plans concerning the nightscape in 2000 and carried out work to improve said areas in 2002 and 2009.

As people considered their quality of life and leisure activities more and more important, interest in nightscape increased. Accordingly, Seoul Metropolitan Government established departments that took responsibility for improving nightscapes, urban design and urban management as well as promoting tourism in order to enhance the quality of culture and citizens' lives.

However, as there are differences in values and standards of nightscapes between public organizations and private organizations and light pollution has increased, managing nightscapes in a systematic way has emerged as an area of major interest.

"Basic Plan on Nightscape in Seoul" was developed in accordance with 『Landscape Act』in 2008. 『Act on Prevention of Light Pollution by Artificial Lighting』 (here in after referred to as Act on Prevention of Light Pollution) was enacted in 2012 to reflect changes in the conditions. The basic plan on nightscapes developed in 2008 was required to be revised to meet the changing needs of citizens.

Seoul Metropolitan Government set basic goals and directions of nightscapes based on a survey of the present conditions of lights to reflect changes in circumstances.

A plan on the prevention of light pollution in Seoul proposed details on which the basic plan on nightscapes and media façade management based on 'Seoul's lights which urban attraction and various cultures keep in good harmony'. Seoul Metropolitan Government aimed to create nightscapes which can improve the beauty of Seoul and promote tourism and prevent light pollution. Seoul Metropolitan Government has endeavored to rethink the nightscapes of Seoul as attractions by developing a plan on the improvement of nightscapes.

3. Main Policy Contents

LEDs have led the emergence of industries whose production methods are completely different from those of existing industries and signify a rapid change of traditional industrial structures. Lots of lights have been replaced with LEDs with the help of advances in IT. Lighting has developed to an LED based digital lighting system, smart lighting and human centric lighting.[65]

Lighting for landscapes has shown the highest growth when examining the growth of LEDs in lighting markets all over the world. HID accounted for 80% of outdoor lighting in 2010 but it is expected that HID will make up less than 30% of outdoor lighting and LED will take up over 70% of outdoor lighting in 2020.

[65] 2016, A plan on light environment management by Seoul

1) Examples of major projects for improving lighting in Seoul

Classification	Public facilities			Private facilities	
	Cultural assets (31)	Bridges on the Han River (27)	Public facilities (96)	Buildings (302)	Media façades (50)
Main facilities	Fortress Wall of Seoul Five palaces Myeong-dong Cathedral	Banpo Bridge Hangang Bridge Wonhyo Bridge	Seoul Namsan Tower, Sejong Center for the Performing Arts, Main office of Bank of Korea	Jongno Tower Samsung E office LG Gangnam Tower	Seoul Square, Sejong Center for the Performing Arts, Hanwha Galleria

※ The number of lights for landscapes: 506

① Project of improving security lights in Jongno, Seoul(2015)

It was reported that there were about eighty complaints every year caused by sleep disturbance resulting from security lights in Ewha Byeokwha Village, Jongno-gu. Authorities concerned carried out a project that replaced diffusion security lights with LEDs to improve lighting in Ewha Byeokwha Village.

After conducting the project, the lighting and beauty in the area improved considerably and light pollution such as light trespassing and glare reduced significantly by the installation of screens which blocked forward light and backlight efficiently.

② Project of improving security lights in Songpa-gu, Seoul (2013)

Seoul Metropolitan Government selected dark alleys, places which have lots of waste of electric power due to poor security lights, places which have excessive penetration of lights, places near elementary schools, middle schools and high schools or markets as targets.

6,382 high voltage sodium lamp security lights (100W) were replaced with cut off type LED security lights (50W). When analyzing the effects by selecting thirty buildings in which high voltage sodium lamp security lights were replaced with LED security lights, it was found that the amount of light which penetrated through windows reduced and brightness increased by over three times.

③ Project of improving security lights along Uicheon in Gangbuk-gu, Seoul (2012)

202 high voltage sodium lamps and metal halite lamps installed in a 3km long trail along Uicheon in Gangbuk-gu, Seoul (ssanghangyo~wolgyegyo 2) were replaced with LEDs which led to energy savings of up to 50 percent by means of a 3 stage control system (50 percent energy saving by four stage brightness control system). The waste of light pollution and energy

was reduced by preventing lighting from being diffused.

< 4 stage brightness control system >

Stage 1: 100% by 22 o'clock →stage 2: 75% after 22 o'clock →stage 3: 50% from o o'clock

	
LED security light 75W 100% (reduction of energy by over 70 percent compared with existing lights)	Dimming 50% (reduction of energy by over 50 percent compared with existing lights)

④ Project of improving lights for advertisements in Dobong-gu, Seoul (2014)

Dobong-gu has been replacing signboards to improve beauty since 2009 and completed the improvement of signboards installed in 88 shops located in a section from the intersection near Sophia Hotel to exit 1 and 4 of Ssangmun Station. The channel letter type that applies LEDs was used in replacing signboards. The replacement led to energy savings of over 75 percent.

2) Present condition of the operation of lights for public use

① Streetlight switching system – Namsan Mountain

Radio waves of 142MHz are used in switching streetlights in Seoul. Distribution box switches on or off switch after receiving the radio wave.

Relay stations have been installed in six places as radio waves which are emitted from streetlight control centers located in Namsan Mountain may be jammed by mountains or buildings.

It was not possible to check whether streetlights were in good condition and therefore each district has been installing remote monitoring systems starting in 2006 to observe and monitor the conditions of the streetlights. At present, 20 districts monitor 2,358 distribution boxes out of 6,840 distribution boxes all over Seoul. 7,611 streetlights are currently monitored.

② Security system switching system

Most security lights are installed on security light poles, electric light poles and building walls. Electric power is supplied from electric light poles installed by KEPCO (Korea Electric Power Corporation).66

Security lights are switched electronically. The reason for which each light is switched not by radio waves supplied but by the streetlight control center is to reduce costs. Installing radio receivers on each light costs a lot. The electronic switching system controls lights considering sunrises and sunsets occurring during the changes in seasons.

③ Tunnel • underground roadway switching system

Entrance connections, entrances, basic parts, exits and exit connections vary in the intensity of illumination of lights as well as varied use in tunnels or underground roadways so that drivers can drive more smoothly. For entrances and exits, the intensity of illumination is controlled by means of an outdoor sensor in a manner in which the intensity of illumination of the lights is switched partially.

④ Lights for parks switching system

Lights for parks are switched electronically, like security lights, in which radio waves are supplied via a streetlight control center located in Namsan Mountain. Lights for large parks are switched by a janitor's office.

⑤ Lights for landscape switching system

Lights for landscape are mainly used to highlight the beauty of objects. Most lights for landscapes are controlled by a lighting control system program. "Rules on implementation of ordinance of prevention of light pollution and lighting management in Seoul" provides that "lights for landscapes shall switch on 30 minutes from sunset and switch off at 23 o'clock".67

3) Examples of new technologies for improving lighting environment

① Sun visors controlling forward light •backward light suitable for streetlights (2013)

Sun visors controlling forward light •backward light suitable for streetlights was developed to solve the problem of light trespassing on agricultural land and residential areas.

Tin plates were attached to streetlights to protect drivers from light trespass arising from streetlights but this caused the overall lighting deteriorate as it blocked light.68

New sun visors that can be applied to streetlights which cause light pollution (light trespassing on agricultural land and residential areas) was developed as a part of a 'study of development and application of standard for installation •management of lighting fixtures'. Developed sun

66 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

67 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

68 2016, A plan on light environment management by Seoul

visors were designed to block light trespassing effectively while the quality of light was maintained. Performance of the sun visors was verified by measuring lighting and conducting simulations.

② Sun visor attaching to security light fixtures (2015)

The National Institute of Environmental Research developed sun visors attached to security light fixtures (4 types). The sun visor was designed to be attached to security light fixtures which cause the most light trespassing. Light trespassing could be reduced at a cost of 50 thousand won to 100 thousand won - 25-50 percent of the cost required to replace light fixtures.

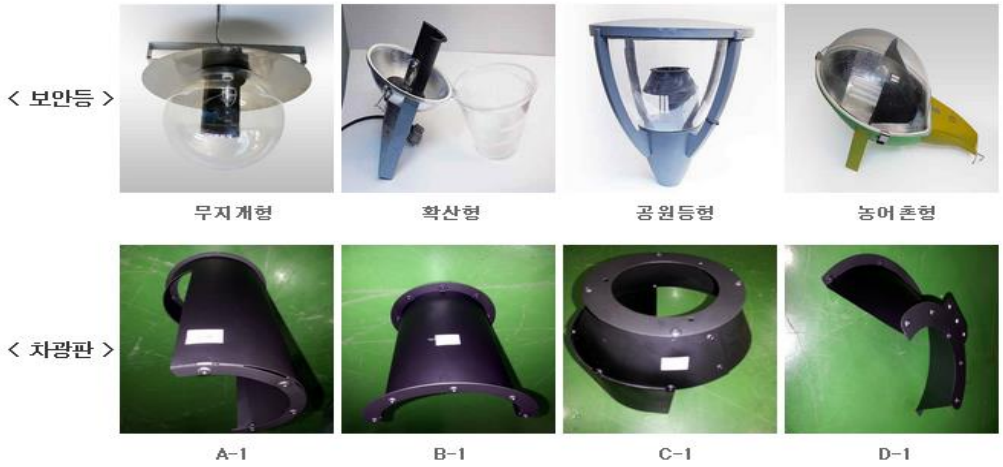


Figure 3. Sun visors attached to security light fixtures

The sun visor was designed in a manner that a plate shaped accessory is attached to security light fixtures so that light can be blocked. There are four types of sun visors.

The developed sun visor was designed to block light trespassing arising from backward light. The sun visor allows forward light to be kept while backward light is lowered by 60%. It was found that the intensity of the vertical illumination in residential areas was reduced to 1.1~7.1lx from 8.9~17.9lx.

③ Light fixture realizing rotationally symmetrical luminous intensity distribution by prism (2015)

This technology, which can be applied to bollard shaped and post top shaped LED fixtures, was designed to prevent glare by applying a ring shaped prism to the outside of light sources while the performance of the fixture is maintained.

The prism was applied by optics of the existing light fixture controlled light by the simple repetition of patterns while Clear Guide technology reduces glare by dispersing light by means of a ring-shaped light guide. This technology provides style options depending on the light distribution of light fixture.69

[69] 2016, A plan on light environment management by Seoul

4. Policy Effects

1) Economic effects

① Using lighting for tourism

Some districts in Korea make good use of lighting to attract tourists and vitalize the local economy. At the Busan Port Festival held in Busan, an LED waterboard and media façade lighting were used which provided various attractions. Four hundred thousand people visited the Port Festival held in Busan in 2015. The festival has played an important role in vitalizing the economy of Busan and improving its overall image.

② Energy saving by LED technology

LEDs have made a great contribution to saving energy as they consume less power compared with other light sources. LEDs make it possible to create various advertising designs. They can be installed in narrow spaces in which it is not easy to place neon or fluorescent lamps. LEDs are expected to help reduce greenhouse gas emissions and power consumption as they are highly efficient in saving energy.

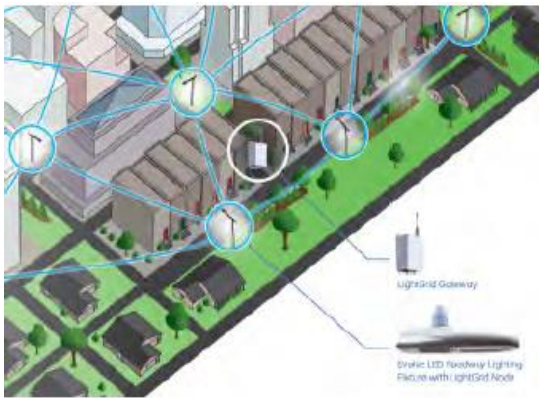


Figure 4. LED wireless lighting system block diagram

Figure 5. System network block diagram

2) Environmental effects

① Effect in terms of humanities

At night, there are bright places such as shopping areas and entertainment districts as well as quieter places, for example residential areas. It is desirable for lights to be in good harmony with their surroundings.

However, 『beauty of night』 is disappearing because there are excessive lights from cars, signboards and other sources.

Projects that aim for recovering 『beauty of night』have been implemented.

② Effects in terms of human engineering

There have been a total of 3,141 complaints about light pollution in Seoul from 2009 to June 2013. Out of the 3,141 complaints, 2,918 which accounted for 92.9% resulted from sleep disturbance or excessive brightness by artificial lighting. Sleep disturbance makes it difficult for citizens to live a healthy life and is likely to cause cancer.

Smart lighting monitoring • control system can minimize effects on the human body by turning off or dimming lights which are likely to cause light pollution.70

3) Additional effects

①Improvement in quality of life

Lighting control reduces sleep disturbance resulting from artificial lighting that accounts for 80 percent of complaints by dimming unnecessary lighting which leads to the improvement of quality of life.

Lighting control makes contributions to the improvement of the safety of citizens because it can detect faults and take actions to remedy these and adjust the intensity of illumination as needed.

② Contributions to industry such as job creation

Jobs to be created are done so by dividing costs (such as material costs and construction costs) required for the implementation of 『smart lighting city Seoul』by unit wage.

Table 6. Calculation of job creation effects by the project of「smart lighting city Seoul」

classification	Necessary cost (million won)	Average unit wage (won/day)	Necessary workers (won/day)	Necessary workers (year/person)
Material cost	38,761	184,486	210,103	785
Construction cost	24,708	184,486	133,929	500
Cost of design and supervision	5,203	205,518	25,317	95
Maintenance cost/year	4,203	184,486	22,782	85
total	72,875	758,976	392,131	1,465

This project can create 1,465 jobs. 85 maintenance related jobs will be kept as long as the

[70] 2015, A plan on prevention of light pollution in Seoul

system operates. The lighting control industry is expected to grow rapidly with the standardization of the lighting related system, advancement of technology and mass production.[71]

5. Challenges

1) Absence of relevant regulations and standards

Before the Act on Prevention of Light Pollution by Artificial Lighting was established, light pollution was controlled based on「Road Act」, 「Landscape Act」and 「Outdoor Advertisements Etc. Control Act」. The Act on Prevention of Light Pollution by Artificial Lighting was enacted in 2012 to regulate and manage light the pollution systematically and was implemented in 2013.

Seoul Metropolitan Government managed nightscapes based on 'basic plan on nightscape in Seoul (2000 and 2008) but it was unsatisfactory because it was more concerned with the creation of good light than the management of good light.

Seoul Metropolitan Government enacted an ordinance of light pollution in 2010 for the first time in Korea but the ordinance was limited in managing light pollution and did not provide the means to manage the light pollution systematically.

When assessing the impact of light pollution on the environment, it was found that lighting of 41 percent exceeded acceptable light emission levels; lighting for space accounted for 68%, decorative lighting 70%, and lighting for advertisements 30%.

In Seoul, advertisements have been installed in a disorderly manner. When NASA photographed 19 cities around the world, it showed that the lighting in Seoul was immoderate.

It seems that the supply of LEDs has been responsible for such disorderly building decoration. Lights in the center of cities are abused and wasted due to the absence of proper awareness of lighting.

Table 7. Present condition of outdoor lighting

(unit :place/light)

classification	total	Lights for space			Lights for advertisements	Lights for decoration
		streetlights	Security lights	Lights for parks		
quantity	1,320,048	234,663	226,849	34,119	800,000	24,417

[71] 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

Table 8. Complaints of light pollution (all over Seoul)

classification	total	2015	2014	2013	2012	2011	Prior to 2010
Number of complaints	6,686	1,216	1,571	778	857	706	1,558

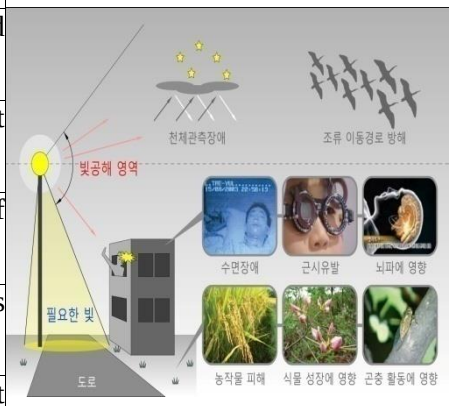
2) Lack of awareness of light pollution

Light pollution has a bad effect on the lives of citizens but most people are unaware of the 'Act on Prevention of Light Pollution by Artificial Lighting' and consider light pollution a waste of energy.

It is necessary to have various channels from which everyone can assess information easily so that people can be provided with information on light pollution.

Table 9. Types of effects of light pollution

classification	Types of damage	Conceptual diagram of light pollution
Effects on the human body	Changes in biorhythm, insomnia, cancer	
Effects on the ecosystem	Decline in the breeding of animals and growth of plants	
Astronomical observations	Two thirds of world population cannot see stars	
Energy efficiency	Waste of energy, excessive emission of carbon dioxide	
Negligent accidents	Poor traffic environments – such as glare	
Urban nightscapes	People do not feel comfortable at night due to excessive light. Identity of night is lost	



3) Unsatisfactory measures for maintenance

It is expected that citizens' interest in light pollution and complaints of light pollution will increase after the Act on Prevention of Light Pollution by Artificial Lighting' is implemented. Some districts may have difficulty in handling complaints concerning light pollution due to a lack of departments in charge of light pollution.

It is necessary, therefore, to prepare measures to deal with complaints arising from light trespassing and light pollution in residential areas.

4) Relaxation of acceptable light emission levels

Major advanced countries and international organizations have implemented systems for a long time and divided areas into four separate categories.

It is necessary to strengthen relaxed levels considering the real condition of domestic light environments. It is also necessary to designate zones to consider light environments in downtown areas that change day by day due to the development of light sources and manage such light pollution efficiently.

6. Solutions

1) Designation of lighting environment management areas

① Article 9 of the Act on Prevention of Light Pollution by Artificial Lighting (Designation of lighting environment management area)

Prepared measures to solve light pollution and the top three problems of inconvenience by designating and managing areas or zones that light pollution has occurred or is likely to occur.

② Establishment of the foundation for effective management of light pollution by securing effectiveness of laws

Analyze types of damage from light pollution and the occurrence of light pollution so as to apply the intensity of illumination appropriately considering the living environment of citizens such as green areas, residential areas and commercial areas.

Table 10. Types of damage from light pollution

(unit: cases)

classification	sum	Disturbed sleep	Inconvenience	Glare	others
total	3,560	3,045	397	99	19
Year of 2015	1,216	1,074	75	62	5
Year of 2014	1,571	1,424	136	4	7
Year of 2013	773	547	186	33	7

Table 11. Types of occurrence of light pollution

(unit :case)

classification	sum	Lighting for space	Lighting for advertisements	Electronic display	Decorative lighting	others
total	3,560	2,905	420	43	92	60
Year of 2015	1,216	928	173	33	39	43
Year of 2014	1,571	1,392	123	5	39	12
Year of 2013	773	585	124	5	14	5

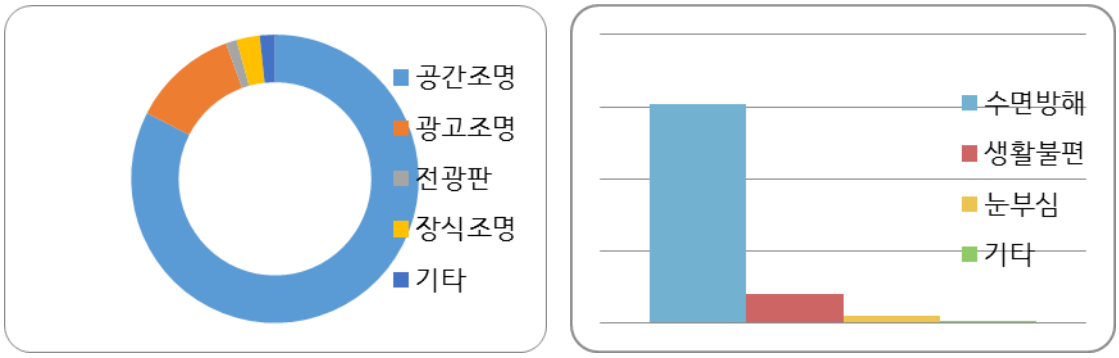


Figure 6. Types of occurrence of light pollution

③Enactment of the ordinance of the prevention of light pollution in Seoul (2010.07) and revision (2014.07)

Seoul Metropolitan government designated lighting environment management areas (class 1 ~ class 6) in 2010 and prepared standards for the installation of lights according to use and provided administrative guidance should violations occur.

Seoul Metropolitan government has operated the Good Light Committee and Award for Good Light and lighting support system to encourage citizens to take part in the prevention of light pollution and reviewed a plan on the classification of lighting environment management areas and standards for detailed designation and boundaries according to classes.

Seoul Metropolitan government held a public hearing to publicize light pollution and encourage citizens to participate in activities to reduce light pollution and to take the opinions of lighting environment management areas (plan) from citizens and those concerned.

Figure 7. The public hearing

④ Environment impact assessment of light pollution (2013.08.28 ~ 2014.03.25)

The environment impact assessment of light pollution aims to promote environmentally friendly and sustainable development as well as a healthy and pleasant life by predicting and assessing the impact on the environment when planning a project that is likely to have noticeable effects.

The environment impact assessment conducted by the Seoul Metropolitan Government showed that 41 percent exceeded acceptable light emission levels and suggests that it is urgent to designate and manage lighting environment management areas.

Table 12. Measurement and analysis of light environments according to use of lighting

Types of lighting	Places measured	Number of lights measured	Number of lights exceeding acceptable level	Percent of exceeding acceptable light emission level(%)
Lighting for space (streetlights, security lights, lights for parks)	114	1,494	911	60.9
Lighting for advertisements (advertising signboards, electronic displays)	97	5,049	884	29.0
Decorative lighting (lights for landscapes)	85	287	209	72.8

The light pollution prevention project was carried out first targeting lighting for spaces in a way that citizens could feel the reduction of light pollution.

Lights for advertisements need continued management as there are so many lights for advertisement installed. The management of large electronic displays has been strengthened because it requires light pollution management for drivers and pedestrians.

Lights for decoration cause less light pollution compared to other lights because they are small in number and turn off after 11 o'clock in the evening. Policies that aim to encourage voluntary improvement and reduce light pollution by managers has been implemented.

⑤ Designation of lighting environment management areas by stage (2015.05.07)

Before the designation of lighting environment management areas by stage, opinions of residents, heads of district and city councils were taken (members of five councils including Dobong-gu council stated opinions) by providing notice of lighting environment management areas (plan)('15.2.16~3.16) and the Good Light Committee reviewed the designation.

Opinion polls of the designation of lighting environment management areas showed that both citizens and shop owners consented to the designation of lighting environment management areas. Discussion meetings showed that all heads of the interested parties agreed with the designation of lighting environment management areas.

Lighting environment management areas were designed by stage. Green areas, residential areas and commercial areas that came under stage 1 were announced first and industrial areas that fell under stage 2 were announced by establishing detailed acceptable light emission levels considering use of land.

Setting the goals and direction of light pollution management	Setting direction of Seoul's light policy (mayor policy no.30, 2012.02.07)
↓	
Environmental impact assessment of light pollution	(Article 9 Paragraph 3 of law) (2013.08.28~2014.03.25)
↓	
Development of the designation of lighting environment management area plans	(Article 4 Paragraph 1 of enforcement regulation) (mayor policy no. 374, 2014.12.26)
↓	
Public notice to 25 districts about intent	(Article 4 Paragraph 2 of enforcement regulation) (2015.02.16~2015.03.06)

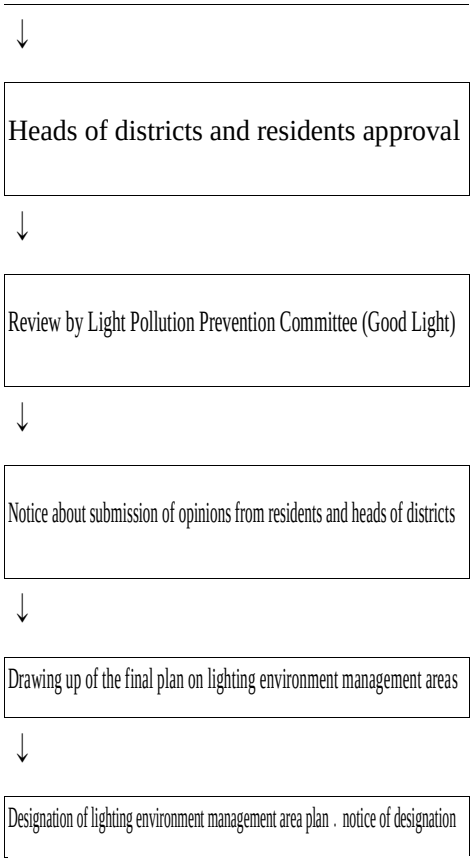


Figure 8. Procedures for designation of lighting environment management areas

Artificial lighting was determined as a target of the designation based on Article 9 of the Act on Prevention of Light Pollution by Artificial Lighting (Article 2 of enforcement decree of the same act).

<Lights subject to outdoor artificial lighting management>

□ l i g h t i n g f o r s p a c e : s t r e e t l i g h t s , s e c u r i t y l i g h t s , l i g h t s f o r p a r k s
□ advertisements: permissible outdoor advertisements (electronic displays, protruding signboards, signboards 1 0 m o r m o r e i n w i d t h)
□ decorative lighting: lights installed on 5-story or higher building or those whose total floor area is 2,000㎡ or more, lodging facilities, amusement facilities, bridges

Lighting environment management areas were designated for green areas, residential areas and commercial areas on July 30, 2015 (enforcement date: 2015.08.10(Mon)). Lighting environment management areas were classified into four classes considering the use of land.

Table 13, Designation of lighting environment management areas

lighting environment management areas	designation	area (㎢)
total		605.59
Class 1	Green areas for conservation, Natural green areas (national parks, urban nature parks, ecological and scenery conservation areas, wildlife reserves, cemetery parks)	110.40
Class 2	Productive green areas, natural green areas (areas that do not come under class 1)	124.20
Class 3	Residential areas (exclusive residential areas, general residential areas, semi-residential areas)	325.70
Class 4	Semi-industrial areas	19.99
	Commercial areas	25.30

Table 14. Acceptable light emission levels by class (Article 6, Paragraph 1 of enforcement regulations of the same act)

target	Criteria for measurement	Reference value	Lighting environment management area				
			class1	class2	class3	class4 semi industrial industrial area	Commercial area
Lights for space, Electric advertisements	① vertical illumination (lx)in residential area	Maximum value	Less than 10			Less than 15	Less than 25
advertisements	② brightness of surface (cd/㎡)	Maximum value	Less than 50	Less than 400	Less than 800	Less than 900	Less than 1,000
Electric advertisements	③ brightness of surface (cd/㎡)	Mean value (around 24 o'clock	400 / Less than 50	800 / Less than 400	1000 / Less than 800	1250 / Less than 900	1500 / Less than 1000
Decorative lighting	④ brightness of surface (cd/㎡)	Mean value	Less than 5		Less than 15	Less than 20	Less than 30
		Maximum value	Less than 20	Less than 60	Less than 180	Less than 240	Less than 300

※ Lighting fixtures installed before the designation of lighting environment management areas have a grace period of 5 years

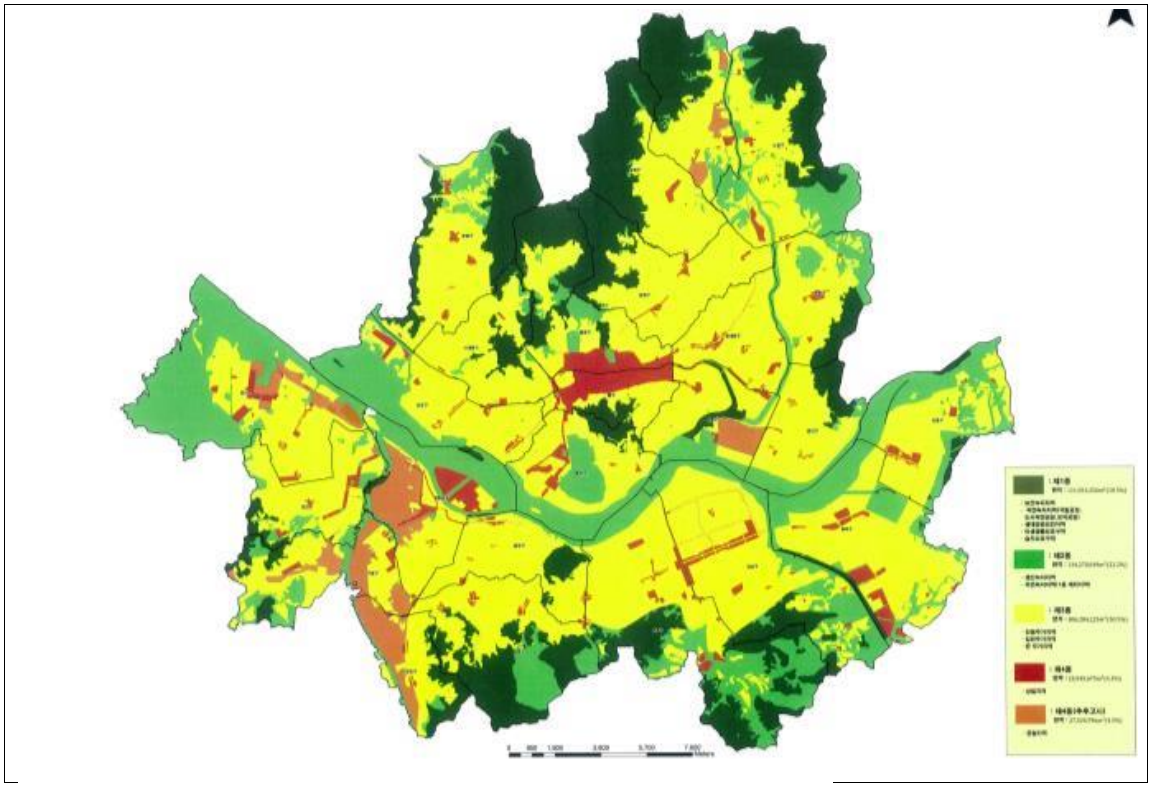


Figure 9. Map of the designation of lighting environment management areas

The qualitative effect of the designation of lighting environment management areas includes the removal of light pollution, improved safety of citizens walking, energy saving and the protection of the ecosystem. Quantitative effects of the designation of lighting environment management areas is the reduction of electric energy; yearly savings of electric power are 409,630 MWh (40,261(security lights) + 45,799 (streetlights) + 4,207 (lights for parks) + 315,056 (lights for advertisements) + 4,307 (lights for decoration)) which amounts to a yearly ton of oil equivalent of 94,215 TOE. Table 15 below shows the expected effect by area.

Table 15. Expected effect by area

Areas		Before designation	After designation
Value of Seoul	Identity	Unplanned • disorderly light (my lighting)	Light of consideration for citizens and moderation (our lighting)
	Beauty	Confusing and poor	Globalization of Seoul's brand value (Lighting Urban Community International held in Seoul in 2016)
	Tourism	Tourists were concentrated into commercial areas	Tourists were distributed evenly all over Seoul (Han River, Namsan Mountain, central area etc.)
Life quality of citizens	Safety of citizens	Unsatisfactory walking environments	Improved women's safety in residential areas
	Sleep disturbance	Excessive lights disturbed sleep	Relieved sleep disturbance by removing unnecessary lights
	Road safety	Glare may cause negligent accidents	Improved safety of drivers and pedestrians
	Complaints	over 700 complaints annually	Complaints are expected to be reduced gradually
Protection of ecosystem	Astronomical observation	Two thirds of the world population cannot see stars	Citizens can see stars even in the center of the city
	Plant growth	Bad effects on plant growth such as over growth	Smooth plant growth, ecofriendly green areas
Energy saving	Electric power saving	Waste of electric energy	Energy reduced by 30 ~ 70 percent
	Reduction of Co2	Excessive emission of Co2	Emission of CO2 reduced by 50%

2) Drawing up a plan on the prevention of light pollution considering characteristics of light environment

It is advisable to draw up a plan on the prevention of light pollution which considers the characteristics of the light environment, use of lighting, types of lighting and lighting environment management areas.

Lighting environment management areas were designated as four classes considering use, present condition of land use, order of the Ministry of Environment, environmental impact assessment of light pollution, opinions from residents and autonomous districts and a review. A plan on the prevention of light pollution according to lighting environment management areas that considered characteristics of areas in Seoul was therefore then proposed. The plan which aimed to improve existing lighting fixtures and maintenance and to prevent light pollution was

prepared.

3) Proposal of action plans on the sustainable and systematical prevention of light pollution

The manual of light pollution was prepared and distributed so that those concerned can better manage light pollution in a sustainable and systematical way and owners, designers and constructors of lighting fixtures can observe regulations on light pollution.

It is advisable to publicize the dangers of light pollution so that people will participate in activities which aim to reduce light pollution and its damaging effects.

4) Strengthening management systems by implementing technology to reduce light pollution

The light pollution management system was established by setting objective standards for light pollution reviews and implementing technology to reduce light pollution. The management system aimed at reducing light pollution was prepared to improve the safety and life quality of citizens by conducting demonstration projects.

Seoul's light policy aims at lights free of pollution, energy saving, participation of citizens and good light under the vision of "creating night which citizens feel comfortable". The basic goal and direction of the plan on the prevention of light pollution are "Seoul, city of attractive light in which citizens feel comfortable".72

① A plan on the selection of smart lighting that uses the internet and its subsequent implementation (one complex)

It is possible to control the intensity of illumination via a two-way communication between the central system and lighting by constructing an integrated system that connects lighting for public use and lighting for private use (ex. Lights for advertisements). It is possible to provide information on streetlights, CCTV, WiFi, fine dust, traffic and tourism.

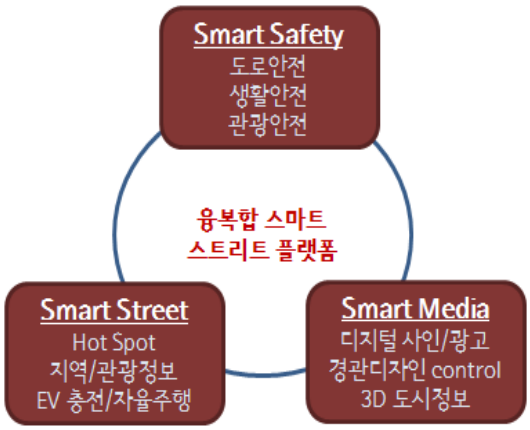


Figure 10. Convergence smart street platform

[72] 2015, A plan on prevention of light pollution in Seoul

Efforts to find ways to control the intensity of illumination, color and brightness according to the movement of objects, space, season, time and weather and make it possible to provide information on CCTV · lighting for landscape · WiFi · fine dust, traffic and tourism have been made.

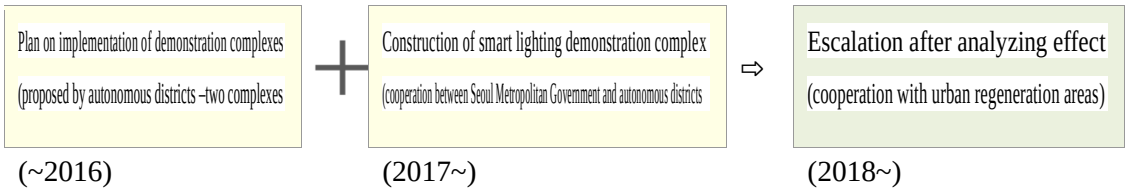


Figure 11. Action plan on the smart lighting city

② Construction of the smart lighting demonstration complex

It is advisable to carry out this project with the cooperation of Seoul Metropolitan Government and autonomous districts and organize consultative groups consisting of residents (consultative groups: decision making/city.district: support for projects).

③Expansion by stage after analyzing the effects of demonstration project

Analyze effects in terms of safety of the citizens (improvement in the intensity of illumination), reduction of light pollution, energy saving and convenience.

5) Construction of a smart lighting demonstration complex free of light pollution

Seoul Metropolitan Government pushed ahead with a project of constructing a smart lighting demonstration complex free of light pollution in 2016 with a view to making a contribution to creating good light and improving citizens' negative awareness of acceptable light emission levels by building exemplary demonstration complexes. One autonomous district was selected out of the 25 districts in Seoul.

The smart lighting system adjusts the intensity of illumination according to traffic to save energy on lights for public use (streetlights, security lights, lights for parks) and lights for private use (lights for advertisements) around Tongilro in Seodaemun-gu(Muakjae Station~Hongje Station).

The demonstration project cost about 2 billion won and maximizes its effects by keeping pace with existing projects of improving signboards. The project will play the role of test bed for smart lighting systems by converging various advanced technologies (installation of beacons and public wi-fi) in the demonstration complex. The demonstration complex will be constructed in 2017 and then demonstration complex projects will be expanded.

Table 16. Target of improvement of lights for advertisements in demonstration complexes

Section		Number of buildings	Number of businesses	Number of signboards
Hongeun Intersection~Hongje three way intersection(780m)		58	383	1,149
Hongje three way intersection ~exit no. 3 of Muakjae Station(520m)		47	217	423
Total	Hongeun Intersection ~ exit no. 3 of Muakjae Station	105	600	1,572

Table 17. Target of improvement of lights for public use in demonstration complexes

Types	Target of improvement
Streetlights	A total of 252 lights (underground roadway CDM 250W 116 lights, lights for waling 70W 136 lights)
Security lights	A total of 175 lights(12 sodium lights, 29 metal lights, CDM 93 lights, LED 41 lights)

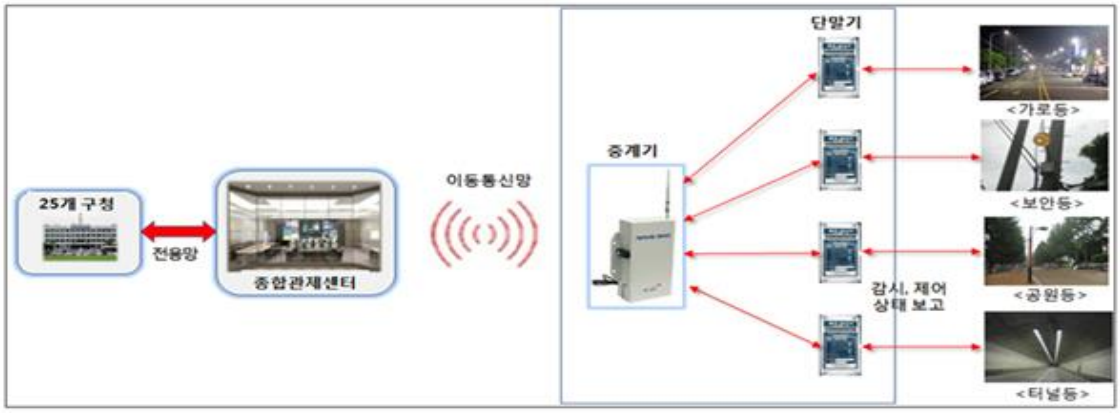


Figure 12. Diagram of smart lighting system

Building Retrofit Program

Jae Min Song, University of Seoul[73]

1. Timeline

Based on the Seoul Energy Declaration of April, 2007, Seoul established a goal of reducing 15% of energy consumption and 25% of greenhouse gas emissions by 2020 compared to figures from 1990. As of June, 2009, Seoul is carrying out such reinforced energy saving policies so as to reduce 20% of energy consumption and 40% of greenhouse gas emissions by 2030 in comparison to the 1990 figures. One of the more important energy consumption reduction policies is the Building Retrofit Program (BRP). The BRP was initiated as a result of the C 40 Mayors Summit held in New York in May, 2007. BRP was introduced to materialize and implement the agreed BRP in the public sector. BRP is a financing program for the private and public sectors to reduce greenhouse gas by finding high energy loss factors of energy-consuming buildings and to modify the insulation, lighting, roof, and windows and thus save energy and maximize the overall efficiency.

Early BRP mostly focused on the existing public buildings of Seoul City Government. For the BRP in the public sector, Seoul analyzed the building, mechanical, and electric energy of 34 affiliated public agency buildings with an annual 300 Total of Oil Equivalent (TOE) or more energy consumption from October to December, 2007. From these models it then considered various improvement solutions. Based on the analysis results, Seoul started remodeling a pilot project in March, 2008 to reduce energy consumption and improve the efficiency of the public agencies.

As climate change response became an increasingly important political issue, Seoul established and executed the Comprehensive Measures for One Less Nuclear Power Plant Initiative in 2012 to preemptively respond to the problem of climate change by reducing energy demands and extending renewable energy production. Accordingly, the BRP was extended as one the most important policies of the Comprehensive Measures for One Less Nuclear Power Plant Initiative on the basis of existing policies. In 2012, Seoul also included all types of buildings – from existing building to housing (including detached ones to aged apartments) – in the BRP for the

[73] Translation by ESL®

first time in Korea. For the energy welfare through energy saving, it was extended to all types of buildings, including the housing of the low-income class. More specifically, Seoul implemented the BRP for 761 large and medium energy-guzzling buildings and 10,000 detached houses to innovatively improve the overall energy efficiency of buildings that were consuming 58% of all energy consumption in Seoul and provided on-site energy analysis & consulting for small houses and buildings. It also tried to improve the energy efficiency of 51,000 public rental households and 59 social welfare facilities. Finally, it had 30 universities developed as low-carbon green campuses to improve the energy efficiency of all types of buildings.

The BRP has been viewed positively as a key facet of the Comprehensive Measures for One Less Nuclear Power Plant Initiative thus far in contributing to considerably reduced energy consumption and thus greenhouse gas emission of buildings that were consuming a large portion of energy in Seoul.

2. Background Information

In the 2000s, many countries started to recognize the global challenges of energy efficiency, renewable energy, and greenhouse gas reduction through the G8 and APEC summits. The United Nations Framework Convention on Climate Change and the Kyoto Protocol demanded the reduction of greenhouse gas. Seoul also faced the important challenges of reducing energy consumption and thus greenhouse gases. In particular, Seoul was accountable for 10.9% (49,565GWh) of nation-wide power consumption as of 2011 but its energy self-sufficiency rate was only 2.8% - making it vulnerable to energy security. Seoul was faced with gradually increased energy consumption and so required energy crisis measures for unstable energy supply and others associated problems.

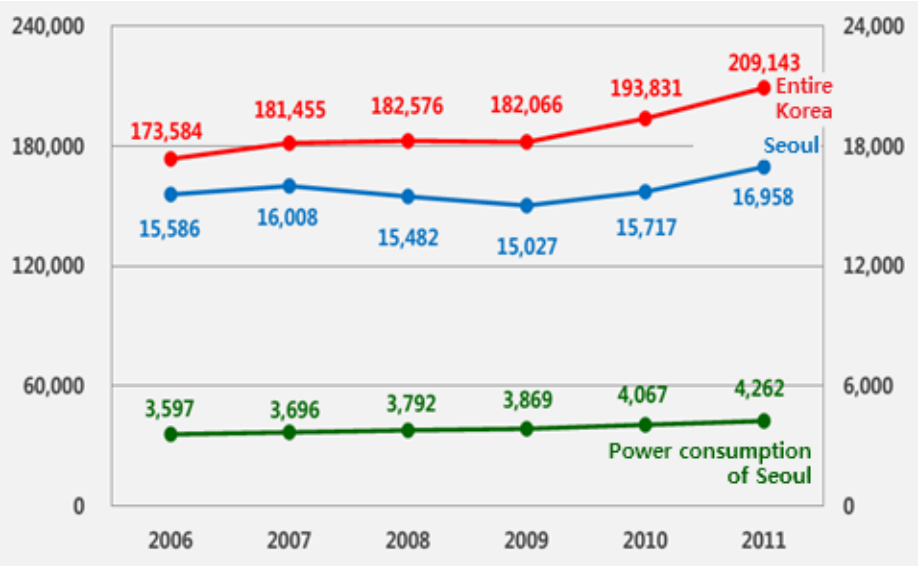


Figure 1. Trend of increasing energy and power consumption in Seoul (Source: Introduction of One Less Nuclear Power Plant Policy (2012), Seoul City Government)

As most responsible for energy consumption and carbon emission in Seoul, energy consumption in buildings was the most important target of Seoul's energy measures. Seoul had been reinforcing design criteria and introducing different green building policies but energy consumption in residential and commercial building was exceeding 50% of the entire energy consumption in Seoul every year. Moreover, the improved financial state of citizens and the increased number of buildings drove a continuous increase in energy consumption in building and thus it became urgent to establish energy policies for these buildings.

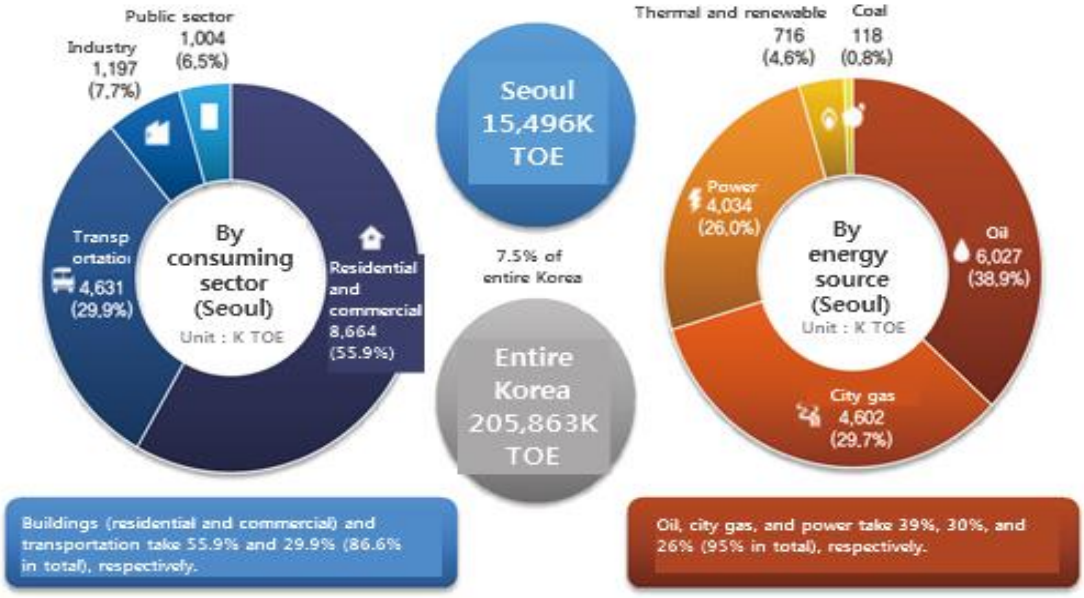


Figure 2. Seoul energy consumption by sector and source

(Source: Introduction of One Less Nuclear Power Plant Policy (2012), Seoul City Government)

Seoul, therefore, introduced different new energy saving policies for building. They included the following methods designed to tackle the growing problem: building energy saving criteria for new buildings, building energy efficiency ratings, housing performance rating labeling, and eco-friendly building certifications. Now, construction permission is not given to new buildings that do not fulfill the Evaluation Criteria of Construction Committee, Seoul and Total Energy Consumption Criteria of Building. However, while the energy saving policies for building are targeting mostly new buildings, policies on existing buildings were not enough . Criteria and guidelines for old buildings have not been established and there was not enough consultation on the analysis and efficient energy saving of old buildings – it was instead dependent on the voluntary participation of the private sector. Indeed, 73% of buildings had been built before the insulation criteria were reinforced (2001) as of 2008. Therefore, it was impossible to save energy consumed in buildings efficiently with the participation of only new building without enhancing the energy efficiency of old ones. To this end, BRP was introduced in Seoul to improve the energy efficiency of old buildings.

Table 1. State of aged buildings as of 2008

Classification	Completed construction before 1980		Completed construction between 1981-2001 (accumulated)		Total as of 2008 (accumulated)	
	Architectural area (K m²)	Ratio (%)	Architectural area (K m²)	Ratio (%)	Architectural area (K m²)	Ratio (%)
Apartment houses	31,438	1.9	1,196,110	71.7	1,668,685	100
Detached houses	162,666	35.8	230,011	50.6	454,448	100
Non-residential	139,132	11.7	668,712	56.2	1,189,575	100
Total	333,236	10.0	2,094,833	63.2	3,312,708	100

(Source: Min Kyeong Kim (2010), How to Save Building Energy? SDI Policy Report No.79)

3. The Importance of the Policy

The BRP is meaningful in creating an active vision by maximizing the energy efficiency as well as reducing the greenhouse gases emissions and switching the focus of the energy system from fossil fuels to renewable energy. Seoul has previously considered energy issues second to other important policies and the greenhouse gas reduction was pursued mostly based on alternative and renewable energy development. On the other hand, zero energy has already been required for new housing in the UK, Germany, France, the US, and other industrialized countries. Furthermore, energy saving criteria have been applied to old buildings to reduce energy consumption in building and improve efficiency. Seoul, therefore, has come to focus its energy policies on the demand efficiency instead of supply because of anti-nuclear trends, increasing oil prices, and the high energy dependence on imports. In this context, the BRP aims to improve the energy efficiency of new buildings, as well as old energy-guzzling buildings. Considering that the energy-guzzling buildings consume 21.9% of energy consumption in buildings sector, the BRP to improve their energy efficiency has prevented potential problems which could be generated from the energy guzzlers.

The BRP is also meaningful in extending civic participation in promoting energy saving in building. The BRP was initially applied to public buildings but then extended later to all buildings so as to widen its scope and encourage civic engagement. Seoul had initially set a goal of housing energy efficiency to 10,000 households by 2014 but already reached 12,784

households by the end of 2013, which indicates a rapid increase of civic participation. The BRP contributes to real energy cost saving including utility bills, and improves housing values by improving housing exteriors leading to more attention and engagement from the public.

4. Relevance with Other Policies

1) Energy Use Rationalization Act

The Energy Use Rationalization Act was legislated in 1979 to promote reasonable energy consumption and to improve the efficiency of thermal equipment. It had served as a framework act for the energy field until the Energy Act was legislated in 2006. Alongside the legislation of the Energy Act, the Energy Use Rationalization Act defined energy use as including government plans, equipment specification, and tests to promote reasonable and efficient energy use. The Energy Use Rationalization Act demanded an established framework plan on energy use rationalization and prescribed efficient energy use of central and local governments (Article 8). The BRP was also implemented on the basis of Article 8 of Energy Use Rationalization Act and Article 15of Enforcement Decree of the Act. In addition, the BRP is applicable to the equipment with the high-efficiency defined by the Energy Use Rationalization Act. It is also part of a larger effort to encourage public participation through proactive promotion and incentives by the public sector to reduce energy consumption in building and improve its efficiency by finding thermal and electric energy waste and thus improving lighting, heating and cooling, air-conditioning systems, insulation, roofs, and windows.

2) Raising of Climate Change Response Fund

To respond to global climate change issues, Seoul put into legislation the Ordinance on Establishment and Operation of Climate Change Fund for the first time in Korea and accordingly established the Climate Change Fund on October 1, 2007. The the City Gas Business Fund established and operated since 1992 was renamed as Climate Change Fund as the project scope was extended to greenhouse gas reduction and the development and supply of new renewable energy in order to respond to climate change. The Seoul Climate Change Fund supported the BRT, as well as renewable energy supply to civil housing and certification costs for eco-friendly buildings (terminated).

The fund was financed with the profits from its operation, the investment dividends of the Korea District Heating Corporation, and the shared dividends of the Korea Gas Corporation. These amounted to KRW 101.5 billion as of end of 2014. The operation scale was KRW 61.3 billion in 2014 which was then used as loan or subsidy for projects on the reduction of greenhouse gas emissions and the development and supply of new and renewable energy projects – including the BRP, renewable energy supplies to private housing, the installation of the Solar Power Plant, and the development of energy-independent villages.

3) Comprehensive Measures for One Less Nuclear Power Plant Initiative

Seoul established the Comprehensive Measures for One Less Nuclear Power Plant Initiative in 2012 to save 2 million TOE of energy (equivalent to the power generated by 1 unit of nuclear power plant) by 2014. This would be done by reducing energy demands and increasing the production of sustainable and eco-friendly energy. In addition, it aims to increase the electricity self-sufficiency rate (2.95% as of 2011) by 20% by 2020. To this end, Seoul established 3-year comprehensive measures for the period 2012 to 2014, including 23 policy agenda and 71 projects, and designate 6 agenda as major component of one less nuclear power plant initiative,which are increased production of renewable energy, improved energy efficiency of building sector, establishment of eco-friendly and high-efficient transportation system , revitalization of and job creation in energy industry, rearrangement of the spatial structure to reduce energy consumption, and creation of public atmosphere to save energy, and. BRT ,therefore, remains one of most important policies in enhancing energy efficiency and has been selected as one of 10 key projects. The aim of BRP project is to implement it for 3 years over 12,200 energy-guzzling buildings, medium and large buildings, detached houses, apartments, office buildings, public rental housing, city social welfare facilities, and schools.

Table 2. Saving goals of Comprehensive Measure for One Less Nuclear Power Plan Initiative by policy means

(Unit: 10K TOE/year)

Classification	2012	2013	2014	Total
(Renewable) Energy production	9	15	17	41
Energy efficiency	22	34	55	111
Energy saving campaign	10	14	24	48
Total	41	63	96	200

(Source: Seoul Metropolitan Government (2014) Seoul Environment White Book 2014)

Seoul is implementing phase 2 of the One Less Nuclear Power Plant Initiative because it achieved its goals in the first half of 2014. Phase 2 aims to continuously develop the previous phase while reducing 4 million TOE of energy by 2020. The BRP is one of the most important projects and will thus extend the size and subjects – including audit cost, cool roof installation, and monitoring cost as well as current windows and doors, insulation, and facilities with high-efficiency. Building which gained green building certification or building energy efficiency certification may enjoy tax reductions of up to 15% , and the same benefits will be applied to the retrofitted existing buildings.

4) Energy Service Company (ESCO) investment

The ESCO is a government project designed to procure and repay investments to modify or complement existing facilities with low-efficiency to the one with high-efficiency. The BRP was initially limited to qualified building owners and ESCOs but is now applicable to anyone who is retrofitting buildings. The facility investment of ESCO investment can help reduce installation costs of the energy saving equipment and solve accompanied technical risks. Additionally, systematic and professional services can be provided for the energy saving facilities by ESCOs, and ESCO investment offers benefits like financing and taxation support.

5. Political objectives

By establishing the Comprehensive Measures for One Less Nuclear Power Plant Initiative, Seoul aimed to reduce 500,000 TOE of energy consumption from 2012 to 2014 by expanding the BRT to reduce energy consumption in building sectors that was consuming 55.8% of the total energy output. To this end, Seoul looked to promote public participation by expanding the BRT to include energy-guzzling buildings, welfare facilities, universities, medium and large buildings, and detached houses on top of the public buildings, the target of the initial phases initiative and by gradually reducing interest on loans. Here are the specific and quantitative objectives of the BRP – one of the key projects of the ComprehensiveMeasures for One Less Nuclear Power Plant Initiative established in 2012. Seoul suggested a quantitative target number of buildings for each type. Currently, Seoul is in phase 2 of the One Less Nuclear Power Plant Initiative process aiming to extend the BRP to 90,000 buildings and houses by 2020.

Table 3. BRP goal of phase 1, One Less Nuclear Power Plant

Classification	Description	2012	2014
BRP for energy-guzzling and medium & large buildings	·Intensive retrofitting of 375 energy-guzzling buildings with an annual consumption of 2,000 TOE of energy or more ·Insulated windows & doors, LED lighting, and improved heating and cooling system: Energy saving of 22% (13 TOE/year) ·80% of project expenses, loans of up to KRW 1 billion (2.5%/year) ·Case : Northeast building of S Tower	700 locations	1,221 locations

BRP for 10K detached houses	·Insulated windows and doors, high-efficiency boilers, and LED lighting improvement ·Intensive implementation through ESCO by community ·Long-term and low-interest unsecured loans of up to 80% (KRW 5 million) of the project cost to alleviate the burden of the low-income class (payable in 8 years with annual interest rate of 2.5%)	2,500 households	10,000 households
Public rental housing facility improvement	·15-year or older 51 complexes out of 570 ones ·Replacement of aged pipelines and elevators, and improvement of window and door chassis ·Installation of eco-friendly LED lighting and stand-by power interruption consent	262 sections	842 sections
BRP for city social welfare facilities	·From more effective projects, in conduction with ESCO ·Through energy saving measurement, savings are reused for the social welfare budget ·Achieved 100% retrofitting of social welfare facilities owned by the city government	30 locations	59 locations
Low-carbon green campus development	·Green campus serving as a local climate and environment center ·Energy efficiency improvement, green fields, and support for the creation of green roof: Seoul GT R&D support, etc. ·Climate Change Response Fund to support 80% of project costs, loans of up to KRW 1 billion (annual interest rate of 2.5%), and KRW 25 billion budget for ESCO from the government ·Pilot project: Korea University	10 campuses	30 campuses
Primary, middle, and high eco school project	·Planning ways to establish eco schools in cooperation with the city government, education office, and the Ministry of Education and Science ·Announcement of effect of eco school project to invite all schools ·Posting of feasibility and cases on the school home page	30 campuses	60 campuses

(Source: Seoul Special City Government (2012), Comprehensive Measure for One Less Nuclear Power Plant)

6. Main Policy Contents

The BRT provided loan support to those who installed energy saving and production facilities on buildings. The BRP is announced publically every year and selects the most suitable beneficiaries through a series of evaluations. Those who conduct BRP for all types of buildings in Seoul, including house owners, building owners (including tenants), ESCO businesses, constructors, city gas providers, and energy saving unit manufacturers, can apply for it. Table 4 shows the planned or ongoing installation projects on energy saving equipment subject to the program – this is not applicable to those who have already finished retrofitting. The support can reach up to 100% of the required finance: KRW 2 - 15 million for housing and KRW 5 million - 2 billion for buildings. In particular, universities and building groups can be supplied with up to 2 times the support cap through evaluations. As of 2016, the support can be level-repaid in 8 years at an annual 1.45% interest rate. The BRP loan can be applied every year from the announcement date to the specified deadline, and it is provided through a bimonthly evaluation by the Loan Board of Seoul Metropolitan Government, Korea Energy Agency, and external experts and, finally, the loan evaluation of the relevant financial institutions. The loan evaluation takes into account both the project suitability and the feasibility to determine support (see Table 6).

Since the BRP was introduced in 2008, it has improved the support system – this has included interest and cap adjustments as well as the extension of the target range to reduce the economic burden on citizens and promote engagement (see Table 5 and Table 7). As the loan application was reduced in 2015, 2016 has further reduced the interest rate so as to promote the project. It has also raised the cap for housing from KRW 10 million to 15 million so as to reduce the actual expenditure of citizens. The fund management system has also been introduced for online applications, loan provisions, and the management of repayments. Furthermore, follow-up management has been added to compare the application details and actual project details through site inspection for increased transparency. Also, more detailed training is provided for the BRP details and construction so as to minimize possible violations that could occur because of insufficient understanding of the applicants.

Table 4. BRP support targets

Classification	Description
Construction sector	- Interior & exterior wall insulation, insulated windows and doors (energy efficiency rating 3 or higher), window pane film (high efficiency certified products), etc. - Heat reflective paint (cool roof)
Mechanical sector	- Construction to enhance efficiency in Heating and cooling - Waste heat recovery equipment - Installation of self-cogeneration system to improve energy production and consumption efficiency - Building automation controller
Electrical sector	- Construction to enhance efficiency in Lighting Energy-saving air-conditioning system

	- Power substation - Installation of excellent stand-by power saving units
Others	- New renewable energy applied to housing and buildings - Energy audit costs, water saving equipment and sprinklers, wall greening, and equipment to use unused energy - Detailed items of financing guidelines for the energy saving facilities and energy use rationalization

Table 5. Qualification for BRP

Classification	Limit of loan		Loan Interest rate	Project details & loan conditions
House	100% of project expenses	Minimum KRW 2 million Maximum KRW 15 million	Annual interest rate 1.45%	·Project details: Installation of energy saving and production facilities ·Loan conditions: Level repayment in 8 years (3-year grace period for buildings) ‣ Support can be provided only to certain floors of apartments, and universities and building groups can be supplied with up to 2 times the support cap through evaluation ‣ Loan requirements of financial institutions must be met ‣ Unsecured loan support for housing under guarantee insurance
Buildings		Minimum KRW 5 million Max. KRW 2 billion		

Table 6. Loan application procedure for BRP

Application for loan	Applicant → City and autonomous district governments
Evaluation	City Government
Recommendation of candidates	City Government → Financial institutions and applicants
Construction Completion & development of completion report	Applicants
Application for loan & Submission of completion report	Applicants → Financial institutions
Consideration ofreport	City Government and financial institutions
Loan provision	City Government → Financial institutions → Applicants
Follow-up Management	City Government and financial institutions

Table 7. Major Improvements in BRP

Time	Improvement	Details
2008.3	Loan support plan established	Interest rate of 3.0%
2012.2	Interest rate discounted Targets extended	3.0% → 2.5% Buildings → Buildings and detached houses (including apartments as of July, 2012)
2012.9	Targets extended	Private sector → Private and public sectors
2013.1	Interest rate discounted	2.5% → 2.0%
2013.8	Targets extended	Building owners (including ESCOs) → BRP implementers (building owners, tenants, etc.)
2014.1	Interest rate discounted	2.0% → 1.75%
2014.4	Support cap increased	Up 80% of project expenses → Up to 100%
2015.10	Improve application process for housing including additional application items	Addition of energy diagnosis cost, criteria establishment for insulation Inclusion of construction details in the project plan
2016.2	Interest rate discounted Support cap increased	1.75% → 1.45% For housing, up to KRW 10 million → KRW 15 million

(Source: Seoul Metropolitan Government (2016), 2016 BRP Loan Support Plan)

7. Technical details

The BRP is a project to improve energy efficiency focused on energy saving and production to reduce the energy loss and inefficiency factors of buildings for the construction, mechanical, electric, and other sectors.

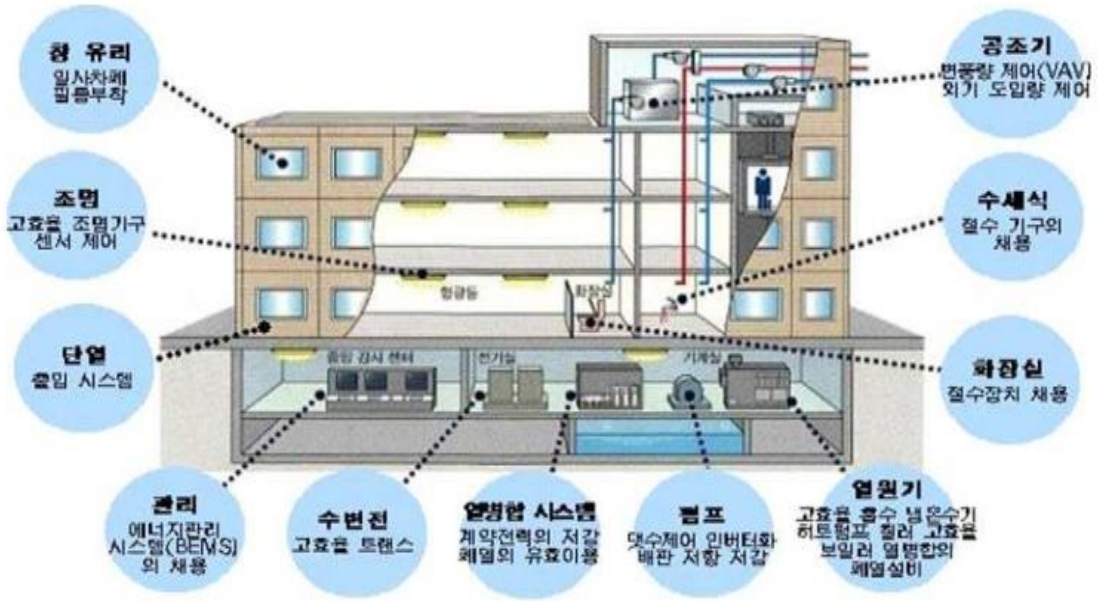


Figure 3. Energy saving facilities of BRP

(Source: Press release of Seoul City Government "Seoul Provides Special BRP Loan to 23 Large Buildings)

1) Construction sector

It is applicable to interior and exterior wall insulation, insulated windows and doors (with an energy efficiency rating 3 or higher), and window pane film (high efficiency certified products). The criteria for new building insulation and for heat transmission coefficient of the energy saving design will be applied to newly installed insulation after the removal of existing ones. Additional insulation can be either interior and exterior insulation, providing it has a heat transmission coefficient of 1.333W/㎡K (heat conductivity class B +thickness of 30㎜) or more and 0.8W/㎡K (heat conductivity class B +thickness of 50㎜) or more, respectively.

2) Mechanical sector

To improve the efficiency of in heating and cooling, it is recommended to replace boilers, cold and hot water dispensers, and freezers with higher-efficiency units; to use city gas as fuel; and to opt for district heating wherever possible. The waste heat recovery equipment is supported through heat exchangers and heat pumps. Installed self-cogeneration systems are designed to improve energy production and consumption efficiency, building automation controllers, and the building energy management system.

3) Electrical sector

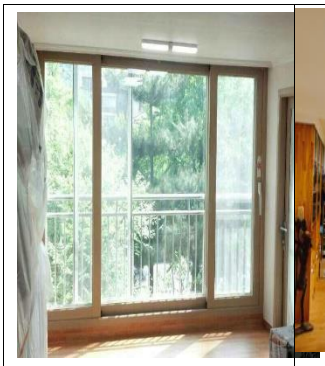
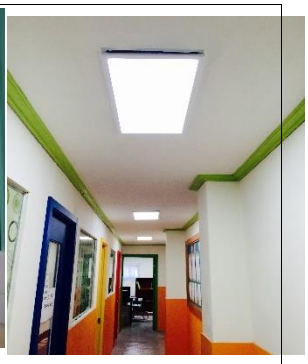
This concerns the installation of high-efficiency LED lighting and lighting efficiency improvement. More than 50% of the entire lighting will be replaced with lighting project

certified with KS or with high efficiency but only with certified lighting with high efficiency ones for public facilities. Installing energy-saving air-conditioning systems (high-efficiency inverters, blowers, and motors), power substations (high efficiency transformers), and excellent stand-by power saving products (certified by Korea Energy Agency) will also aid this process. The installation of 60% or more of intelligent consents for auto stand-by power interruption is planned

4) Others

When applying for energy production facilities to install new renewable energy units (hydrogen fuel cell, geothermal, solar power) in housing and buildings, it is applicable if 50% or more of the project expenses will be spent for the retrofitting. Solar power generation providers will be distributed with loans based on special support plans.

Table 8. Applications of BRP

			
Insulated windows and doors	LED lighting, indoor insulation	Insulated windows and doors	LED lighting

8. Policy effects

The BRP contributed to the growth of Seoul as a green city by contributing to the improvement of the energy efficiency of existing buildings that were consuming large proportion of the total energy in Seoul. The BRP was initiated in 2008 focusing on public agencies and extended to private buildings, including universities and hospitals, and later housing, in 2012.

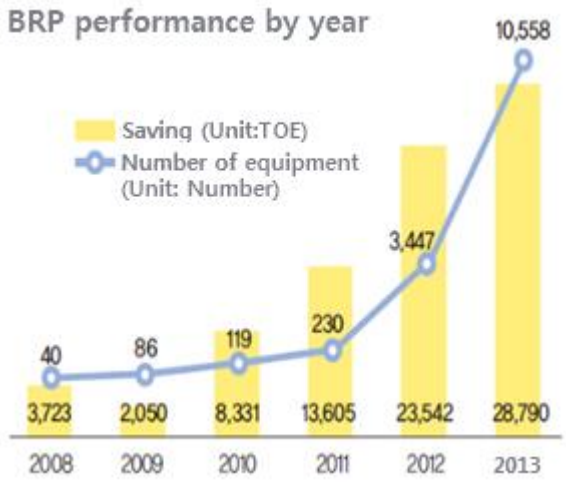


Figure 8. Annual performance of BRP

(Source: Soul Policy Office: BRP: Essential Program for Environment Protection and Economics)

Thus, the number of BRP-engaged buildings and housing increased rapidly (see Fig. 8), and therefore, the energy saving of phase 1 of the One Less Nuclear Power Plant Initiative from 2012 to 2014 reached 187,000 TOE of energy. This is about 9% of 2,040,000 TOE, which is the entire energy saving of phase One Less Nuclear Power Plant Initiative, and demonstrates that the BRP loan support considerably contributed to the improvement in the energy efficiency of buildings.

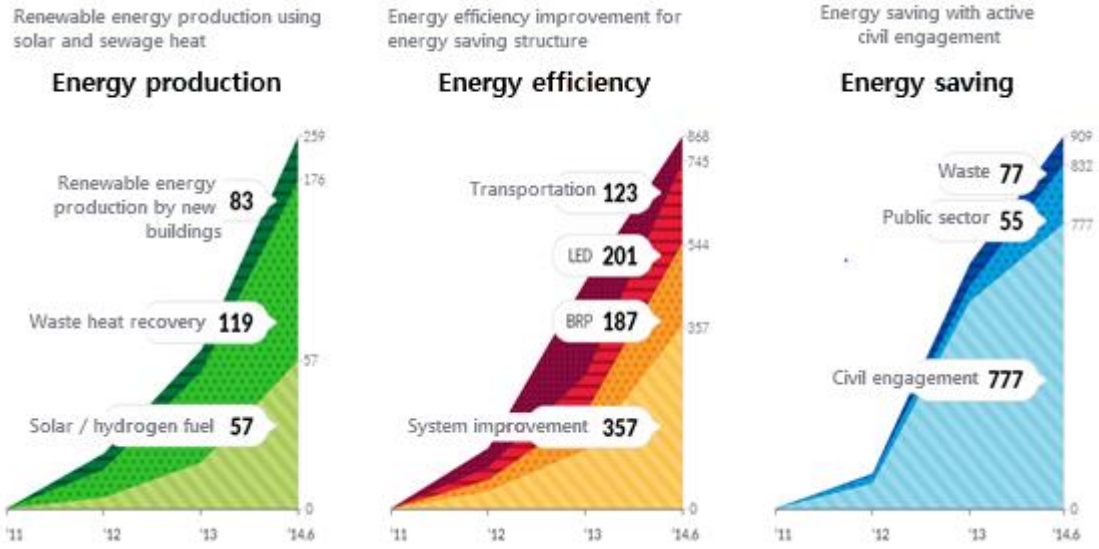
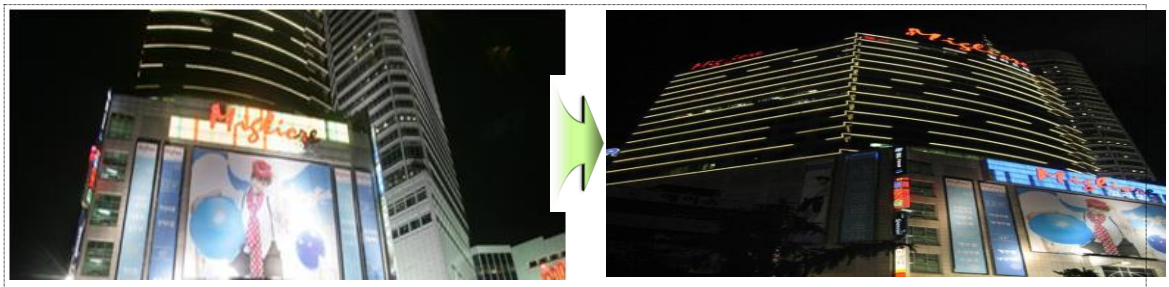


Figure 9. Performance of One Less Nuclear Power Plant by sector (Unit:1,000TOE) (Source: http://energy.seoul.go.kr/seoul/energy/accomp.jsp)

The BRP also signed MOUs with private businesses and groups to reduce project costs by inviting more private businesses. For example, it signed business agreements with LG House Co., Ltd. and Eagon Corporation to supply insulated windows and doors at discounted prices. In addition, it achieved very high satisfaction rates among citizens by assuring quality and follow-ups of the supplied products.

As discussed above, the BRP created environmental effects as well as considerable economic savings. Through the BRP, the Seoul Digital Industry Complex replaced its buildings' heating and cooling systems and thus saved about 83% of its annual power consumption – a figure that amounts to about KRW 100 million of heating and cooling costs. As such, the BRP is developing the foundation forgreen growth of Seoul by creating economic effects of saving energy cost for participants, as well as environmental effects of saving energy consumption and thus reducing greenhouse gas emission.

Miliore, Dongdaemun (2008, retail facility)



◈ Energy saving of 73% (704TOE/year), project cost of KRW 900 million (loan support of KRW 500 million)

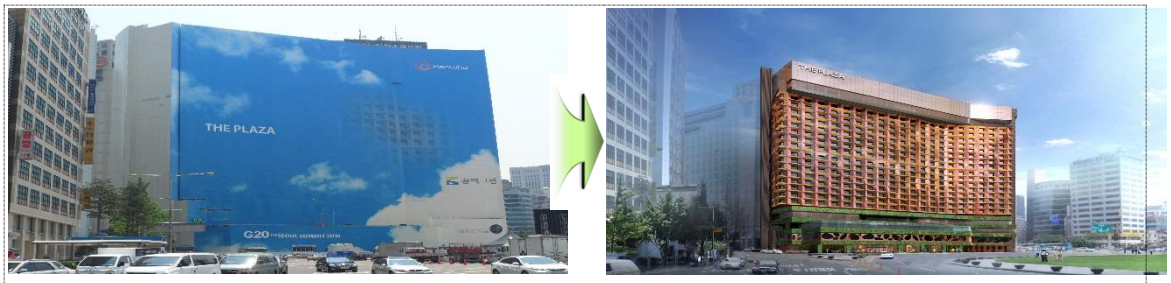
⇒ Installation of 4,522 units of high-efficiency LED lighting (power saving of 3,275MWh)

KLAPP, Yangjaedong (2009, office building)

◈ Energy saving of 28% (23TOE/year), project cost of KRW 1.6 billion (loan support of KRW 1 billion)

⇒ Improved insulation, windows and doors, heating and cooling, and installation of LED lighting, solar power panel, and midnight electricity equipment

Hotel Plaza Seoul (2010, accommodations facility)



◈ Energy saving of 14% (378TOE/year), project cost of KRW 5.1 billion (loan support of KRW 2 billion)

⇒ installation of highly-efficient appliances including building insulation, LED lighting, building automation controllers, waste heat recovery system, and solar power

Northeast building of S tower (2011, office building)

◈ Energy saving of 22% (13TOE/year), project cost of KRW 260 million (loan support of KRW 100 million)

⇒ Building insulation, windows and doors improvement, and LED replacement for existing lighting (53 EA)

In 2013, Seoul was chosen as the Best City oSolving Environmental Issues and thus awarded with a Government Leadership Award by the World Green Action Building Council for such successful implementation of BRP.

9. Challenges & Solutions

Seoul considerably saved energy and reduced greenhouse gas emissions by improving the energy efficiency of existing buildings through the BRP. However, the result has been achieved by continuously improving policies and complementing the system in the process. The biggest challenges for SMG to impelement BRP include a lack of interest in retrofitting (because of economic recession) and conflicting interests between building owners and tenants on the energy efficiency facilities. Here are the policy improvements made so far and future improvements and challenges.

1) Provision of low-interest loans and cap adjustments to promote the project

Seoul has reduced the interest rates of loans to address passive investment in building facility improvements and the disconnection between energy consumption audit and facility improvements because of economic recession. The BRP was initiated in 2008 at an interest rate of 3.0% and has gradually reduced this to 1.45% as of 2016 – a number considerably lower than the commercial rate. Moreover, Seoul has continuously increased the support caps to encourage participation. The year 2014 observed a BRP support cap increase from 80% to 100% and 2016 the limits of loan support for housing from KRW 10 million to KRW 15 million to reduce the actual payment of beneficiaries. However, it is said that the barrier is still high and conditions are rather strict for taking out loans, thus, a further rearrangement of the consulting and data management system is required.

2) Reinforcement of BRP through energy consulting

To effectively improve energy efficiency in housing and buildings from phase 2 of the One Less Nuclear Power Plant, Seoul will provide customized energy audit service in consideration of the energy efficiency levels of housing and buildings. It is planned for energy consultants, energy planners, and energy audit specialists to inspect and evaluate the state of energy consumption and then advise saving plans for housing, stores of small and medium commercial buildings, welfare facilities and educational institutions for free.

3) Solutions for conflicting interests between building owners and tenants

There still remain conflicts of interest regarding energy saving facilities between building owners and tenants. Building owners do not have any incentive because they do not pay energy bills whereas tenants would have such motivation to save energy. However, a tenant rents a building for a certain period and is therefore likely to be reluctant to make upfront investments in energy saving facilities. Seoul initially targeted building owners for the BRT loan but then included tenants from 2014 in consideration of the conflicting interests between the two parties. Still, the tenants have uncertainty over their futures and need consent from building owners to install such energy saving facilities; it thus remains difficult for them to take out loans and implement the project. In order to expand the BRP, it will therefore be necessary to consider the physical condition and rental conditions of buildings for loans and support so as to reduce the burden on tenants while also offering incentives to building owners who do not directly use their buildings.

Volume Based Waste Fee (VBMF) System for Municipal Solid Waste

Shin Lee / Yoo Gyeong Hur, University of Seoul[74]

1. Policy Implementation Period

- 1994 Piloted Volume-based waste disposal system (Commercial arcades - Jung -gu, detached housing area ⁻Seongbuk-gu, apartments- Songpa gu)
- 1995 Volume-based waste fee system launched (The first implementation at the national level)
- 2010 Reusable VBWF bags in place
- 2013 Volume-based food waste fee system launched

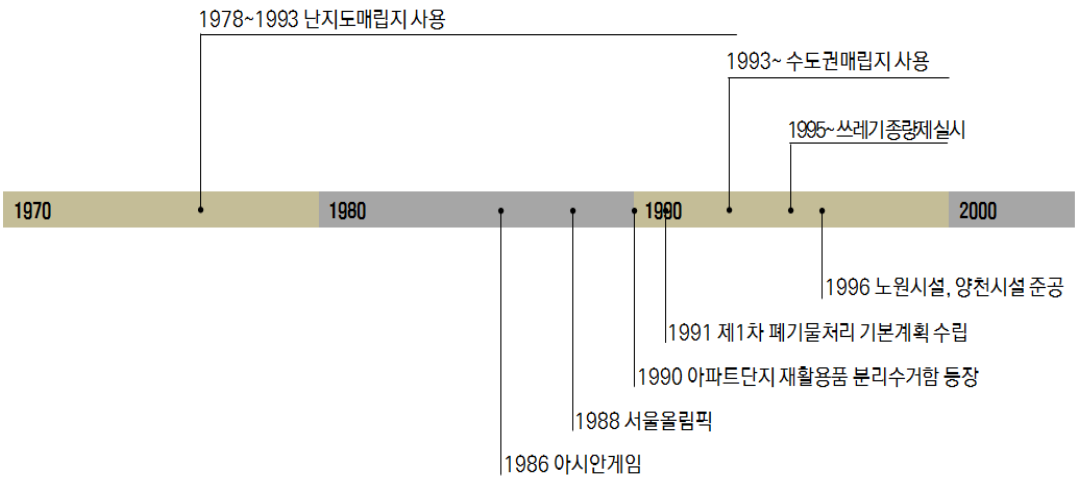


Figure1. Seoul's Waste Treatment before and after the Launching of the Volume Based Waste Fee System
Source: The Seoul Institute (2015)

[74] Translation by ESL®

2. Background Information

After 1980s Korea enjoyed unprecedented economic revitalization and abundance of industrial products based on economic development that started in earnest since 1960s and overall change in industrial structure. The amount of waste generated in the city skyrocketed due to mass production and consumption of affordable plastic products and synthetic packing material due to the development in domestic production technology.

In the meanwhile, due to the shift in the tendency of huge population, who used to flock to Seoul for living and work, started moving out to the suburb area, Seoul's neighbouring cities were turning into new towns accommodating Seoul's excess population. As a result, it got more difficult to secure landfill sites in the suburb and even impossible to do so in Seoul, which had been major waste treatment facility. Gyeonggy Province and City of Incheon were not exception in having difficulties in securing landfill sites. Government took the lead in promoting the establishment of the landfill sites (Sudokwon Landfill Site) where Seoul, Gyeonggi province and Incheon could share. However, it was not smooth at all to establish the Sudokwon Landfill Site as the sense of repulsion towards non-preferred facilities like landfills was already widespread.

While going through difficulties in securing landfill sites, Seoul established a waste treatment plan with the focus on reducing dependence on landfills in 1991. The plan mainly covered constructing 11 incineration facilities. However, even that plan was severely opposed by residents of designated facility area. Civic groups pointed out problems in the plan arguing the size and the number of planned incinerator facilities construction was excessive. So far, as a result, 4 incinerator facilities have been built in Seoul.

As an alternative to reducing waste volume to be buried, recycling policy had been promoted. In 1990, the recycling bin started to be installed in apartment complexes. Due to a level of success so the bins were installed in detached houses area as well. However, residents were not accustomed to separating recyclables from garbages so it was not unusual to find the trash from the recycling bins.

It required a huge amount of costs to construct incinerator facilities and promote recycling in order to overcome the situation where landfill sites got farther away from the downtown. In 1991, Seoul and autonomous gu (administrative district, borough) spent a whopping 280 billion KRW in waste management while residents spent only 25.4 billion KRW. Residents, who discharged the garbage, shared only 9 percent of the costs in waste management.

Due to such situations in 1980s and 1990s, government was desperate in finding ways to invite active public participation in recycling and charge the public more for the growing costs of waste treatment.

Volume-based waste charge system is a sort of solution based on 'The Polluters Pay Principle.' The theory supporting the need for the volume based waste charge system had already been raised in 1980s. However, before the volume based system was in place, waste treatment fees were levied based on the gross area of the building or on the property tax. Back then, waste treatment fees were collected as a type of tax. Table 1 below summarizes the changes of the

waste charge systems up until the implementation of volume based waste charge system in 1995.

Table 1. Seoul's Waste Fee System until 1995

Year	Waste Type	Fee Grade	Basis for Fee Imposition
1980s	General Waste (Small quantity)	7	Building's Total Floor Area
	General Waste (Large quantity)	-	Weight
	Business Waste	6	Building's Total Floor Area
Early 1990s	Residential Waste	9	Building's Total Floor Area/Property Tax Amount
	Business Waste (Large quantity)	2	Weight
	Business Waste (Small quantity)	6	Building's Total Floor Area
1994 (Preparation Period)	Residential Waste	9	Building's Total Floor Area
	Business Waste (Small quantity)	6	Building's Total Floor Area
	Business Waste (Medium)	1	Volume
	Business Waste (Large quantity)	2	Volume
	Construction Waste	-	Volume
	Discarded Home Appliances	7	Type. Volume
	Discarded Furnitures	7	Type. Volume
1995 (Implemented Year)	Genearl/Food Waste	-	Size/Number of standard Trash Bag
	Bulky Waste	-	Type/Size/Number
	Recyclables	-	Free of Charge

Source: The Seoul Institute (2015)

3. The Importance of the Policy

The type of waste subject to the VBWF system is municipal solid waste (MSW) generated from households, commercial sectors and small businesses. Designated waste and industrial wastes defined by Waste Management Act are not subject to VBWF system. VBWF system is based on the 'pay-as-you-throw-principle', which charges according to the amount of discharged waste by selling mandatory standard garbage bags. People should use pre-paid garbage bag in order to discharge waste.

VBWF system has been designed to charge in proportion to the amount of discharged waste and to the costs required in the waste treatment. People are induced to reduce the waste amount on voluntary basis. Wastes discharged as reclyable goods are exempted from collection fees, thus inducing recycling from separate waste collection, which is good both for the residents and authorities. Reduced amount of discharged waste means reduced fees for the residents and also means less dependency on the incinerating facilities and landfill facilities. VBWF system is meaningful as a policy as it changes residents' patterns of waste disposal.

The efforts to change citizens' pattern of waste disposal by awareness campaign or education may be more convenient but may not gain desired results or may gain, yet, very slowly. As a way to control behaviors against environmental protection, government rules and regulations have long been resorted to but enforcement requires human resources, giving rise to high cost for the policy implementation or due to insufficient number of personnel, enforcement had not been conducted. Regulation-oriented approach may not encourage consumers to make voluntary efforts to reduce pollution lower than permissible level. On the contrary, when residents are encouraged to change their behavioral patterns by gaining economic incentives (via VBWF system) proportional to the amount of the reduced amount of discharged waste, residents are motivated to reduce the waste more. After all, VBWF is a very environmentally desirable and effective way to bring about changes in behavioral patterns of residents.

4. Relevance with Other Policies

Today's waste management policy aims to reduce the waste volume based on the reduced waste generation at source and reuse of recyclable wastes. The waste management policy also plans to recover material or energy from the waste and turn them into resources. Lastly, the wastes, which had not been processed from the previous two steps, are requested to be processed safely by being incinerated and buried.

Therefore, it is very important to make a reasonable estimation and strike a balance between the amounts of waste to be generated, waste to be recovered as resources, and waste to be processed by burning or burying. Particularly, VBWF system has direct impact on other relevant waste management policies including policies on waste management facilities as VBWF system makes a huge contribution to suppressing waste in the first phase, waste generation, of the waste management policy.

Until 1980s, private sector took the lead in the recycling market whose focus had been collecting discarded papers, scrap metals and glass bottles. Recyclable wastes were collected by junk men. To the low income people, scavenging for recyclable items had been a crucial means of livelihood at the Nanjido landfill. Recycling bin installed by civic groups and Korea Resources Recovery and Reutilization Corporation (KORECO) started to appear by the time when it was hard to secure landfill site and incineration facilities had become controversial in 1990. The recycling bin started to spread across detached house area since 1992. As social conflicts got intensified over incineration facilities and waste landfill, high expectation were pinned on turning the wastes into recyclable items as alternatives to incineration and reclamation. Obviously, the separate disposal and collection of wastes and recyclables had not been settled as it was not unusual to find wastes mixed in the recycling bins or recyclables items in the waste bags. The VBWF system implemented since 1995 had solved such problems. The VBWF system implemented in Korea has been remarkably effective in settling the separate collection and disposal of voluminous papers, plastic containers and cans, which requires purchasing standard waste bags to throw away their garbage, thus waste collection fee is charged in proportion to the amount thrown away.

The government revised the Waste Management Act in 1998 saying starting in 2005 so the direct land-filling of food waste generated in urban areas would be completely banned. With the implementation of the VBWF system, residents living around waste treatment facilities including incineration and landfill site expressed opposition to the facilities, as food waste was discharged using the VBWF bags, which gave rise to the various environmental problems including creating serious foul order and harmful insects.

Meanwhile, autonomies, responsible for the MSW, faced more difficulties when supply of recyclables increased. It was not unusual to see recyclable items piled up in the regional authorities' recycling depository as there was no available market for the recycled goods. Also, due to free-fall of trade prices, private sector refused to purchase the recyclable items. Selecting and securing food waste treatment facilities were also serious headaches as residents around the would-be facility sites were deadly opposed to them and the other option of using private facilities were simply too expensive.

In the end, VBWF system had met the policy goals of waste reduction and separate disposal and collection of recyclable wastes but it generated the demand for policies such as securing markets for supply and demand of recyclable markets and establishing food waste management facilities, which led to the introduction of Expanded Producer Responsibility (EPR) in 2003 and ban on the direct land-filling of food waste in 2005.

5. Policy Objectives

● Reduced waste generation at source

● Settlement of separate disposal and collection of recyclable items.

● Reduced dependence on the waste processing facilities (incinerating facilities and landfill facilities)

6. Main Policy Contents

Volume-based Waste Fee system is a policy to charge fees in proportion to the amount thrown away. In Seoul, all wastes should be discharged in accordance with VBWF system, with the exception to the recyclable items, bulky waste and coal briquette whose discharge are otherwise specified, and fees are charged proportional to the amount discharged. Depending on the waste type, their volumes are measured differently. Wastes are divided into general wastes (or MSW) to be incinerated or buried, food waste, and recyclable waste which could be turned into resources.

General waste refers to waste to be incinerated or to be buried. Waste volume is measured through standard garbage bags, which were taken by the district, or gu, offices to be divided into household, commercial, and business use. Bags are in 2, 3, 5, 10, 20, 30, 50, 75, and 100 liter sizes, with people able to purchase the size and quantity of bags they wish at designated stores. General waste therefore is treated based on volume based charge system.

Food waste could be discharged in various ways. People may use standard waste bags sold by local authorities, standard plastic container equipped with electronic chip or sticker, and weight-based payment using electronic card with RFID. In the case of RFID based food waste treatment, discharger should swipe a card before gaining access to residential waste bins. The chip containing user's name and address allows the authorities monitor the weight of individual's waste. The system accumulates the fee on a monthly basis, and each household receives a monthly food waste disposal bill.

Other items such as papers, plastic packaging materials, glass bottles, scrap metals, discarded home appliances, discarded florescent lamps, used batteries and used cooking oil are classified as recyclables and should be discharged in the way prescribed by the Ministry of Environment.

Table 2. Seoul's Way to Measure and Charge IAW VBWF system

Category	General Waste	Food Waste
How to Measure	● VBWF bags (Standard waste bags)	● RFID-based weight measuring device ● Chip or sticker ● VBWF bags (Standard waste bags)
Types of VBWF bags	● General use bags: 3ℓ, 5ℓ, 10ℓ, 20ℓ, 30ℓ, 50ℓ, 75ℓ, 100ℓ ● Reusable bags : 10ℓ, 20ℓ ● Public Use: 30ℓ, 50ℓ, 100ℓ	● General Use : 1ℓ, 2ℓ, 3ℓ, 5ℓ, 10ℓ *VBWF bags bigger than 20ℓ are allowed to use only during national holidays or kimchi-making season when sizable amount of discharge was unavoidable.
Colors of VBWF bags	● General use bags and reusable bags: White ● Public use : blue	● General Use : Yellow
Materials of VBWF bags	● PE bags ● Biodegradable bags	● PE bags ● Biodegradable bags
		

However, ordinary VBWF bags are little better than disposable trash bags which could be used only once. The Korean Government, for its part, as an effort to solve, albeit partly, such issue, allowed shopping giants such as E-mart, Home plus, Lotte mart, Nonghyup Hanaro mart, Mega mart to offer the reusable VBWF bags and customers could use them as standard trash bags.

Since 2013, food waste has been subject to volume-based waste fee system in Seoul. The chip or sticker system requires a discharger to buy a payment chip or sticker and attach it to a standard collection container to be picked up. The container serves as a disposable volume measuring device or monthly volume measuring devices. The merit of RFID system is that it accurately scales waste volume and fees are charged according to the total volume. However, RFID system could be quite complicated as it has to be equipped with weight measuring device, discharger recognition system, and volume tracking & storage devices.

When disposing large items, discharger should buy sticker from the regional authorities and place it on the item before they are picked up, or let them be picked up by garbage haulers.

Discharge Fees

In accordance with the VBWF system, dischargers pay partial or all costs of collecting and treating them when they throw away municipal solid waste and food waste. The amount of fee

is determined by the volume of generated wastes, which is why the system is named as volume-based waste fee system. The price of VBWF bags includes the costs of collection, treatment, manufacturing, and sales profit of the VBWF bags.

8. Policy Effects

1) Reduction of Household Solid Waste Generation

According to Seoul's statistics, the volume of waste generated in Seoul had been reduced by 8 % in 1995 and 11% in 1996 compared with that in 1994, which was tantamount to reduction of 1,1712 ton/day. Since the VBWF system has been instituted, consumers have shown changed pattern of waste generation, improved awareness of waste disposal, which well explains the cause of the reduction in statistics. For example, consumers got sensitive to over-packaging of products, brought only product part, while leaving the package materials at the sales shop, requested the collection/return of packaging material when delivered, which, in turn, affected product design. Some quarters, of course, argued the waste reduction was hardly due to the VBWF system, but due to reduced consumption of coal briquette, changes of charging basis from volume to weight, dwindled production and consumption in the wake of economic crisis that hit Korea hard in 1998 and the Government's separate implementation of relevant policy. However, reduced waste generation was a very natural consequence of the policy considering the principle of environmental policy, VBWF system. Therefore, the level of the policy effect could be controversial but it does not make sense to argue against the effect per se.

Table 3. Changes in the Waste Generation

Change	1994 (Preparation Period)	1995 (Implemented Year)	1996 (Institutionalization Period)
Generated Volume (ton/day)	15,397	14,102	13,685
Generated Volume (kg/day)	1.43	1.33	1.31

2) Contribution to the Settlement of Separated Disposal and Collection of Waste and Recyclable Goods

The most apparent outcome of the VBWF system is its contribution to the settlement of separated disposal and collection of waste and recyclable goods in a short space of time. In accordance with the VBWF system in Korea, discharged recyclable waste are collected by authority free of charge. Papers, plastic products and cans are sizable which means the more you discharge the recyclable items (instead of throwing them away in VBWF bags), the more you

can save.

Recycling performance (the recycled amount) in 1996 had increased by 881 ton/day compared with that in 1994. Out of overall waste treatments, the recycled volume had shown significant rise from 20.5% in 1994, to 29.3% in 1995 (the year VBWF system was introduced), to 29.5% (2 years into the introduction of VBWF system). The separate disposal and collection of wastes and recyclables had led to reduced demand for waste treatment facilities.

Table 4. Changes in the Recyclables Generation

Category	1993 (Flat Rate)	1994 (Preparation Period)	1995 (Implemented Year)	1996 (Institutionalization Period)
Waste Generation (ton/day)	16,021	15,397	14,102	13,685
Recyclables Generation (ton/day)	2,940	3,156	4,131	4,037
Recycling rate (%)	18.4	20.5	29.3	29.5

3) Securing Waste Treatment Costs from Profits of VBWF System

In 1991, Seoul's financial independence of the cleaning budget was as low as 9%, which was calculated by dividing the total profits from the sales of waste bag and recyclable materials, fees for the disposal of bulky waste, and penalties by the annual waste disposal cost. In other words, dischargers' share of responsibility in cleaning was very low (SMG, 1992). With the implementation of VBWF system, dischargers' share of payment had risen by 28% from 119.9 billion KRW in 1993 to 153.6 billion KRW. While the overall fees from VBWF system had risen, the charge per household had not increased. That is due to improved equity of the system. For example, monthly payment per household had risen from 2,102 KRW to 2,288 KRW. Yet, the number of households paying the fees had risen from 1.69 million to 2.97 million. The implementation of the VBWF system had improved unreasonable charging system, which led to the rise in the revenue from the VBWF system.

Table 5. Changes in Profits from the VBWF System

Category	1993(Flat Rate)	1995 (Implemented Year)	1995/1993
VBWF Revenues (million won)	119,912	153,638	1.28

4) Creation of Economic Benefits

In 2005, Korean government assessed the outcome of the VBWF system to commemorate the 10th anniversary of the system which had been in place since 1995. The assessment said that

one ton of waste reduction generated economic benefit of 144,071 KRW and one ton of recycled waste creates economic value of 18,901 KRW. The benefits generated from the waste reduction were due to the cost savings from waste collection and transport, and installation and operation of treatment facilities. In addition, benefits from recycled goods equaled to the total value of recycled goods subtracting the costs of collection, transport, selection and processing of the recycled goods. If those calculations were included in the outcome of Seoul's VBWF system, Seoul had created economic benefits of 96.1 billion KRW by reducing the costs in waste collection, transport and treatment and by creating market value of 6.1 billion KRW with the recyclables.

Table 6. Changes in Discharger Fees

Category	Changes (1996-1994, ton/year)	Benefits (KRW/ton)	Scale of Benefits (billion KRW/year)
Reduced Amount	-624,880	144,071	900
Recycled Amount	+321,565	18,901	61
Total Benefits	-	-	961

9. Challenges and Solutions

1) Supply of Collected Recyclable Waste

Recyclable wastes are categorized into papers, plastic containers, scrap metals (including can) and glass bottles. The VBWF system, which stipulates collection of recyclable goods for free, helped settlement of the separated discharge and collection of recyclables in a short period. In the meanwhile, recyclables had not been well utilized, which became the burden of the government. In particular, main headache was how to make use of plastic containers (made of PE, PP, PS or PVC) except PET. Even though they are designated as recyclables but those recycling infrastructure for plastic materials was inadequate. Moreover, as VBWF system virtually focused on charging plastic containers, producers were not responsible for the recyclable waste. The deposit-refund system was in place, which levied a refundable container deposit on consumers. However, that system applied to only a few limited items including paper pack, PET bottles, iron can and glass bottles. Unfortunately, many producers gave up on the deposit, so the deposit-refund system did not really help supply and utilize the recyclable wastes.

Solutions

First of all, when it comes to the problems in the plastic containers, government offered loan on installation and operation of plastic recycling facilities to the manufacturers.

In addition, products manufactured using recycled plastics were preferentially purchased by the public sector. Also, in 2003 expanded producer responsibility (EPR), replacing the deposit-refund system, was imposed on the manufacturer to resolve insufficient recycling infrastructure

for recyclable wastes (including plastic containers), which held the manufacturer responsible for the costs of managing their products at the end of life. Also, the items subject to the EPR have been expanded to include paper pack, plastic containers, scrap metals (including iron can), glass bottles, big and small home appliances, discarded florescent lamps, and used batteries. As a result, the issue of supply and demand of collected recyclable waste had improved dramatically.

2) Food Waste

Difficulties in Implementing VBWF System

Even though the VBWF system had been in place, food wastes were discharged into standard food waste bin in most autonomous districts and flat rate was levied on each household regardless of the amount discharged. Some district collected free of charge not to use VBWF bags. That's because VBWF bags made of PE (polyethylene) could function as foreign matter while the food waste is processed into animal feed and fertilizer, deteriorating product quality, which became main reasons the consumers are reluctant to purchase.

Also, autonomous districts had hard time in arguing whether it's proper to impose charge on food waste which would turn into resources, while recycable items were collected free of charge.

Solutions

The Seoul Metropolitan Government (SMG) has instituted VBWF systems for food waste since 2013 with the goal of reducing food waste taking into account the difficulties in turning the food waste into resources and the hardships in applying expanded producer responsibility (EPR) and the generation of too much food waste.

Considering relatively heavier weight of food waste, the government has recommended authorities to adopt weight-based waste fee (WBF) system instead of volume-based system and the WBF system has reportedly reduced the food waste by ten to thirty percent. Under the WBF system, the discharged weight of food waste is recorded for each resident and the fees are levied based on the weight tracking record. The devices for WBF system has been installed only in some apartment complexes as it is costly to install and operate weight measuring devices and enough space is necessary for the installation of device. Detached houses and restaurants have widely used VBWF bags for food waste or standard waste bin tagged with chip.

Foul Odor from Food Waste

Throughout the first year while VBWF system was in place, there had been significant amount of complaints on foul odor in many places including roads leading to the landfill facilities and waste management facilities. The foul odor was created from the food waste and it got even

more serious since the VBWF system had been introduced. That was because papers which used to absorb leachate and the foul odor from the food waste were separately discharged in accordance with VBWF system.

Solutions

The problem of foul odor had been resolved by a massive change in the food treatment system whereby food waste have been separately disposed, collected and treated. Since 1998, the SMG has embarked on the construction of food waste treatment facilities, has secured and run 5 public food treatment facilities and also has commissioned private facilities for the food waste treatment. Starting in 2005, direct land-filling of food waste has been banned.

3) Waste Bags

Material

Broken glasses and small-size construction wastes are sharp and heavy, often causing injuries to the sanitary workers particularly during collection procedure.

Solution

Since 1997, special VBWF bags have been manufactured especially for wastes, which both discharger and collectors find hard to handle, including broken glasses, small-size construction wastes and etc. These bags are made of durable ‘poly propylene.’

Environmental Issues

VBWF bags, the essence of VBWF system, is very convenient especially in big cities like Seoul as the system naturally imposes fee in proportion to the amount of generated wastes. However, many had pointed out whether it is proper to use the throw-away type VBWF bags.

Solution

As a way to resolve this, government recommended shopping giants including E-mart, Homeplus, Lotte mart, Nonghyup, Hanaro club, Mega mart to sell VBWF bags as shopping baskets instead of free plastics bags so shopping giants in Seoul started to follow government’s recommendation. These VBWF bags are called as reusable bags which are also used as

shopping baskets in addition to its original use as VBWF bags. The prices of reusable VBWF bags are the same with those of ordinary VBWF bags.

4) Negative Public Sentiment against the Implementation of VBWF System

VBWF system had been instituted with the strong support of government, cities and some academics who felt sense of crisis due to the difficulties in securing sites for waste treatment facilities, not with the support of the general public. After all, VBWF system is quite inconvenient program to the perspective of citizens, the dischargers, and many experts argued that other nations would not introduce the VBWF system for fear of reckless illegal dumping.

Solution

In order to overcome such a negative social atmosphere against the VBWF system, authorities had made enormous efforts to get rid of institutional stumbling blocks and explored benefits and effects as well as possible problems, and thereby secured a chance to persuade general public.

- Thorough Preparation

It is imperative to figure out what type of VBWF system is proper for the city during the preparation stage. Seoul selected VBWF bags as a means to measure the waste volume because it's hard to identify dischargers in this overpopulated but cramped city with lots of high-rise buildings such as apartment complexes and shopping malls.

However, it could be desirable to use waste bins for area with lots of detached houses and with roads stretching in all directions. Also, the use of waste bins could prevent the waste of throw-away VBWF bags, ward off illegal dumping by concluding contracts with the dischargers on the size of trash bins, and save waste collection fees by using automatic loading system.

- Cooperation with Civic Groups

In the settlement of VBWF system, civic groups in the environmental field had played a crucial role. While the introduction of the VBWF system had been discussed, civic groups were not by and large positive to the idea. They were also worried about fly-tipping not to pay charges for the wastes and were doubtful of government, arguing the government tried to shoulder the entire burden of waste reduction and turning the waste into resources to the general public. However, the civic groups started changing their attitude after they participated in the pilot projects and site monitoring in the year when the VBWF system was introduced, and ascertained publics' passion for the system. The civic groups had steadily partaken in pilot project evaluation, year one evaluation, year two evaluation, and ten year evaluation. Even nowadays, they have taken part in the progress evaluation of volume-based food waste fee system. Positive attitudes and evaluation of civic groups have made a huge contribution to changing the tone of media coverage and the public awareness of the issue.

5) Illegal Dumping

When introduction of the VBWF system was considered, one of the most worrisome side effects was illegal littering not to pay waste collection charges. As worried, some threw away municipal wastes or business waste into public trash bins on the street, disposed of waste in remote area, or

discharged waste in non-VBWF bags.

Solution

In order to prevent littering, some local authorities installed reflectors in vulnerable places, made flower garden, got rid of public waste bins in the down town. Due to such a series of efforts, the number of violations had been dramatically decreased, even though not perfectly eradicated. In addition, penalties were imposed on the violations or VBWF bags were offered to low income family free of charge.

Figure 4. Illegal Activities and Countermeasures

6) Legal Framework for the Institutionalization of Volume-based Waste Fee System

- Legal Grounds for the Volume-based Waste Fee System

Legal grounds for volume-based waste fee (VBWF) system is 'Waste Management Act' and specific implementation of the act is determined by regional authorities' ordinances. The Waste Management Act includes penalties against the violators.

Each regional authority's ordinance defines specifics of the implementation which are types of waste subject to the VBWF system, ways of discharge, charge, color and materials of standard

plastic bags (VBWF bags), safety management of manufacturing and inspection of VBWF bags, how to designate shops in charge of supply, purchase and sales of the VBWF bags, rules the seller have to follow, the standard of cancelling the designated VBWF bag sales shops.

The size, material, strength and type of the standard litter bags are determined by Korea Federation of Plastic Industry Cooperation (KFPIC). The standard VBWF bags should be manufactured in accordance with the standard of KFPIC and if they fail to meet the standard, they will not pass the inspection.

To prevent the manufacturing and use of fake litter bag, seals stamped on the surface of the VBWF bags are kept by local authorities (or collection and transport agency authorized by the local authorities) and are handed over to the manufacturers only when the VBWF bags are manufactured. If fake bags are manufactured or distributed, violators will be subject to criminal penalties equivalent of fabrication of the official documents.

Table 7. Legal Framework for Implementing Seoul's VBWF System

Category	Details
Waste Management Act	‣Recommend the implementation of the VBWF system ‣Establish ordinances relevant to the implementation of the VBWF system. ‣Ban illegal dumping and implement regulations to impose fines to those doing illegal dumping ‣ Revise relevant rules and regulations of the local autonomous governments: rules and regulations of the ordinance, VBWF system implementation guide, VBWF system implementation guide of food waste
Regional Autonomies' Waste Management Ordinance	‣Contents: Designate wastes subject to VBWF system, ways of discharge, collection fees, color and material of VBWF bags, manufacturing .inspection.safety management of VBWF bags, shops for the supply, purchase, sales of VBWF bags
Korea Federation of Plastic Industry Cooperation (KFPIC)	‣Type : VBWF bags made of PE, VBWF bags made of LLDPE , VBWF bags containing LDPE (CaCO3+HDPE) ‣9 types of biodegradable VBWF bags
Progress Report	‣Contents: Implementation, manufacturing and sales of the VBWF bags, ways and frequency of waste collection, financial independence of waste management and financial dependence allotment rate, discharge of bulky waste and collection of disposable vinyl bags, enforcement performance of illegal activities and etc.
Criminal Law	‣If fake bags are manufactured or distributed, violators will be subject to criminal penalties equivalent of fabrication of the official documents.

Promotion of Phased Price Rise of VBWF Bags

On August 1 2015, the prices of VBWF bags rose in 4 regional autonomies in Seoul including Yongsan-gu, Nowon-gu, Youngdeungpo-gu, Dongjak-gu. With a 20 liter VBWF bag for municipal solid waste as a basis, the price was previously determined between 340 KRW and 380 KRW but rose to 400 KRW and 490 KRW. With a 2 liter VBWF bag for food waste as a basis, the price has risen to 140-210 KRW from 50-80 KRW. The rise was not confined to a couple of autonomous districts but 14 autonomous districts had already raised the price in the first half of 2015 and other districts also had plans to raise the price.

Table 8. Basic Price of VBWF bags for General Waste and Food Waste

Category		Collection & Transport Fee	Treatment Cost	Manufacturing Cost	Sales Profit	Total	Deviation
General Waste	20L (Basic Price)	402	190	51	22	665	1.00
	20L (Currently)	308	12	21	22	363	0.55
Food Waste	2L (Basic Price)	142	149	10	4	305	1.00
	2L (Currently)	101	5	10	4	120	0.39

Seoul had good reasons to raise the price of VBWF bags. Above all, Seoul residents' share of charge included in the price of VBWF bags had been lowest among local autonomies. It cost 665 KRW to dispose of 20 liters of MSW while the price of 20 liter VBWF bag was 363 KRW, which meant Seoul residents paid only 55% of the waste treatment costs. In regards to food waste, situation was even more worrisome. The price of 2 liter VBWF bags for food waste was 120 KRW while the food waste treatment costs for that volume was 305 KRW, residents took only 39% of the cost burden.

Table 9. Nation-wide Average VBWF Bag Prices

(20ℓ, 2014)

Category	National Average	Average of Metropolitan Cities	Seoul	Busan	Dae-gu	In-cheon	Gwang-ju	Dae-jeon	Ulsan
Price (KRW)	457	650	363	850	430	620	740	660	600

While national average price of VBWF bags was 457 KRW, the price in Seoul was 363 KRW,

80% of national average or the lowest in the nation. Even if we factor into different processing methods and costs for local autonomies, VBWF bags in Seoul were apparently cheaper than in other regions.

As the residents' share of waste treatment cost was low, district's financial strain got severer. While the price of VBWF bags had not changed a lot since 1995 (the year the system was introduced), prices kept rising, causing bigger treatment costs. In addition, profits from the sales of the VBWF bags have had a direct impact on the district's financial condition as starting in 2015 sales profits of the VBWF bags have been directly managed by the districts.

Table 10. Guidelines in the Price Raise of VBWF Bags

Category	Current Fee	Autonomies' Average	'15	'17
General waste (20ℓ)	340KRW ~ 400KRW	363 KRW	437 KRW	492 KRW
Food waste (2ℓ)	40KRW ~ 160KRW	120 KRW	133 KRW	187 KRW

To resolve such problems, Seoul announced guidelines in the price rise to make different prices of VBWF bags from districts to districts to similar level and in raising the lowest rise of VBWF bags in Seoul in phases until 2017.

In other words, the price of VBWF bags will have been raised gradually and by 2018 the prices of VBWF bags in all the autonomous districts in Seoul would be similar level. Final prices for 20 litter VBWF bags will be 492 KRW and 2 liter volume-based food waste fee bags will be 187 KRW.

To sum up, price rise of the VBWF bags mainly aims to reduce the financial burden of local districts. More fundamentally, it aims to curb waste generation at source.

People would be more discrete in discharging if the VBWF bags are more expensive, or they would go so far as not to generate unnecessary waste in the first place. To curb the waste generation, VBWF system has been instituted and for the same purpose the prices of VBWF have been raised.

Model Cases of Volume-Based Waste Fee System

The model cases in Dobong-gu, Seoul

Separate Disposal and Collection of Recyclable Waste

Dobong-gu (gu, administrative district) came up with 6 different guidelines depending on the housing types. Basically, the waste collection from apartment complexes made independently by residents while those living in ordinary residential area required district office to be actively

involved in the collection and disposal of wastes and recyclables.

a) Professional Collection System

Garbage collection team was organized in respective sub-districts, dong, and one cleaning personnel and one driver took a recycling waste collection vehicle together to collect the recyclable waste on the road, joined by an official in charge of waste management from the sub-districts office. In addition, they entered into a business relationship with recycling shops. Professional team members brought necessary equipment and collected recyclable materials and sold the recovered materials to the shops. The profitability was maximized and residents' involvement increased.

b) Compensation for Recyclable Materials

The Volume-based Waste Fee System represents a right way of waste separation and collection but to the perspective of residents it could be a very inconvenient system. It does not make any sense if the recyclable materials-- which residents separated from trash with much effort -- are to be collected free of charge while residents are asked to bear considerable inconveniences following the system. As compensation (toilet paper) was made for the recyclable materials, residents were motivated to participate and the compensation had a level of promotional effect in a short space of time.

c) Separation of 5 types of Recyclable Waste

Recyclable waste is separated into 5 types (newspapers, scrap paper, milk cartons, bottles, metals) and there are certain ways of discharging the recyclable waste. Collected waste, already separated into 5 types, could be sold at the recycling shops immediately upon collection.

d) Daily Collection Drive in One Single Zone

The one-size-fits-all approach was not pursued to the waste collection based on sub-districts, dong, but flexibility was added to the collection process to ensure adjustment of collection methods and schedules, etc. In other words, they divided the entire sub-district into five zones and focused on the promotional drive and thorough waste collection in one zone a day, not covering the entire five zones in a day. The sanitary workers were ordered not to collect improperly discharged garbage at the door and induced the residents to load the garbage bags onto the waste collecting truck when they hear the signature song.

e) Collection and Selling on the Same Day

As the recyclable materials were collected in the morning and sold in the afternoon, the recyclable waste selection yard were no longer necessary. The recovered recyclable materials, depending on the items, were sold directly to the private recycling shops not only to the public recycling companies. In that way, the profits from the recyclables management were

maximized and returned to the residents.

f) Implication

The key drivers for the success were 1)the active involvement of residents who were encouraged to do what they had to, 2) high proceeds from the sale of recovered recyclable materials by relevant administrative authorities, 3) return of the proceeds to the residents, and 4) efforts by the authorities to motivate residents' participation. To ensure success, intensive educational session was conducted, hosted by the head of district office. On top of that, instead of perfunctory committee gathering, public officials had face-to-face encounter with residents for promotion of the program.

References

- Yoo, Ki-young (2015), Seoul Solution Waste, The Seoul Institute , 'Waste' section, The Seoul Institute
- Seoul Metropolitan Government, 1992, 92 Seoul City Administration
- Minister of Environment, 2011, Guide in separate discharge of recyclable resources and etc. (Ministry of Environment, Directive, No.859, 2009. 8. 18)
- Ministry of Environment, 2012. 11, Volume based Waste Fee system implementation guide
- Ministry of Environment, Resources Recirculation Bureau, (2012) Implementation guide on volume-based waste fee system for the discharge of food waste
- Sohn, Youngbae(2001), Volume-based waste fee system, Who established it and how did it go? 'Monthly magazine waste 21', 2(7) : 1-5
- Oh, yong-sun, 2006, A Critical Evaluation on the Effect of Environmental Improvement by Volume-based Waste Fee System, 「Korean Association for Policy Studies Newsletter」, 15(2) : 245-270
- Korea Institute for Industrial Research·Korea Environment Corporation, (2013). A study on the performance evaluation and development of volume-based food waste fee system
- Ministry of Environment·Korea Environment Institute, 2012, Modularization of Korea's economic development experience : Volume-based wastee fee system
- SBS, 2015. 8. 6, The price of volume-based waste fee bags, should it be raised?

Waste Heat Recovery Project

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1. Policy Implementation Period

- 1960~1985: General waste disposed at local landfill sites
- 1978~1993: Waste disposed at Nanji landfill site
- 1986: Mokdong incineration facility operation started
- 1991: Seoul City - Basic Waste Disposal Plan founded
- 1992~2005: 4 resource recovery facilities constructed
- 1993: Waste disposed at capital area landfill site
- 2007~2010: 4 resource recovery facilities - sharing agreed

2. General Information

In Korea, the economic development of the 1960s prompted the growth of waste disposal as well. Generated waste was used as bank materials at housing sites in the suburban areas. Nanji landfill began operation in 1978, and waste disposal switched to landfill.

Through rapid development, Seoul successfully held the 1986 Asian Games, and 1988 Olympics and was thus becoming an international city. However, internally it was faced with the problems of waste disposal (e.x. Nanji landfill), and waste disposal was becoming a social issue of the time.

To resolve this, Seoul Metropolitan Government (SMG) founded its 'Basic Waste Disposal Plan' in 1991, and planned the construction of major incineration facilities.

[75] Translation by ESL®

3. The Importance of the Policy

Large cities with a high population density dispose proportionally large volume of waste, and if the city takes care of such amounts on its own, its land cannot be used flexibly. However, if the location of landfill site is far away from the city, the cost for transportation grows considerably.

Incinerating waste within the city area has many benefits. Waste can be disposed in 1 to 2 days, therefore requiring smaller facility capacity. After incineration, the weight and volume of the waste significantly decreases, and incinerated waste does not emit much odor. Even when it is placed at landfill sites, it becomes more efficient in terms of space and management.

Moreover, the heat energy generated during incineration can be used in city areas. Therefore, incineration can be considered an important waste management policy in the cities.

4. Relevance with Other Policies

Modern waste management policy is composed of three steps: First, the amount of waste is restricted through recycling and reducing the waste itself. Second, waste that had to be generated goes through energy recycling or is recycled as material to be used as a further resource. Finally, waste that cannot be handled by the previous two steps, safe disposal is required – such as through the use of incineration or landfill.

Therefore, predictions should be made for the total amount of waste, the amount of waste that can be recycled, and the amount of waste that should be dealt with through incineration or landfill. Overall, an appropriate balance should be made with these values in mind.

Seoul observed its rapid growth and first considered incineration as the most appropriate method with which to reduce landfill, rather than reducing the total amount of waste. However, the volume-based waste fee (VBWF) system in 1995, the extended producer responsibility (EPR) in 2003 and direct landfill ban of food waste helped reduce the overall amount of waste in general. This aided in the reduced dependence on incineration and landfill.

5. Policy Objectives

- Maximize the processed waste in order to minimize the amount of waste disposed at landfill sites.
- Install an appropriate amount of waste disposal facilities to maximize the resource recovery rate.
- Minimize toxic materials in the incineration process and improve safety for local residents.
- Complex coordination with supplementary facilities for local residents to improve welfare.

6. Main Policy Contents

1) Securing Common Incineration Facilities

There are four incineration sites in Seoul: Yangcheon Facility, Nowon Facility, Gangnam Facility and Mapo Facility. These are all in operation within the city of Seoul (with the capacity of more than 400 tons per day). Plans for these facilities began in 1991.

When the plan was founded in 1991, the design was to build 11 incineration facilities to take care of 16,500 tons per day, but only 4 facilities have since been constructed. The construction started in October 1992. Yangcheon Facility was built in February 1996, Nowon Facility in January 1997. Gangnam Facility followed in December 2011, and Mapo Facility was completed in May 2005.

Yangcheon Facility started its construction in December 1992, and was finally finished in February 1996. It has a capacity of 400 tons, with 2 incinerators that can process 200 tons per day. Nowon Facility also started its construction in December 1992 and finished in January 1997. It has a capacity of 800 tons: 2 incineration units that can process 400 tons per day. Gangnam Facility's construction started in December 1994, and finished in December 2001. Its capacity is 900 tons per day, the largest among all 4 facilities. There are 3 incineration units each of which can process 300 tons per day. The construction of Mapo Facility started in December 2001 and completed in May 2005, whose capacity is 750 tons with three incinerators capable of taking 250 tons per day.

Table 1. Construction of Incineration Facilities in Seoul

Category	Yangcheon Facility	Nowon Facility	Gangnam Facility	Mapo Facility
Capacity	400 Tons/Day (2 Units)	800 Tons/Day (2 Units)	900 Tons/Day (3 Units)	750 Tons/Day (3 Units)
Construction Period	1992.12~1996.2	1992.12~1997.1	1994.12~2001.12	2001.12~2005.5
Area	14,627㎡	46,307㎡	63,813㎡	58,435㎡
Construction Cost	32.1 Billion KRW	74.3 Billion KRW	115.5 Billion KRW	171.2 Billion KRW
Incinerator	Stoker Type	Stoker Type	Stoker Type	Stoker Type +Rotary Kiln
Air Purification Facility	Wash Tower Semi Dry Reactor Bag Filter SCR Catalyst Tower	Electric Precipitator Wet Wash Tower Bag Filter SCR Catalyst Tower	Wash Tower Semi Dry Reactor Bag Filter SCR Catalyst Tower	Semi Dry Reactor Bag Filter SCR Catalyst Tower Police Filter

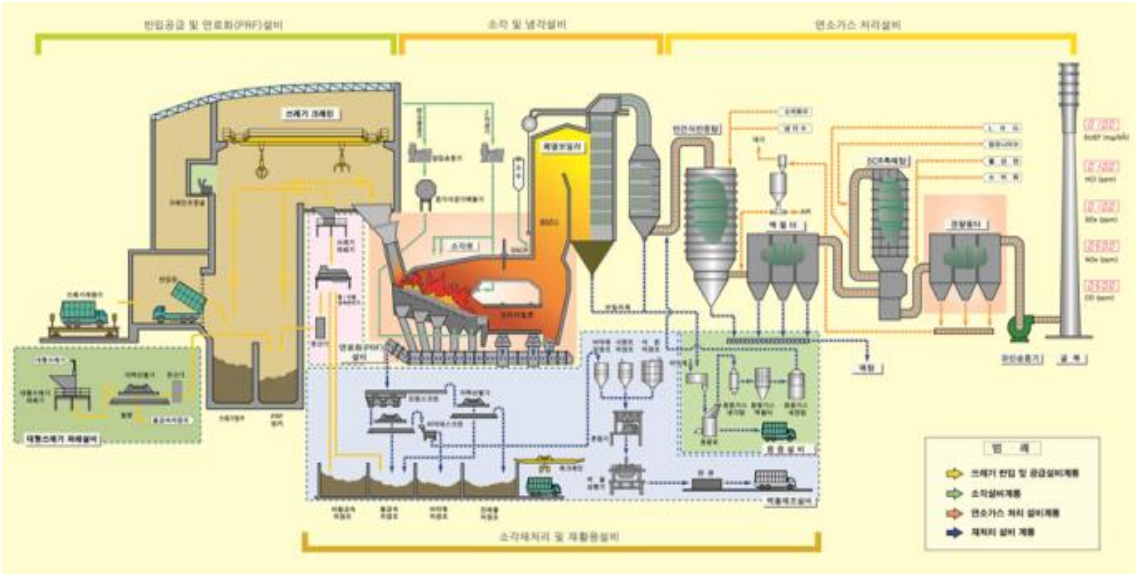

Figure 1. Mapo Incineration Facility Structure

These incineration facilities can process up to 2,850 tons per day. The capacity has been estimated based on the amount of waste disposal at the time they were designed, and the estimated amount for the time afterwards. When comparing of the original 1991 plans (11 facilities, 16,500 tons processed per day) to the actual capacity (4 facilities, 2,850 tons per day), only 36% of the facilities were built and the capacity stood at about only 17%. It seems they will not provide much help for the management of municipal solid waste (MSW) in Seoul. However, various waste reduction policies (i.e. the introduction of VBWS, the expansion of recyclying, food waste into resource) was in place while the facilities were being constructed. In the 2000s, when the 4 facilities started operations, the target amount had been significantly reduced, and therefore the 4 facilities could cover more MSW in Seoul. Yangcheon Facility, for example, was designed expecting about 400 tons of waste from Yangcheongu. But the district only generated 212 tons in 2002, 101 tons in 2012: 53% and 25% of the capacity, respectively. The Nowon Facility also processed about 25% (2002) and 15% (2012) of their capacity, and there was 33-34% recorded for the Gangnam Facility. Mapo Facility had been designed to process MSW of Mapogu, Junggu and Yongsangu whose capacity is 750 tons per day. However, the amount of MSW generated in the three local districts was only about 60% of their capacity in 2012.

Table 2. Capacity of Incinerator facilities in Seoul and Actual Volume of MSW

Facility	Assigned Area at Design Phase	Capacity (Ton/Day)	MSW in 2002 (Ton/Day)	MSW in 2012 (Ton/Day)
Yangcheon Facility	Yangcheongu	400(1.00)	212(0.53)	101(0.25)
Nowon Facility	Nowongu	800(1.00)	201(0.25)	121(0.15)

Gangnam Facility	Gangnamgu	900(1.00)	294(0.33)	305(0.34)
Mapo Facility	Mapogu, Junggu, Yongsangu	750(1.00)	-	453(0.60)

Reduction of generated MSW enabled the expansion of assigned area for 4 incineration facilities. Starting from 2007, the 4 facilities started to accept MSW of neighboring districts. Yangcheon Facility took MSW of Yeongdeungpogu and Gangseogu's waste as well as that from Yangcheongu. Gangnam Facility also started processing MSW of 7 other districts. Until today, 4 incineration facilities in Seoul are taking care of MSW from 22 local districts, among 25 districts in the city.

Before the facilities were shared, the 4 facilities were not utilized as much. As shown in the 2005 records, Yangcheon Facility processed only 33% of its capacity, Nowon Facility 19%, Gangnam Facility 24% and Mapo Facility 59%. This is because the local district and residents did not want the facilities to process waste from other areas. The reduced amount of MSW was a success, but this affected the incineration facility utilization rate, and concerns arose about the aging and malfunctioning of incinerators, pollution prevention facilities or controlling devices. While the facilities in Seoul were not effectively used, MSW from the city was sent to the Sudokwon Landfill Site (meaning landfill site capital region for the metropolitan Seoul), 45 km from Seoul. The cost and energy for transportation increased, causing problems for the Seoul Metropolitan Government which has built and run its own incineration facilities.

However, it is not recommended that local districts build and operate incineration facilities on their own, especially in terms of securing expert human resources. Because waste incineration facilities require high-end technology, and should be operated for 24/7, they require a large amount of human resources. Each incineration facility uses about 70 employees per facility, and there are many positions that require staff with national certifications, up to 12 to 20 such experts per facility. Of course, the operation costs are huge because certified employees are required in industrial safety, electronic, energy utilization, environmental pollution prevention, firefighting, high-pressure gas management and more. The size of facilities themselves is big as well. The operation cost for the 4 facilities ranged from 8.3 billion to 21.3 billion KRW in 2012. Barring the Mapo Facility, the facilities recorded losses in the region of 0.5 to 1.5 billion KRW. Therefore, the overall operation cost showed losses of 15.5 billion KRW, subsidized by Seoul Metropolitan Government (SMG). SMG and the central government paid 393.1 billion KRW, the entire construction cost of the facilities.

Table 3. Seoul City Incineration Facility Operation Profit (in 2012)

(Unit: 1 Mil. KRW)

Category	Income	Expense	Profit (Income - Expense)
Yangcheon Facility	3,236	8,384	-5,148
Nowon Facility	4,659	14,606	-9,947
Gangnam Facility	19,794	21,338	-1,544
Mapo Facility	14,472	13,378	+1,094
Total	42,161	57,706	-15,545

Considering the above listed facts, it is more efficient for SMG, rather local districts, to run large and technology-concentrated facilities such as incineration facilities in terms of securing expertise and reducing costs.

To resolve the problems previously mentioned and reduce the overall operational costs, SMG began regionalizing its incineration facilities in 2001, by sharing the 4 facilities with neighboring districts. However, it was difficult to turn facilities of the metropolis into regional facilities. First of all, residents in the four incineration facilities' areas had to agree on such changes. Through the resident consultative group, the residents can deal with facility operation, their health and welfare. They also monitor waste composition, according to the agreement made with SMG. Until gaining agreements from the residents, SMG and resident consultative groups met and negotiated numerous times for 1 to 9 year period.

Sharing facility had positive effects on many aspects. First of all, the number of districts using the facilities increased to as many as 22 districts in 2014. Moreover, facility-sharing improved the utilization rate significantly from 19-59% (33% of the entire capacity) in 2006 to 77-92% (85% of the entire capacity) in 2012.

After sharing facilities, 4 incineration facilities were secured as regional facilities for 25 local districts, dividing Seoul into 4 areas in processing the MSW. 25 local districts that are sharing the facilities are divided as follows: Southwest Region (Yangcheon Facility), Northeast Region (Nowon Facility), Southeast Region (Gangnam Facility) and Northwest Region (Mapo Facility).

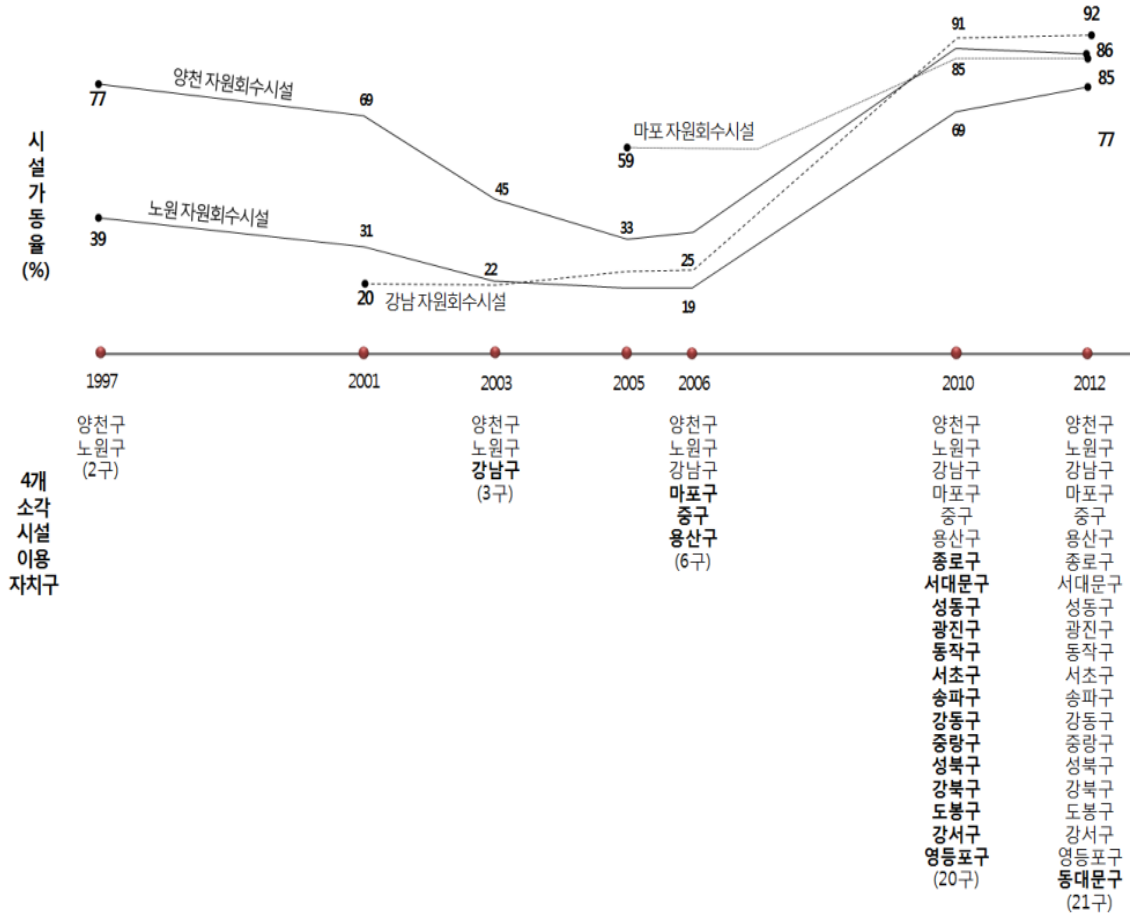

Figure 2. Facility Operation Rate and Changes in Districts after Sharing the Incineration Facilities

Figure 3. Incineration Facilities in Seoul and their Assigned Areas

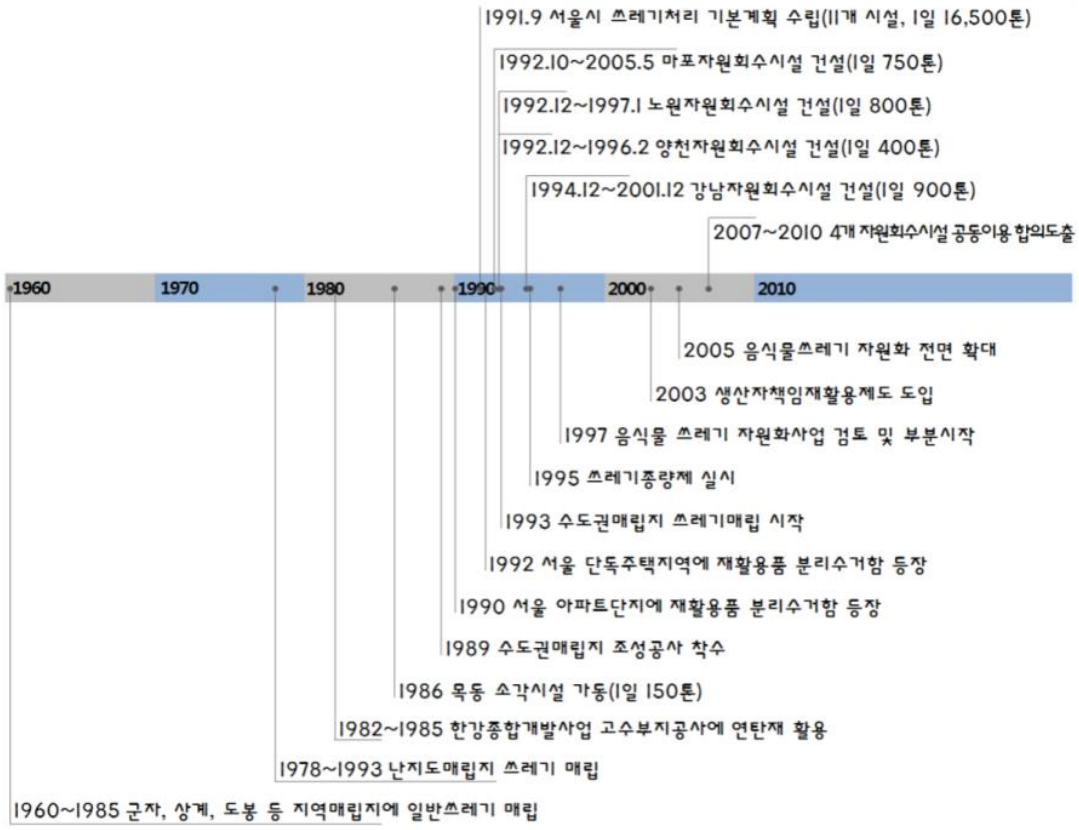

Figure 4. Construction of Incineration Facilities in Seoul and Major Changes in the Waste Management Policy

2) New Town Construction and Incineration Facility-District Heating Facility Cooperation

Cities in Korea rapidly developed over the last 60 years. Suburban areas were developed as housing sites to accommodate the population influx from the rural to metropolitan areas. Yeouido (1967) and Yeongdong (1967) were developed in the 1960s. In the 1970s, Jamsil (1971) was developed to disperse the concentration in Jongro and Junggu. In 1980s, the Gaepo (1981), Godeok (1981), Mokdong (1983) and Sanggye (1985) areas were all developed as large-scale residential areas.

During the construction of new town, 2 incineration facility sites have been secured where the Yangcheon Facility (May 1983, construction decided in Mokdong New City Development Plan) and Gangnam Facility (January 1986, city facility decided as waste disposal facility) were built. The other two incineration facilities have experienced similar situations. Mapo Facility had been constructed k in the World Cup Park, a part of the Sangam Housing Area which started its construction in 2000. Nowon Facility had its location assigned as a waste disposal facility in December 1977, before the Sanggye area was developed in1985.

As shown in the above examples, construction of incineration facilities connected to new town development makes it relatively easier to find construction sites, and to reduce objections from local residents that cannot be avoided in the construction process. Moreover, utilizing the heat

from incineration as a heat source for district heating is another profit of connecting the construction of incineration facility with new town development. District heating started in Lock Part, New York, U.S.A in 1877, and spread to other parts of America, Europe and Japan. In Korea, the first such approach was the feasibility study on the remodeling of Seoul Thermoelectric Power Plant into cogeneration thermal power plant to provide heat in Yeouido, Dongbuichon and Banpo in 1981. The actual start was in Mokdong and Shinjeongdong, providing heat to 20,000 houses. After the first and second oil shock, the social interest in energy efficiency was high in the 1970s. In 1987, remodeling of the Seoul Thermoelectric Power Plant into cogeneration thermal power plant was determined. In 1989 district heat scheme was determined for 5 cities including Ilsan. Along with this trend, the 4 incineration facilities in Seoul could also be connected with district heating facilities. Yangcheongu provides heat to 140,000 houses, and the incineration heat ratio for district heating is 16%. Nowon provides heat to 128,000 houses at a 23% rate, and Gangnam to 176,000 houses with a 27% incineration heat ratio. The Mapo area shows the highest incineration energy rate, as much as 57%. Heat is provided to 70,000 houses.

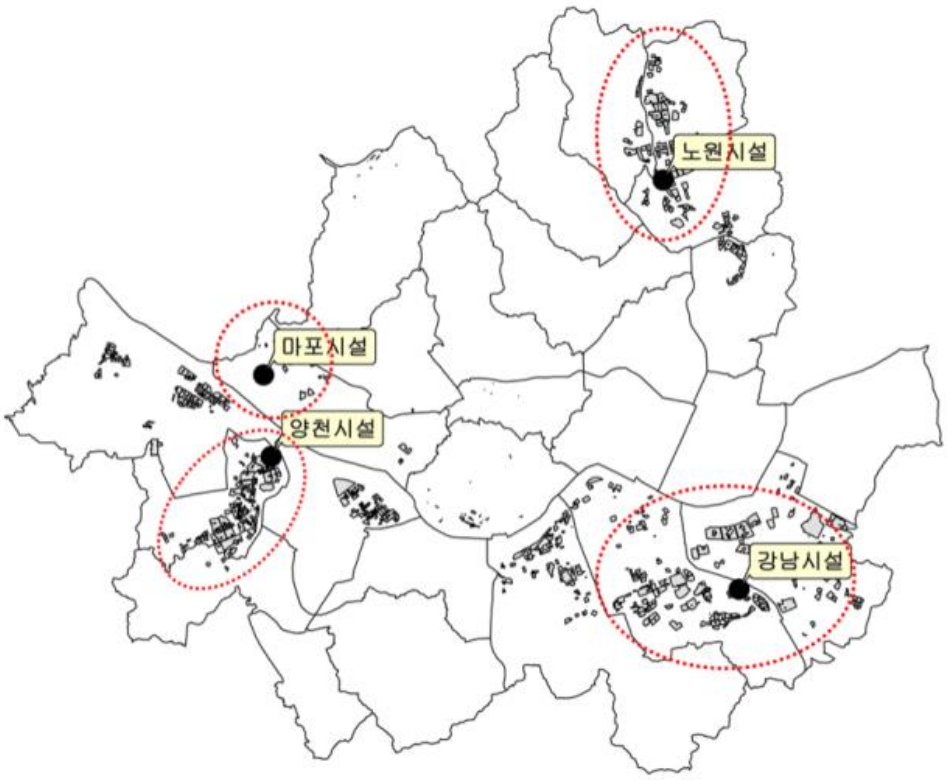

Figure 5. District Heating and Location of Incineration Facility in Seoul

In other words, all four incineration facilities in Seoul have district heating facilities, providing heat from waste incineration. The heat recovered from the incineration takes up to 16-57% of the energy source of the district heating facilities.

Table 4. Incineration Facility. District Heating Facility Cooperation Status

Category	Yangcheon	Nowon	Gangnam	Mapo
Size of the District Heating Facility	140,000	128,000	176,000	70,000
Energy Recovered from Incineration Facility	Heat Electricity	Heat	Heat	Heat Electricity
Energy Source Of District Heating (2012)	Heat from Incineration: 15.7% Heat from Energy Generation 51.0% Produced Heat: 33.3%	Heat from Incineration: 23.2% Heat from Energy Generation 37.8% Produced Heat: 39.0%	Heat from Incineration: 27.0% Heat from Energy Generation 12.7% Produced Heat: 60.3%	Heat from Incineration: 56.8% Heat from Energy Generation 33.8% Produced Heat: 9.4%

3) Environment Pollution Management

MSW incinerators are source of various pollutants such as incinerators, storage systems and transport vehicles. There are also general materials such as foul odor, dust and nitrogen oxide. Various characteristic pollutants from MSW incinerators also include hydrogen chloride, sulfur oxides and dioxin.

Dioxin, in particular, was a cause of concern in the early 1990s across the world because of the soldiers who were exposed to defoliant during the Vietnam War and their children who developed disorder. And at the same time waste incineration facilities became known as a major source of dioxin.

As a result, citizens started to question about incineration methods, and concerns arose among neighboring residents about facility and environmental measures. In response to such concerns, SMG has prepared thorough measures against environmental damage in terms of both facility installation and operation.

First of all, the city has installed and operated extremely complex gas purification facilities. The biggest concern among local residents is that of pollutants, emitted along with gas from incineration. This contains heavy metals such as mercury, caustic substances such as sulfur oxides and nitrogen oxide as well as toxic materials such as dioxin. Seoul's incineration facilities have neutralization, dust reduction and catalyst facilities to remove such materials, which consume more than 50% of the construction cost. Even during operation, considerable cost is expended in such facilities' chemical, energy and replacement of the air purification equipment.

The gas emission report in 2012 showed that all 4 of the facilities have less than 1/2 of emission standard, and other materials are also about 1/10 ~ 1/1,000 of the standard, suggesting strict management of the emission.

Table 5. Gas Emission Report of Incineration Facility in Seoul (2012)

Category	Emission Standard	Yangcheon	Nowon	Gangnam	Mapo
Dust (㎎/S㎥)	20	2.07	1.74	1.14	0.88
Sulfur Oxides (ppm)	30	0.43	0.14	0.29	0.34
Nitrogen Oxide (ppm)	70	23.00	23.78	12.39	16.67
Carbon Monoxide (ppm)	50	10.30	7.16	10.55	1.07
Hydrogen Chloride (ppm)	20	2.26	0.48	2.73	1.15
Dioxin (ng/N㎥)	0.1	0.000~0.009	0.000~0.003	0.000~0.002	0.000~0.000

※ Dioxin Emission Standard Strengthened: 0.5→0.1ng/N㎥(2003.7)

※ Dust Emission Standard Strengthened: 30→20㎎/S㎥(2010.1)

※ Nitrogen Oxide Emission Standard Strengthened: 80→70ppm(2010.1)

Second, disposed waste is examined so that the incineration facility will not have toxic materials. Blocking the pollutants from the incinerators are as important as operating excellent pollutant restriction facilities.

Heavy metals, such as mercury, are included within the waste material and spread into the atmosphere during the incineration process as gas. Dioxin is known to be formed when aromatic material and chlorine are combined during the incineration. Types of waste capable of generating dioxin include food, waste with high water contents and PVC products. Thus, dioxin is generated during the incineration of the waste. Therefore, such materials are asked to be separately disposed by houses and businesses.

Despite strict management and guidelines, we cannot rule out the possibility of such materials being mixed in the waste. Therefore, the incineration facilities search transport automobiles at random for heavy metals and have them return if such materials are found. The automobile will then receive a penalty. It is meaningful that such investigation and monitoring is done by people recommended by the resident consultative group. They work whenever waste is being brought into the facility. Right after food waste recycling completed, about 10-20% of food waste contained in the waste used to be brought into the incineration facilities. But now it is maintained at a rate lower than 5%. This is because there is thorough and vigilant observation on the waste.

Third, air pollutants are measured in real-time and statistics are displayed. This is one of the representative management systems, along with thorough purification facilities and examining waste brought into the facilities. The system measures pollutants in emitted gas in real time, and

then displays these figures to the public. The figures include the tele-monitoring system, auto dioxin collection and electronic displays of gas density. To secure the objectivity of these figures, facility operators cannot approach such measurement devices. Among the devices, the tele-monitoring system automatically measures dust, SO2, HCI, NOx, CO and O2, flow amount and temperatures with device installed in the middle of the incinerator chimneys, and then transfers the results to the central control room and the government's control center in real time.

At the same time, results are displayed on electronic displays, so that local residents can see the numbers. 3 electronic displays have been installed in Gangnam, and 1 each for Yangcheon, Nowon and Mapo. Dioxin is the least-trusted pollutant by the residents. Dioxin cannot be measured in real-time, unlike other pollutants. Therefore, the material should be collected once every 6 months (within 1 day), and the collected material is then moved to labs for analysis. Therefore, the residents did not trust the results because of the time period without measurement, and the possibilities of material manipulation. To resolve the distrust and overcome the limitation in the measurement method, Seoulhas installed auto dioxin collectors in all of the 4 facilities' chimneys. The kit absorbs and stores 3-6 months of dioxin from the gas, and the amount can be calculated based on the collected amount and the period. The kit is utilized to analyze dioxin density, and the new kit is replaced to collect dioxin in the following period.

Gas Emission Electronic Display Near the Incineration Facility

Auto Dioxin Collector Kit

Figure 6. Gas Emission Electronic Display Board and Auto Dioxin Collector

Fourth, the time and number of garbage truck is limited. Waste transportation causes odor, emits exhaust fumes and increases traffic on roads. To resolve such issues, the waste is brought only in the night and early morning so that citizens are exposed less and the roads used more efficiently. Moreover, waste coming from the districts other than the facilities' own districts should be transported with automobiles more than 11 tons in capacity. The number of automobiles operated is fundamentally restricted.

8. Policy Effects

1) Landfill Reduction

Seoul does not have a landfill within its city, and there is a very low chance that the city will have one even in the future. Therefore, reducing the amount of landfill waste is the core task of management of MSW. In this sense, sharing the 4 facilities in Seoul is contributing significantly to reducing landfill of MSW in Seoul.

The amount of waste landfilled in 2012 was only 10% of the amount in 1997, which was right after Yangcheon and Nowon facilities began operation. First of all, the overall waste amounts (incineration + landfill) had been reduced to a 1/3. Moreover, the incinerated waste increased up to 3-4 times compared to that of the 1997 record. The landfill rate had thus been significantly reduced from 93.6% in 1997 to 25.4% in 2012.

If facilities were not shared and the incinerators only processed local districts' waste (Yangcheongu, Nowongu, Gangnamgu, Mapogu, Junggu, Yongsangu, Junggu, Yongsangu), the landfill rate would have remained the same as 2006, about 76.3%. The statistics explained above are also reflected in Seoul City's waste management record. After facility sharing commenced, the landfill rate was about 7.8% in 2012 (it was 61.9% in 1997).

Table 6. Change in the Landfilled Amount after Sharing Facility

Category	Before Sharing			After Sharing	
	1997	2003	2006	2010	2012
Incineration Facility	Yangcheon Facility Nowon Facility	Yangcheon Facility Nowon Facility Gangnam Facility	Yangcheon Facility Nowon Facility Gangnam Facility Mapo Facility	Yangcheon Facility Nowon Facility Gangnam Facility Mapo Facility	Yangcheon Facility Nowon Facility Gangnam Facility Mapo Facility
Incinerated Amount in 4 Facilities (Ton, [1])	187,096	162,795	320,562	740,287	771,110
Landfilled Amount (Ton, [2])	2,730,200	1,866,096	1,033,738	527,790	262,435
Incineration + Landfill (Ton, [3]=[1+2])	2,917,296	2,028,891	1,354,300	1,268,077	1,033,545
Landfill Rate (%. [2]/[3])	93.6	92.0	76.3	41.6	25.4
Landfill Rate (%), based on domestic waste)	61.9	42.4	24.8	14.4	7.8

2) Energy Reduction

The low-heating value of MSW waste brought into the incineration facilities in Seoul is 2,762 kcal per 1 kg. Seoul's incineration facilities can recover about 74% of the heat generated from incineration. The facilities use part of the heat in their operations, and sell the most of the remaining heat to neighboring district heating facilities. Energy sales recorded before sharing facility was 561,411 Gcal in 2006. The number increased to 1,269,336 Gcal in 2012, after the facilities began their shared operations.

Before sharing facility, about 52,000 households could get heat and hot water from the recovered energy. After sharing, the recovered energy increased and over 50,000 more households were able to get heat.

Utilizing heat from incineration also has a significant meaning in terms of the environment. The incineration heat can be used for heating water and house, and this leads to reduction in LNG. The carbon dioxide emissions can be reduced, leading to reduced greenhouse gas emissions. The reduced amount of greenhouse gas emissions was recorded at 27,000 tons in 2006 and 60,000 tons in 2012. This is as much as emissions from 540 busses in Seoul in one year.

Table 7. Comparison of Energy Substitution Effect of District Heating, Before and After Sharing Facility

Category	Before Sharing (2006)	After Sharing (2012)	Note
Amount of Incineration Heat Sold (Gcal)	561,411 (1.0)	1,269,336 (2.3)	‣ Yearly heat and hot water use per house: 10.9 Gcal
Amount Substituted for Gas (LNG ㎥) (House)	59,597,770㎥ 51,506 Houses	134,749,045㎥ 116,453	‣LNG 1 N㎥ = 9,420 Kcal ‣ Yearly heat and hot water use per house: 10.9 Gcal
Reduction in Greenhouse Gas Emission (Ton CO2) (City Bus, Unit)	26,725 Tons 239	60,426 Tons 540	‣LNG 1 N㎥ = 2.23 kg CO2 ‣ Seoul City Buses' Greenhouse Gas Emission: 112 Tons CO2

9. Major Challenges and Solutions

1) Objection from Local Residents, following Incineration Facility Installation

From the planning stage, installation of incineration facilities had been stubbornly objected to by the majority of citizens, as they were understood to create pollutants including dioxin.. During construction, neighboring residents objected that their property values were being damaged along with the contamination of the environment. Due to severe objections, questions were also raised as to why SMG was building the facilities, rather than letting the 25 districts build them on their own.

Much time was spent due to the disputes with the residents. During such period, public attention gave been shifted to resource recycling. A total of 14 years (1992 ~ 2005) was spent building the 4 facilities, and there have been 396 complaints from nearby residents. The complaints usually were in the form of group demonstration (67%), and the rest were objections through documents. The main objections varied from fundamental disagreement with the construction itself, changes of plans such as relocation, reducing the capacity, installation of strict pollution controlling facilities.

Solutions

Long-term and regular medical checkup of the resident has been conducted. Seoul started health t monitoring for exposure in 2000 to track residents' health issues that can result from the incineration facilities. The city also has operated pollution-controlling facilities, limiting traffic and observing the waste materials. The monitoring is to track the health of neighboring residents who could be affected by dioxin and other toxic materials from the incineration facilities. At the same time, the monitoring helps evaluate environmental impacts in objective terms. This enables us to confirm the safety of such facilities, resolve concerns of the residents, and in case such negative impacts occur, find a solution to the issue. The investigation can be divided into 3 types in a broad sense: air quality assessment (environmental impact), assessment of the dioxin and heavy metal in residents' blood (impact on human body) and assessment of the general health and mental status (health impact). Fixed research groups, volunteers and facility employees undergo human body and health investigations. Recently, the investigation has been reduced only for the fixed research group. On the contrary, more pollutants were added such as dioxin in atmosphere or black carbon density. The 10th investigation was conducted in 2014. Assessed items, methods and targets are decided upon agreement with resident consultative group. Investigations up to this day have not shown any negative impact on the environment, human body or health from the incineration facilities.

Table 8. Assessment of Health of Residents around Incineration Facilities in Seoul

Assessment Period	2000 ~ 2004	2005 ~ 2008	2009 ~ 2012	2013 ~ 2015
Number of Assessment	3 Times	3 Times	3 Times	3 Times
Target Areas	Yangcheon Facility, Nowon Facility, Gangnam Facility related and reference areas			
Assessed Items	‣ Environmental Impact Assessment: Dust, heavy metal, odor ‣ Impact Assessment on Human Body : Dioxin and heavy metal in blood, etc. ‣ Impact Assessment on Health: Medical checkup, recognition and evaluation on quality of life		‣ Same as step 1 and 2 ‣ Added dioxin evaluation in atmosphere ‣ Added 'autumn season to environmental impact assessment	‣ Same as step 3 ‣ Traffic impact assessment out of environment impact assessment (black carbon, etc.)
Assessed Group	Separate Assessment on Residents and Workers in Affected Areas and Control Areas		Separate Assessment on the Residents in the Affected Areas'	Assessment on Local Residents in Affected Area's
Assessment Method	Separate Follow-up Study on the Control Group	Follow-up Study on the Separate Control Group and Affected Group	Follow-up Study on the Affected Group	Follow-up Study on the Affected Group
Assessed Population	‣Heavy Metal: 270 ‣Dioxin: 53	‣Heavy Metal: 270 ‣Dioxin: 75	‣Heavy Metal: 270 ‣Dioxin: 100	‣Heavy Metal: 360 ‣ Dioxin . Tumor Marker:100
Note		‣ Dioxin investigation targets increased	‣ Dioxin investigation targets increased	‣ Tumor Marker examination added ‣ Traffic effect evaluation added ‣ Comparison of diseases with district-based statistics from National Health Insurance Corporation

Program to enhance convenience local residents

Subsidy is provided in heating cost for public housing, monthly maintenance fee or rent, environmental improvement costs (waterproof or painting), facility fees or medical costs for residents in affected area. Main targets of subsidy are residents within 300m radius of the incineration facility boundary. A total of 12,367 households including 3,413 households for Yangcheon Facility, 6,190 households for Nowon Facility and 2,934 households for Gangnam Facility. The fund is called as Resident Support Fund, created in accordance with ordinance of SMG. The fund is secured from grants of SMG, of districts sharing facility and profits from the grants management. Seoul's grant includes grants for constructing the incineration facilities and subsidies for heating facility in affected areas (within 70%) and grants fee on bringing in the waste. Subsidy for fee on bringing in the waste includes 10% for total waste, and additional 10% paid by neighboring districts that share the facility. Fund from sharing districts are decided based on facility-sharing agreement. As for Yangcheon Facility, sharing districts will pay 21,000 KRW fund per 1 ton, separate from the waste fee. The fund's profit is mainly interest from banks. The total amount of Resident Support Fund is 169.9 billion KRW from 1996 (when Yangcheon Facility started its operation) to 2013. The fund for waste brought into the 4 facilities is 25,260 KRW per 1 ton. Affected areas will receive about 13.56 thousand KRW per 1 house.

Table 9. Resident Support Fund Statistics (1996~2013)

Category	Total	Yangcheon Facility	Nowon Facility	Gangnam Facility	Mapo Facility
Resident Support Fund (Mil. KRW)	169,945	45,230	63,765	60,275	675
Affected Population (Household)	12,537	3,413	6,190	2,934	0
Incinerated Amount (Ton) (1997~2013)	6,727,728	1,389,705	1,767,559	2,023,626	1,546,838
Resident Support Fund (KRW/Ton)	25,260	32,547	36,075	29,785	436
Resident Support Fund (1,000 KRW/Households)	13,556	13,252	10,301	20,544	-

Continuous efforts to earn the trust of local residents

There can be various reasons for residents to be opposed to the construction of incineration facility. The representative ones include drop in the property value, pollutant emission followed by impacts on the environment, health and human body. Traffic inconvenience due to increased number of garbage trucks is also included.

Drop in the property value does, in fact, occur. However, the effect becomes clear when the dispute becomes extreme including demonstrations. Where there are no disputes, the impact on real estate disappears. However, Seoul has offered subsidies for heating costs, maintenance fees, rent, facility fees, medical checkup costs and more, based on the decision that the possible impact and concern can also be counted as damage to neighboring areas. The Resident Support Fund founded from 1996 to 2013 is offered about 1,356 thousand KRW per house.

Seoul has taken a few measures to restrict damages to neighboring areas that can be affected by air pollutants. Representative residents can take part in observing the facilities to help ensure that there is no water, food waste or toxic materials in the waste. When caught, the waste is not brought into the facility and the automobile is temporarily suspended from operation. Moreover, air pollution is measured in real-time and displayed on electronic display board. Materials that cannot be tracked in real time are collected for more than 3 months in a tracking analysis. Moreover, resident health monitoring has been conducted since 2000 to help better understand the impact on the environment, human body and health.

The various measures are not in place because the problems arise. They are in place to build trust with the residents. The same methods can be used for other waste disposal facilities, such as food waste or landfill sites.

Presentation for residents, complaint acceptance

Seoul has opened 121 public discussions and presentations to collect residents' opinions regarding the construction of incineration facilities. Neighboring residents strongly objected to the construction, and the result was reduced capacity for both the Nowon Facility and Gangnam Facility. Therefore, Nowon Facility's capacity has been reduced to 800 tons from 1,000 tons, and the Gangnam Facility to 900 tons from 1,900 tons. Moreover, the Gangnam Facility was at first promoted to be shared with the Songpagu region, but used only by Gangnamgu.

The discussions and negotiations were done over a period of 3 to 13 years. Since the project periods were extended, there have been difficulties in pursuing the plans because at times the land was used for other purposes, or budgets were changed.

A lot more time was also required to obtain agreements from the residents, to use the 4 facilities as regional facilities. For the Gangnam Facility, SMG and the resident consultative gropu had about 160 meetings over the course of 5 years. The agreement on sharing facility was finalized on May 7th, 2007. As many as 100 meetings were held for the Nowon Facility, and the agreement was concluded on June 30th, 2007. Mapo had had 40 meetings over 1 year, and was settled on February 10th, 2009.

It took relatively longer for Yangcheon Facility: 9 years. There had been 150 meetings, and the agreement was finally made on May 10th in 2010.

Subsidiary Facilities for Residents

These regional incineration facilities have various subsidiary facilities such as swimming pools, fitness centers, golf courses, cultural lecture halls, study rooms and auditoriums. Those facilities are provided for the local residents at low cost.

Table 10. Subsidiary Facilities in the Incineration Facilities in Seoul

Category	Yangcheon Facility	Nowon Facility	Gangnam Facility	Mapo Facility
Construction Period	1992.12~1996.2	1992.12~1997.1	1994.12~2001.12	2001.12~2005.5
Area	14,627㎡	46,307㎡	63,813㎡	58,435㎡
Construction Cost (Subsidiary Facilities)	32.1 Billion KRW (8.1 Billion KRW)	74.3 Billion KRW (9.4 Billion KRW)	115.5 Billion KRW (9.4 Billion KRW)	171.2 Billion KRW (9.5 Billion KRW)
Subsidiary Facilities	Swimming Pool Fitness Center Study Room Auditorium	Swimming Pool Fitness Center Cultural Lecture Hall Study Room	Swimming Pool Fitness Center Cultural Lecture Hall Study Room	Sauna Fitness Center Golf Driving Range Study Room

2) Incineration Facility Installation and Management - Roles and Costs

Seoul has been divided into 25 local districts for the administrative convenience. It is the same as other metropolis, composing physical boundaries for the administrative convenience. However, the boundaries act against securing sites for non-preferred facilities such as waste landfill or incineration. It can be preferable for each district to have its own facilities, but disputes will arise. Having facilities for each district will also cause size to be reduced and therefore a loss of efficiency will be dropped. Reduced size also hinders stable operation of pollution prevention facility.

This is why metropolitan governments, rather than regional districts, install and operate large-scale waste disposal facilities such as incinerators or landfills. Along with Seoul, Tokyo in Japan, London in Britain, and Paris in France operate the same way. Another common factor is that local districts take care of waste collection, transportation and recycling in many metropolises

including Seoul. This is because local districts may have more direct contact with residents so it is easier for them to ask for the residents' cooperation than the metropolises, therefore, they can collect waste more efficiently.

Although the local districts and metropolises have clearly different roles, the needs and location selection needs to be flexible enough to be based on the opinions and requests of the local districts. In particular, it is desirable for local districts to determine the location and capacity of the facilities and districts that will share the facility. This is because the local districts, rather than metropolises, can understand the residents and the needs for the waste management better. For example, it took 7 years for the Gangnam Facility to be designed and completed because disputes continued over both the capacity and location even after construction started. On the other hand, for Mapo Facility, it took only 3.5 years, because the capacity, location and districts that will share the facility were all decided before the construction started.

Local districts' request for installation of facilities	- Facility capacity (more than 400 ton per day considering the heat recovery efficiency) - Agreement from the districts that will share the facility - Multiple candidate locations for the facility in the districts
Basic Design	- Regions that will share the facility - Quality and quantity of the waste - Role division between the sharing districts that will share the facility
Determination and announcement of Location selection plans, selection of candidate locations	- Foundation of location selection council - Check-out of accessibility and resident status - Safety in land size, ground quality, and vulnerability to water related disaster, landslide, and cracks - Restrictions such as cultural artifact, school, military facility, height limits and water supply protection
Candidate Locations Search	- Suggestion of support measures to local community and affected region - Results of Environmental Impact Assessment when the facility is installed

Location selection and announcement	- Agreement from residents of affected areas (for Hanam Facility, consents from 2/3 of residents) - In case there is no affected area, agreement from residents of Tong and Ri (for Hanam Facility, consents from 2/3 of residents)
Selection of Construction company (preliminary design, impact assessment)	- Examination of preliminary designs - Evaluation of technological capability and past construction records - Construction cost evaluation
Presentation for residents	- Preliminary designs and environmental impact assessment- Collect resident opinions
Detailed design and construction commencement	- Reflect resident opinions - Selection of affected areas selected within 2 years of establishing installation plan of waste disposal facility, foundation of resident consultative group, performance of environmental impact assessment
Test operation and pre-performance test	- Witnessed by resident representative, or designated organization - Supplementary construction in case of errors
Commencement of Construction and operation	- Various examinations on facility performance - Dioxin density measurement - Environmental impact assessment

Figure 7. Bottom–Up type Construction Process of Incineration Facility

References

- Seoul Metropolitan Government, 1991, 「 Seoul Metropolitan Government - Basic Waste Disposal Plan」
- Seoul Metropolitan Government, 2013, 「2012 White Paper of Environment: Seoul's Environment」
- Seoul Metropolitan Council, 2006, 「Studies of Resource Recovery Facility Productivity Improvement」
- Yoo Gi Yeong, Jo Hang Mun, Kim Gui Yeong, 2013, Studies on Integrated Operation's Efficiency for Seoul City Group Energy Facilities and Environmental Facilities, Seoul Institute
- Lee Beomhyeon, 2012, 2011, Economic Development Experience Module Project: Korean New City Development, Ministry of Land, Transport and Maritime Affairs, Korea Research Institute for Human Settlements
- Korea District Heating Corporation Hwaseong Branch, 2013, 「Handbook of District Heating Facilities」
- Ministry of Environment, 2013, 「National Waste Generation and D