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## 5. Joint Use of the Municipal Waste Incineration Infrastructure in Seoul

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Policy Area: Environment

## Background

Status: 4 Incineration Facilities with Processing Capacity of 2,859 Tons a Day

Seoul has incineration facilities in operation in Yangcheon, Nowon, Gangnam, and Mapo, with a combined processing capacity of 2,850 tons of municipal waste a day. The plans for these facilities were developed in 1991, with construction beginning in October 1992. Yangcheon was completed in February 1996, Nowon in January 1997, Gangnam in December 2001, and Mapo in May 2005. At the beginning, the 4 facilities had only processed municipal waste from their own districts but began in 2007 to process waste from adjacent districts as well. For instance, the Yangcheon facility incinerates the waste from 3 districts, and Gangnam from 8 districts. These facilities handle municipal waste from 22 of the 25 districts in Seoul.

**Figure 1** - Seoul's Incineration Facilities & Their Coverage



Before these incineration facilities were built, Seoul's municipal waste went to Nanjido Landfill, where today's World Cup Stadium stands. Nanjido had its specific purpose as a landfill, but before Nanjido, waste was used to fill up and develop sites in land development programs, according to records. In the 1980s when Nanjido was used as a landfill, South Korea saw rapid economic growth. It hosted the Asian Games in 1986 and the Olympics in 1988. South Korea's international status increased, and the number of foreign visitors soared. Behind the scenes however was a serious waste management problem, due to increasing volume and worsening management conditions, aggravated by the widespread use of plastic products. Nanjido Landfill was located along the road that leads from the international airport to downtown, and the problem of waste management was exposed in plain sight.

In 1991, Seoul established plans to build 11 more incineration facilities with a total processing capacity of

16,500 tons per day.<sup>7</sup> At the time, there were 23 gu districts in Seoul; 11 incineration facilities would mean there would be 1 for every 2 districts. The current 4 facilities (with a capacity of 2,850 tons/day) are reduced by 36% in number and by 17% in capacity compared to the original plan, but each incineration facility handles the waste coming from 6 or 7 districts. Plans for additional incineration facilities were hotly contested by civic groups for burning potentially usable resources and producing toxic chemicals such as dioxin. During construction this fierce opposition continued, with residents arguing that the facilities would damage the environment and their property values. Others criticized the city for building and planning to operate such highly-disliked incineration facilities instead of leaving the matter to each of the 25 districts. The existing 4 facilities would not be able to cover wider areas if it were not for the volume-based waste disposal fee system, recycling, utilization of food waste, and other innovative waste reduction policies.

**Figure 2 - Major Changes in Seoul's Incineration Facilities & Waste Management Policy**



7. Seoul Metropolitan Government, 1991, The City of Seoul Waste Disposal Plan.

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## Joint Use of the Incineration Infrastructure as a By-product of Social & Technical Policies

Despite many challenges, the City of Seoul built the infrastructure for joint use of the 4 incineration facilities it had by 22 districts, with several triggers spurring the city to change its waste management focus from landfill to incineration in the early 1990s.

First, Seoul did not have sufficient land space for landfills, not even in the surrounding areas. Nanjido Landfill had served its purpose from 1978 to 1993 despite being originally scheduled for 5 or 6 years of use. In accordance with this plan, the city began to look for another landfill in 1982 but could not find a site within city boundaries. In fact, all cities in the capital area shared the problem of insufficient waste management facilities for various reasons, such as the consequent increase in the volume of waste due to the nation's overall rapid economic growth, the Asian Games in 1986, and the Olympics in 1988, as well as the increasing percentage of plastic products in the waste. The national government decided to build a landfill in Gimpo, Gyeonggi-do (located in today's Incheon) at the do (provincial) level. Seoul took part in this and has processed its waste there since 1993. However, residents living near the landfill fiercely objected to the construction. While a landfill for the capital would resolve the immediate need, the same problems – conflict during site development, long distance to the landfill (48 km on average from Seoul), and consequently rising costs – were bound to repeat themselves. In the process of developing a landfill site in the capital area, the parties involved realized that a facility was needed within the city to deal with municipal waste.

Second, the incineration of municipal waste at the time was beginning to be recognized as a method with many advantages. In Japan, Tokyo was operating 18 incineration facilities, handling 80% of the municipal waste. Those countries with limited land space and an advanced tourism industry (e.g., France, Austria, Belgium, and Switzerland) also relied heavily on incineration, doing so within a day or two of receiving the waste, therefore occupying less space. Incineration also reduced the weight of waste to 30% and volume to 10%, as well as destroying most of the odor. Sending the outcome of incineration to a landfill also reduced the burden of securing and managing landfill sites. In Paris, France, heat from waste incineration was recovered for use as energy. This seemed very attractive to Seoul, having experienced the oil shocks in 1973 and 1978, and restrictions on the use of low-grade, polluting fuels such as coal briquettes and bunker C fuel oil in the 1980s. From the late 1970s, the development of new towns in Yeongdong, Yangcheon, Sanggye, and Gangnam gave rise to the hope of utilizing incineration heat as a source of district heating. In fact, as of 2012, Seoul's 4 incineration facilities had district heating facilities nearby and supplied incineration heat as an energy source. Incineration heat accounts for 16–57% of the total energy source of the 4 district heating facilities.<sup>8</sup>

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8. Yu Gi-yeong, Jo Hang-mun, Kim Gwi-yeong, 2013, "Study on the Effectiveness of Integrated Operation & Management of Seoul's Integrated Energy & Basic Environmental Facilities", The Seoul Institute.

**Table 1 - Incineration Facilities & District Heating Facilities Network**

|  | Yangcheon Area   | Nowon Area   | Gangnam Area   | Mapo Area   |
|--|--|--|--|---|
| Scale of District Heating Supply             | 140,000 households   | 128,000 households   | 176,000 households   | 70,000 households   |
| Energy Produced by Incineration Facilities   | Heat, Electricity  | Heat   | Heat   | Heat, Electricity   |
| Source of Energy for District Heating (2012) | · Incineration Heat: 15.7%<br>· Power Generation Heat: 51.0%<br>· Heat Generation: 33.3% | · Incineration Heat: 23.2%<br>· Power Generation Heat: 37.8%<br>· Heat Generation: 39.0% | · Incineration Heat: 27.0%<br>· Power Generation Heat: 12.7%<br>· Heat Generation: 60.3% | · Incineration Heat: 56.8%<br>· Power Generation Heat: 33.8%<br>· Heat Generation: 9.4% |

Third, construction became very time-consuming due to the conflicts with residents, and in the meantime, society began to pay attention to resource cycling. Seoul spent 14 years (1992 – 2005) building 4 incineration facilities, and received 396 complaints from nearby residents. Some 67% of the complaints were in the form of collective protests while the rest were written complaints. The topic of complaints was varied, ranging from objection to construction to demands that the project be modified (moving the site, reducing the size, installing equipment that would prevent pollution etc.). In response, Seoul held 121 public discussions and presentations. Due to the volume of complaints, the Nowon facility was reduced in capacity from 1,000 to 800 tons, and the Gangnam facility from 1,800 to 900 tons. The Gangnam facility was supposed to be used jointly with Songpa-gu but this was changed to use only by Gangnam-gu. The program period (development of plans to construction) was between 3 and 13 years.<sup>9</sup> Because of conflict and project delays, the planned sites were used for other purposes or budget plans changed. It was difficult to execute the program with consistency or according to a system. As mentioned, society also began paying attention to recycling and resource cycling as it experienced the volume-based waste disposal fee system (1995), the Expanded Producer Responsibility (2003), the prohibition on direct burial of food waste (2005); and the “green growth” industry (2008) etc. Incineration as the best method of waste management was disappearing from popular view. Fourth, the waste to be incinerated was substantially reduced in volume in the 1990s and 2000s. Capacity at Seoul’s 4 incineration facilities had been designed to handle waste volumes at the time (in 1991) and for the future, and could handle 2,850 tons a day. There was a huge gap between designed capacity and actual volume (volume that is incinerated and goes to landfill) in 2012. For example, the 400-ton Yangcheon facility was using only 53% of its capacity for waste from Yangcheon-gu in 2002. By 2012, volumes had dropped even further to 25%. Mapo Resource Recovery Facility, designed to handle 750 tons of municipal waste from Mapo-gu, Jung-gu, and Yongsan-gu, was using only 60% of the designed capacity, mainly due to the aforementioned dramatic changes in South Korea’s waste management system (the volume-based waste

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9. Seoul Metropolitan Council, 2006, Study on Improvements to Resource Recovery Facility Productivity

disposal fee system in 1995, Expanded Producer Responsibility in 2003, and banning of direct burial of food waste in 2005). In the end, one of the goals in waste management in Seoul became efficient utilization of the remaining facility capacity, which meant that facilities would be shared with adjacent districts.<sup>10</sup>

**Table 2 - Capacity & Actual Waste Volumes at Seoul Incineration Facilities**

| Facility  | Coverage (Original Plan)     | Facility Capacity (Tons/Day) | Incinerated/Buried (2002, Tons/Day) | Incinerated/Buried (2012, Tons/Day) |
|-----------|------------------------------|------------------------------|-------------------------------------|-------------------------------------|
| Yangcheon | Yangcheon-gu                 | 400 (100)                    | 212 (0.53)                          | 101 (0.25)                          |
| Nowon     | Nowon-gu                     | 800 (100)                    | 201 (0.25)                          | 121 (0.15)                          |
| Gangnam   | Gangnam-gu                   | 900 (100)                    | 294 (0.33)                          | 305 (0.34)                          |
| Mapo      | Mapo-gu, Jung-gu, Yongsan-gu | 750 (100)                    | -                                   | 453 (0.60)                          |

Fifth, expertise and cost effectiveness are better developed when incineration facilities are larger, such as at the city level, than smaller, such as at the gu district level. Waste incineration facilities require advanced technologies and are operated 24 hours a day, and demand a high number of expert and general personnel. Each of the 4 incineration facilities is currently operated by 65 – 77 staff members, with between 12 and 20 nationally-accredited experts in industrial safety, electricity, energy utilization, prevention of environmental pollution, fire safety, and high pressure gas management, etc. The cost to hire experts and operate such large facilities is enormous. As of 2012, the 4 facilities spent between KRW 8.3 and 21.3 billion per year. Excluding the Mapo facility, they operate at an annual loss of KRW 500 million – 1.5 billion. The overall operational loss is KRW 15.5 billion a year, which is covered by the City of Seoul budget. KRW 393.1 billion was spent to build the facilities, all paid by the City of Seoul and the central government. This shortfall is another reason that Seoul shares the incineration facilities between gu districts. The financial burden is too excessive for one gu district to handle, and technical difficulties too complex. This type of program is in the scope of Seoul's responsibilities, as defined by the Wastes Control Act.

**Table 3 - Operational Profit & Loss of Seoul Incineration Facilities (As of 2012)**

(Unit: KRW 1 million)

| Facility  | Revenue | Expenses | Profit (Revenue – Expenses) |
|-----------|---------|----------|-----------------------------|
| Yangcheon | 3,236   | 8,384    | -5,148                      |
| Nowon     | 4,659   | 14,606   | -9,947                      |
| Gangnam   | 19,794  | 21,338   | -1,544                      |
| Mapo      | 14,472  | 13,378   | +1,094                      |
| Total     | 42,161  | 57,706   | -15,545                     |

10. Ministry of Environment, 2013, Nationwide Waste Generation & Management Status

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## Construction of the Incineration Infrastructure for Joint Use

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### Phased Construction of Incineration Facilities Designed to Prevent Pollution

In 1991, Seoul developed a plan to build 11 incineration facilities with a capacity of 16,500 tons, with construction beginning in 1992. Yangcheon was completed in 1996, Nowon in 1997, Gangnam in 2001, and Mapo in 2006. It took 13 years to build 4 facilities.

Construction of the Yangcheon facility began in December 1992 and was completed in February 1996. It can process 400 tons/day with two 200-ton incinerators. Main features include tipping facilities, incinerators, and equipment for prevention of pollution. Air purifying equipment such as scrubbers, semi-dry reactors, bag filters, and selective catalytic reduction (SCR) units remove air pollutants (e.g. carbon monoxide, sulfur oxide, nitrogen oxide, and dioxin). Facilities such as a swimming pool, fitness center, reading room, and auditorium are provided for the residents at affordable rates. A total of KRW 31.8 billion was spent to build the incinerator facilities (KRW 200 million from the central government with the City of Seoul footing the remainder); KRW 8.1 billion was spent on the public-use facilities. Six protests were held by residents and 20 written complaints lodged during the process of construction. The City of Seoul held 20 presentations as information sessions for residents.

Construction of the Nowon facility began in February 1992 and was completed in January 1997, with two 400-ton incinerators giving the facility a processing capacity of 800 tons/day. Main incineration facilities include tipping facilities, incinerators, and facilities for prevention of pollution (electric dust collectors, wet scrubbers, bag filters, SCR units, etc.). Public-use facilities include a swimming pool, fitness center, culture center, and reading room. The incineration facility itself cost KRW 74.3 billion (paid by the City of Seoul) to build, and the public-use facilities KRW 9.4 billion. During the construction, residents held 38 protests and lodged 60 written complaints. The City of Seoul held 18 presentations as information sessions for residents.

Construction of the Gangnam facility began in December 1994 and was completed in December 2001, with three 300-ton incinerators giving the facility a processing capacity of 900 tons/day. Main incineration facilities include tipping facilities, incinerators, and equipment for prevention of pollution: scrubbers, semi-dry reactors, bag filters, and SCR units remove air pollutants (such as carbon monoxide, sulfur oxide, nitrogen oxide, and dioxin). Public-use facilities include a swimming pool, fitness center, culture center, and reading room. The incineration facility cost KRW 115.5 billion (KRW 14.4 billion from the central government, with the City of Seoul footing the rest), while the public-use facilities cost KRW 9.4 billion. During the construction, residents held 5 protests and lodged 38 written complaints. The City of Seoul held 15 presentations as information sessions for residents.

Construction of the Mapo facility began in December 2001 and was completed in May 2005, with three 250-ton incinerators providing the facility with a processing capacity of 750 tons/day. Main incineration facilities include tipping facilities, incinerators, and equipment for prevention of pollution (semi-dry reactors, bag filters, SCR units, and police filter). Public-use facilities include a sauna, fitness center, indoor golf range, and reading

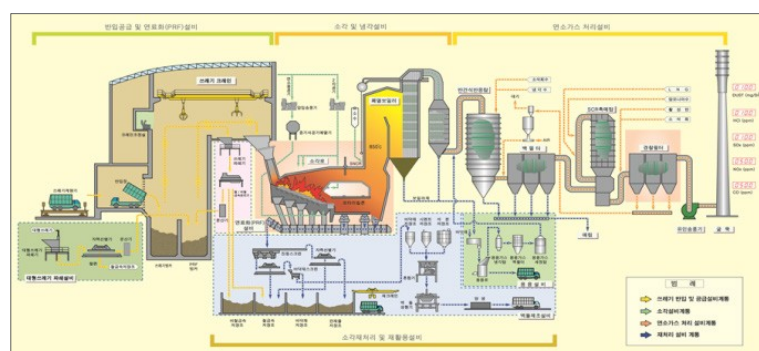


room. The incineration facility cost KRW 1712 billion (KRW 46.9 billion from the central government, with the City of Seoul footing the rest); KRW 9.5 billion was spent on the public-use facilities. During the construction, residents held 184 protests and lodged 45 written complaints. The City of Seoul held 68 presentations as information sessions for residents.

**Table 4 - Outline of Incineration Facility Construction in Seoul**

|                     | Yangcheon Facility  | Nowon Facility  | Gangnam Facility  | Mapo Facility  |
|---------------------|---|---|---|--|
| Capacity            | 400 tons/day<br>(2 incinerators)  | 800 tons/day<br>(2 incinerators)  | 900 tons/day<br>(3 incinerators)  | 750 tons/day<br>(3 incinerators)   |
| Construction Period | Dec. 1992 – Feb. 1996   | Dec. 1992 – Jan. 1997   | Dec. 1994 – Dec. 2001   | Dec. 2001 – May 2005   |
| Site Area           | 14,627 m <sup>2</sup>   | 46,307 m <sup>2</sup>   | 63,813 m <sup>2</sup>   | 58,435 m <sup>2</sup>  |
| Construction Cost   | KRW 32.1 billion  | KRW 74.3 billion  | KRW 115.5 billion   | KRW 171.2 billion  |
| Incinerator Type    | Stoker-type   | Stoker-type   | Stoker-type   | Stoker-type<br>+ Rotary kiln   |
| Air Purification    | <ul style="list-style-type: none"> <li>Scrubbers</li> <li>Semi-dry reactors</li> <li>Bag filters</li> <li>SCR units</li> </ul>    | <ul style="list-style-type: none"> <li>Electric dust collectors</li> <li>Wet scrubbers</li> <li>Bag filters</li> <li>SCR units</li> </ul> | <ul style="list-style-type: none"> <li>Scrubbers</li> <li>Semi-dry reactors</li> <li>Bag filters</li> <li>SCR units</li> </ul>        | <ul style="list-style-type: none"> <li>Semi-dry reactors</li> <li>Bag filters</li> <li>SCR units</li> <li>Police filter</li> </ul> |
| Amenities           | <ul style="list-style-type: none"> <li>Swimming pool</li> <li>Fitness center</li> <li>Reading room</li> <li>Auditorium</li> </ul> | <ul style="list-style-type: none"> <li>Swimming pool</li> <li>Fitness center</li> <li>Culture center</li> <li>Reading room</li> </ul>     | <ul style="list-style-type: none"> <li>Swimming pool</li> <li>Fitness center</li> <li>Culture center</li> <li>Reading room</li> </ul> | <ul style="list-style-type: none"> <li>Sauna</li> <li>Fitness center</li> <li>Indoor golf range</li> <li>Reading room</li> </ul>   |

**Figure 3 - Structure of the Mapo Incineration Facility**





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#### Four Incineration Facilities: Single District Use → Citywide Use

With completion of the Mapo Incineration Facility (750 tons/day) in 2005, Seoul had 4 incineration plants: Mapo, Yangcheon, Nowon, and Gangnam. However, the operation rate<sup>11</sup> as of 2005 was only 33% at Yangcheon, 19% at Nowon, 24% at Gangnam, and 59% at Mapo: the facilities were just not processing as much waste as intended. One direct cause was that the facilities processed the municipal waste only from their own gu district (except the Mapo facility, which processed the waste from Mapo-gu, Jung-gu, and Yongsan-gu). There were many other reasons as well, such as the effectiveness of the volume-based waste disposal fee system, Expanded Producer Responsibility, food waste recycling, various waste management policies introduced after facility design, all of which led to a lower volume of waste to be incinerated. Plus, municipal waste had to be transported all the way to the landfill in the capital area, about 45 km away, instead of using the nearby incineration facilities. This resulted in extra cost, financial burden, and negative environmental impact. The goal of a return on investment would just not be reached. The fact that the facilities were not fully used led to various concerns over potential damage, errors and deterioration of the facilities, each comprised of 2 or 3 incinerator units, pollution-prevention facilities, and precision device controls.

To resolve this issue, Seoul decided to widen the coverage area for each incinerator in 2001 for joint use by adjacent gu districts: the Yangcheon, Nowon, and Gangnam facilities that had resisted processing waste from outside their own districts were forced to accept waste from other districts, while the Mapo facility, which had been processing the waste from Mapo-gu, Jung-gu, and Yongsan-gu, was asked to process more. With consent from the Resident Support Councils of the 4 incineration facilities, the issue could easily be resolved. The Resident Support Council is an organization<sup>12</sup> that represents residents to protect their health and welfare in relation to the incineration facilities, but also discusses other matters of importance according to an agreement with the City of Seoul, such as overseeing the areas where the waste is taken to and monitoring the waste properties. This too proved to be a tumultuous road and required countless numbers of meetings and negotiations. In the whole process of instituting joint use, the City of Seoul met 160 times with the Resident Support Council of the Gangnam facility over 5 years. They finally reached agreement on joint use on May 7, 2007. The Nowon facility had 100 meetings over 6 years and reached agreement on June 30, 2007; the Mapo facility had 40 meetings in one year and reached agreement on February 10, 2009. In comparison,

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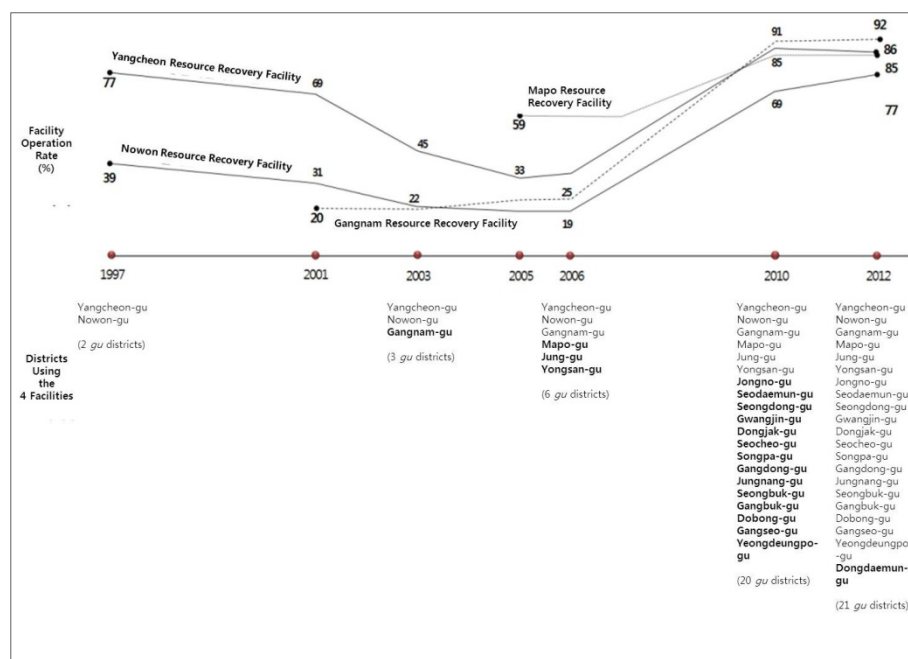
11. Operation rate refers to the actual volume of waste processed by the facility. All incineration facilities go through 30 – 60 days of maintenance each year, during which time no waste is processed. An operation rate that excludes this period and only considers normal operation days is the operation rate against the normal operation days. For instance, the Yangcheon facility has a capacity of 400 tons/day. Based on its normal operation days and the actual volume of waste processed (131 tons), the operation rate against the normal operation days would be 33%.

12. Pursuant to the Promotion of Installation of Waste Disposal Facilities & Assistance, etc. to Adjacent Areas Act, the Resident Support Council is comprised of resident representatives from the affected area, recommended by the gu district council, and 2 experts recommended by the corresponding gu district council or resident representatives from where the resource recovery facility is located (up to 15 members total), upon negotiation by the installer of the waste processing facility (Seoul Metropolitan Government) and the corresponding gu district office and/or its council, in consideration of the distance to the resource recovery facility (waste processing facility), the level of environmental impact, number of residents, etc. The roles of the Resident Support Council are: selection of an expert research institute for an environmental impact study; negotiation on installation of public-use facilities and on the resident support programs in the affected areas; recommending resident monitoring agents; execution of matters agreed upon with the installer of the incineration facility.

the Yangcheon facility needed 9 years and 150 meetings, but finally came to an agreement on May 10, 2010. The success of the plans for joint use of the facilities manifested itself in a number of ways. First of all, the number of districts using the 4 incineration facilities jumped. In 1997, there were only 2 such facilities in Seoul: Yangcheon and Nowon. Only 2 districts used the facilities. Then the Gangnam and Mapo facilities were built, but only 6 districts used them. By 2007, joint use began and by 2010 when the final facility, Yangcheon, reached agreement with residents, the program allowed 20 districts access to the incineration facilities. Dongdaemun-gu and Gwanak-gu joined in 2012 and 2013 respectively. As of 2014, 22 gu districts have access to the 4 incineration facilities in Seoul.

With this change, the operation rate of the 4 facilities, which had been at 19 – 59% (averaging 33% for all facilities) in 2006, rose to 77 – 92% (85% average for all facilities) by 2012. Now the 4 facilities cover the 25 gu districts in 4 zones – Southwest (Yangcheon Facility), Northeast (Nowon Facility), Southeast (Gangnam Facility), and Northwest (Mapo Facility).

**Figure 4 - Facility Operation Rate after Joint Use Agreement & Gu District Joining Dates**



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## Strategies for Construction of Incineration Infrastructure for Joint Use

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### Building Incineration Facilities & Energy Utilization in Connection with the New City Area District Heating Program

For the last 60 years, South Korean cities have enjoyed dramatic growth. City outskirts were quickly developed into residential areas to accommodate the massive population inflow from farming areas. In 1960s Seoul, Yeouido (1967) and Yeongdong (1967) were developed into new city areas, while in the next decade, Jamsil (1971) was created to divert the concentration of urban features away from Jongno and Jung-gu. In the 1980s, large-scale residential areas – Gaepo (1981), Godeok (1981), Mokdong (1983), and Sanggye (1985) – were built.<sup>13</sup> In this process, the Yangcheon incineration facility (with construction decided as part of the plans to develop the new city area in Mokdong in May 1983) and the Gangnam facility (designated as a waste processing facility as part of an urban plan in January 1986) were able to secure their sites with relative ease. The Mapo facility was also built on part of the World Cup Park site in the Sangam Land Development District program carried out from 2000. The site where the Nowon facility was erected had already been designated for waste processing in December 1977, before the Sanggye district was developed in 1985.

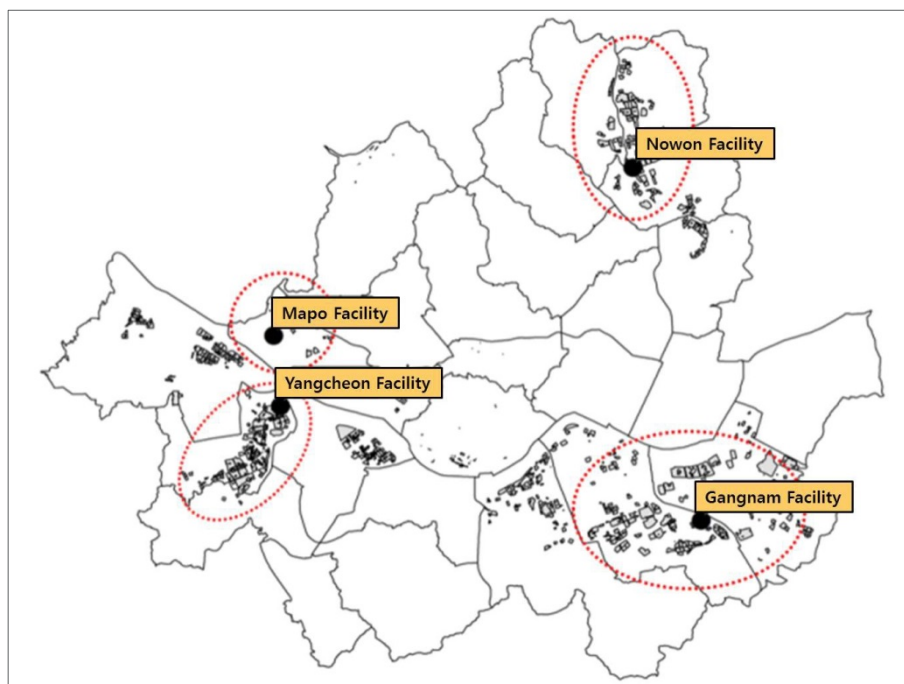
As such, tying the construction of incineration facilities with new city area development made it easier to identify appropriate sites and reduce conflict with local residents. Another advantage of this approach is the use of heat from incineration as a source of district heating. District heating first began in 1877 at LOCK PART in the state of New York, USA and later spread across America, Europe and Japan. In South Korea, the starting point was in 1981 when a feasibility study was conducted on the supply of heating to Yeouido, Dongbu Ichon-dong, and Banpo district, after renovation of Seoul Thermal Power Plant to adopt the combined heat and power method in 1981. The actual program went into effect in November 1985 when power generation heat from the CHP plant and incineration heat were used to provide district heating to 20,000 households in Mokdong and Shinjeong-dong. Because the 1970s were a decade of growing social interest in energy efficiency after the first and second oil shocks, the following decade saw some relevant changes: in 1987, Seoul Thermal Power Plant was changed into a CHP plant, and in 1989, district heating programs were introduced in 5 new cities, including Ilsan, following the Mokdong project.<sup>14</sup> Seoul used this opportunity to connect all 4 incineration facilities with the district heating facilities. In the Yangcheon project, which supplied 140,000 households with heating, the energy share of the incineration heat against district heating was 16%, the share in Nowon (128,000 households) was 23%, 27% in Gangnam (176,000 households) and 57% in Mapo (70,000 households) – not insignificant by any means.

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13. Lee Beom-hyeon, 2012, 2011 Module Program of the Economic Development Experience: Korean-type New City Development, Ministry of Land, Transport & Maritime Affairs and the Korea Research Institute for Human Settlements.

14. Hwaseong Office, Korea District Heating Corporation, 2013, Handbook on Facilities Using District Heating

**Figure 5** - District Heating Coverage & Location of Incineration Facilities in Seoul



### **Stringent Pollution Management to Ease Concerns of the Public**

Incineration facilities that handle municipal waste have multiple sources of pollution such as the incinerators, trash storage bunkers, and transporting vehicles. Pollutants vary from general pollutants (odor, dust, and nitrogen oxide) to pollutants specific to waste incineration (hydrogen chloride, sulfur oxide, and dioxin). When soldiers and their children who were exposed to defoliants used by the US army in Vietnam began to show side effects, dioxin captured the attention of the world in the early 1990s. It was also around this time that incineration was known to be one of the greatest producers of dioxin. In this environment, civic groups in South Korea expressed serious concerns over incineration, and residents living near the incineration facilities expressed concerns over location and environmental countermeasures. Seoul responded by coming up with diverse yet close-knit measures to protect the environment during installation and operation and initiated projects designed to improve the lives of those anxious about the construction.

First, Seoul installed incineration gas purifying equipment to a point that seemed excessive to some. One aspect of pollution from the incineration facilities that residents were most worried about were pollutants emitted alongside incineration gas, which is usually made up of heavy metals such as mercury, corrosives such as sulfur oxide and nitrogen oxide, and toxic chemicals like dioxin. The incineration facilities in Seoul have neutralizers, dust collectors, and catalyst equipment to remove these pollutants, and more than 50% of the construction cost was invested in their installation. Operation of the incineration facilities is also costly in terms of chemicals, energy used, and equipment replacement. During the construction phase, residents were provided with detailed explanations on the features and performance of this equipment and facilities. According to gas emission measurements in 2012, nitrogen oxide emission is less than half of the maximum

permitted level, while the other pollutants listed above were measured at 1/10 to 1/1000 of the legal maximum level.

**Table 5 - Analysis of Gas Emissions from Incineration Facilities in Seoul (2012)**

| Emission            | Legal Maximum                      | Yangcheon     | Nowon         | Gangnam       | Mapo          |
|---------------------|------------------------------------|---------------|---------------|---------------|---------------|
| Dust                | 20 mg/S <sub>m</sub> <sup>3</sup>  | 2.07          | 1.74          | 1.14          | 0.88          |
| Sulfur oxide        | 30 ppm                             | 0.43          | 0.14          | 0.29          | 0.34          |
| Nitrogen oxide      | 70 ppm                             | 23.00         | 23.78         | 12.39         | 16.67         |
| Carbon monox-ide    | 50 ppm                             | 10.30         | 7.16          | 10.55         | 107           |
| Hydrogen ch-lo-ride | 20 ppm                             | 2.26          | 0.48          | 2.73          | 1.15          |
| Dioxin              | 0.1 ng/N <sub>m</sub> <sup>3</sup> | 0.000 – 0.009 | 0.000 – 0.003 | 0.000 – 0.002 | 0.000 – 0.000 |

- Maximum permitted dioxin emission levels strengthened: 0.5→0.1 ng/N<sub>m</sub><sup>3</sup> (July 2003).

- Maximum permitted dust emission levels strengthened: 30→20 mg/S<sub>m</sub><sup>3</sup> (January 2010).

- Maximum permitted nitrogen oxide emission levels strengthened: 80→70 ppm (January 2010)

Second, the city examines the properties of the waste so that nothing toxic is fed into the incineration facilities. While high-performance equipment to prevent pollution is crucial, it is equally, if not more important to stop the potentially polluting elements from reaching the incineration facilities to begin with. Heavy metals such as mercury, usually hidden in the waste, spread into the air when burned. What is known as dioxin is formed during incineration by aromatic compounds and chlorine. The waste that produces such dioxin includes food waste, waste with high moisture content, PVC, etc. Of course people are asked to separate these items when they dispose of their waste, but inevitably some are mixed into the general waste. The incineration facilities conduct random checks on the trucks for materials that will become toxic chemicals. If any is found, the truck is sent back and may be penalized. Investigation and supervision is performed by the people recommended by the Resident Support Council (called the Resident Monitoring Agent<sup>15</sup>). These agents are on duty during the hours when waste is sent to the incineration facilities. When the food waste recycling system was introduced, 10 – 20% of the waste at the incineration facilities was food, but this has been reduced to less than 5%, thanks to this constant monitoring.

Third, the city runs a real-time measurement and display of air pollutants. Seoul verifies that the equipment that removes gases is properly installed and properly monitors the waste properties, and also measures the amount of pollutants in the emitted gas in real time for public disclosure. An automatic tele-monitoring system on the smokestack, automatic dioxin sampler, and gas concentration level display screen are a few of the

15. To ensure that the waste processing is performed in an appropriate manner at the resource recovery facilities, the installer of the waste processing facility (Seoul Metropolitan Government) commissions a local resident recommended by the Resident Support Council with the responsibility of the Agent, pursuant to the Promotion of Installation of Waste Disposal Facilities & Assistance, etc. to Adjacent Areas Act. The Resident Monitoring Agents have a defined set of responsibilities. The scope of their activities (pursuant to Article 32 of the Enforcement Decree of the Promotion of Installation of Waste Disposal Facilities & Assistance, etc. to Adjacent Areas Act) includes: verification of the properties of waste and appropriate processing; confirmation of the normal operation of the pollution-prevention equipment; and verification of the pollution inspection process in the surrounding area.



items in this system. To ensure measurements are accurate, facility operators are prohibited from accessing the measurement equipment. The automatic tele-monitoring system on the smokestack (TMS)<sup>16</sup> is installed at the halfway point up the stack, and measures the levels of dust, sulfur oxide (SO<sub>2</sub>), hydrogen chloride (HCl), nitrogen oxide (NOX), carbon monoxide (CO), oxygen (O<sub>2</sub>), oil/fluids, and temperature. The results are sent to the facility's central control and the government's control center in real time. It is also displayed on the screen for residents of the nearby community to see. Near the Gangnam facility, 3 screens are installed; one each in Yangcheon, Nowon, and Mapo. The measurement of which the residents were most skeptical about was dioxin. Unlike other pollutants, it is difficult to automatically measure dioxin in real time. It could only be measured manually by sampling and taking it to a laboratory (the same day), once every 6 months. This meant that there would be a lag between sampling and the potential for manipulating data during the sampling process, undermining any trust residents had in the process. Seoul responded by installing the same dioxin samplers used in Europe at all smokestacks at the 4 incineration facilities. This sampling kit absorbs dioxin from a small amount of emitted gas over 3 – 6 months, enabling an analysis of dioxin in the gas during that period. After the dioxin<sup>17</sup> analysis, the kit is replaced with a new one, which would then sample the chemicals for the next round of analysis.

**Figure 6 - Pollutant Levels Displayed on Screen; a Dioxin Sampler**



Screen Display near Incineration Facility



Dioxin Sampler Kit

16. The automatic tele-monitoring system on the smokestack (Clean SYS, TMS) is a 24-hour system used at the resource recovery facility or such to monitor air quality at the facilities, measure pollutant and emission levels, and send these measurements to the control center main computer at the Environmental Management Corporation. The automatic tele-monitoring system on the smokestack is installed at the halfway point, and measures the levels of dust, sulfur oxide (SO<sub>2</sub>), hydrogen chloride (HCl), nitrogen oxide (NOX), carbon monoxide (CO), oxygen (O<sub>2</sub>), oil/fluid, and temperature. The data is collected and sent to the control center at the Environmental Management Corporation in real time to check for toxic gas emission. The data can also be seen by nearby residents via a screen installed outside the facility.

17. By definition, dioxin is short for polychlorinated dibenzo-p-dioxins. "Poly" means 'many' and "chlorinated" means that the hydrogen is substituted with chlorine; "di" refers to 'two'; "dibenzo" thus means '2 benzene rings'; "dioxin" means '2 oxygen'; para (p) refers to the fact that two oxygen atoms occupy opposite positions. Dioxin has a chemical structure of 2 chlorinated benzene rings facing 2 oxygen atoms. Its acronym is PCDD or PDSSs. Dioxin, a compound of 2 chlorinated benzene rings, has 75 types with 2 oxygen atoms and 135 furans with 1 oxygen – a total of 210 types.

Fourth, Seoul controls the number of waste trucks and their operating hours. The trucks spread odor during transport, emit exhaust gas, and add to the traffic on the surrounding roads. The city therefore requires trucks to collect the waste at night or in the early morning to reduce people's exposure to the smells and reduce traffic during the day. Any waste that comes from other districts can only be transported on 11-ton or larger trucks to reduce the number of trips required.

Fifth, the city constantly monitors the health of the residents. Other than monitoring waste, controlling truck hours of operation, and ensuring the performance of pollution-prevention equipment, Seoul has adopted a program to monitor the impact on health since 2000. The health of the residents is monitored over the long-term to identify and objectively evaluate the effect of pollutants (e.g, dioxin) from the incineration facilities so as to ensure safety, help ease concerns, and come up with effective measures if any negative aspects are found. There are 3 main areas included in the monitoring: air quality in adjacent areas (environmental impact); the level of dioxin and heavy metals in the bloodstream of residents (physical impact); and general physical and psychological health (health impact). Physical impact and health impact studies are conducted on fixed research groups of community residents, volunteers, and facility operators. Recently, the monitoring has been reduced to the fixed research group as residents requested, but more pollutants – dioxin and black carbon – have been added to the study over time. For study continuity, the 10th research project is underway as of 2014, with categories, methods, and targets determined after discussions with the Resident Support Council. No significant environmental, physical, and health impacts have been identified so far.

**Table 6 - Study of Impact on Health of Residents near Incineration Facilities in Seoul**

| Period    | 2000 – 2004   | 2005 – 2008   | 2009 – 2012   | 2013 – 2015                                      |
|-----------|---|---|---|--|
| Frequency | 3 times   | 3 times   | 3 times   | 3 times  |
| Region    | Areas affected by the Yangcheon, Nowon, and Gangnam Facilities and Reference Areas    |   |   |  |
| Category  | · Health impact evaluation: dust, heavy metals, odor                                  |   | · Same as in Stage 1, 2   | · Same as in Stage 3                             |
|           | · Physical impact evaluation: dioxin, heavy metals, etc. in the bloodstream           |   | · Analysis of dioxin in the air added                                     | · Traffic impact evaluation (black carbon, etc.) |
|           | · Health impact evaluation: general health, awareness, quality of life                |   | · Environment impact evaluation added in the autumn                       |  |
| Group     | · Residents in the affected area and reference area, and worker classification survey |   | · Residents in the affected area and reference area classification survey | · Residents in the affected area                 |
| Method    | · Individually recruited<br>· Follow-up survey  | · Individually recruited<br>Research group follow-up survey | · Research group follow-up survey   | · Research group follow-up survey                |



|                   |   |   |  |  |
|-------------------|---|---|--|--|
| Number of Targets | <ul style="list-style-type: none"> <li>Heavy metals: 270 persons</li> <li>Dioxin: 53 persons</li> </ul> | <ul style="list-style-type: none"> <li>Heavy metals: 270 persons</li> <li>Dioxin: 75 persons</li> </ul> | <ul style="list-style-type: none"> <li>Heavy metals: 270 persons</li> <li>Dioxin: 100 persons</li> </ul> | <ul style="list-style-type: none"> <li>Heavy metals: 360 persons</li> <li>Dioxin, tumor marker: 100 persons</li> </ul>   |
| Remarks           |   | <ul style="list-style-type: none"> <li>Increased number of dioxin testing targets</li> </ul>            | <ul style="list-style-type: none"> <li>Increased number of dioxin testing targets</li> </ul>             | <ul style="list-style-type: none"> <li>Tumor marker test added</li> <li>Traffic impact evaluation added</li> <li>Comparative disease and illness evaluation based on regional data from the National Health Insurance Service</li> </ul> |

Sixth, the city has programs to enhance residents' daily lives in the affected areas. These include programs related to heating bills, management fees, rental assistance for multi-household housing, assistance with housing improvement programs (waterproofing, painting, etc.), and assistance with medical bills and public-use facility fees. Eligible residents include those living within 300m of the incineration facility site boundaries<sup>18</sup>: a total of 12,637 households (3,413 in the Yangcheon area; 6,190 in the Nowon area; and 2,934 in the Gangnam area). The programs are financed pursuant to City of Seoul ordinances, and the related fund is called the Resident Assistance Fund<sup>19</sup>, created with contributions from the City of Seoul and the gu districts that use the facilities as well as profits from management of the Fund. Contributions made by Seoul are comprised of a fund for construction of the incineration facilities; heating assistance (up to 70%) for multi-household housing in the affected areas; and contributions from the fee for facility waste handling (which includes 10% of the facility waste handling fee and an additional 10% handling fee paid by joint users – the gu districts). Contributions from the gu districts that use the facilities are determined according to the joint use agreement. For instance, joint users of the Yangcheon facility contribute KRW 21,000 per ton of waste on top of the handling fee until 2020. Profits from management of the Fund come mostly from the interest earned at the bank. From 1996, when the Yangcheon facility started operations, to 2013, the Resident Assistance Fund created by the 4 incineration facilities totaled KRW 169.9 billion. The amount paid into the fund per ton of waste sent to the 4 incineration facilities is KRW 25,260; the amount of funding per household in the affected area is KRW 13.56 million.

18. Article 17 of the Promotion of Installation of Waste Disposal Facilities & Assistance, etc. to Adjacent Areas Act calls this "an indirectly affected area". The scope of the indirectly affected area as stipulated in Article 20 of the Enforcement Decree of the same Act is within 400m of the incineration

19. Seoul Metropolitan Government assistance fund for areas adjacent to the resource recovery facilities

**Table 7 - The Resident Assistance Fund (1996 – 2013)**

|   | Total     | Yangcheon Facility | Nowon Facility | Gangnam Facility | Mapo Facility |
|---|-----------|--------------------|----------------|------------------|---------------|
| Resident Assistance Fund (KRW 1 million)                            | 169,945   | 45,230             | 63,765         | 60,275           | 675           |
| No. of Residents in Affected Area (Households)                      | 12,537    | 3,413              | 6,190          | 2,934            | 0             |
| Incinerated Volume (tons) (1997 – 2013)                             | 6,727,728 | 1,389,705          | 1,767,559      | 2,023,626        | 1,546,838     |
| Payments into Resident Assistance Fund(KRW/ton)                     | 25,260    | 32,547             | 36,075         | 29,785           | 436           |
| Resident Assistance Fund per Household in Affected Area (KRW 1,000) | 13,556    | 13,252             | 10,301         | 20,544           | -             |

## Benefits of Joint Use

### Dramatic Reduction of Municipal Waste Landfill

One of the greatest weaknesses in Seoul's waste management system is that it does not have its own landfill sites and probably never will. Thus the reduction of waste needing to go to landfill is a crucial goal. Joint use of the 4 incineration facilities significantly help fulfill this goal, with the amount of waste, in absolute terms, buried in 2012 equaling only 10% of the 1997 level, when the Yangcheon and Nowon facilities had just begun operating. One of the reasons for this drop was a reduction of the actual volume of waste (both incinerated and in landfill) to a third, but the incineration capacity being increased by 3 – 4 times since 1997 also cannot be overlooked. The percentage of the waste that goes to a landfill against the incinerated amount dropped dramatically from 93.6% in 1997 to 25.4% in 2012. If the 4 facilities had continued to process only waste from Yangcheon-gu, Nowon-gu, Gangnam-gu, Mapo-gu, Jung-gu, and Yongsan-gu, then the amount of buried waste would still be around 2006 levels (76.3%). Joint use of the facilities has helped enhance Seoul's municipal waste management, and the percentage of waste for landfill is now 7.8% as of 2012 (61.9% in 1997).

**Table 8 - Changes in Landfill Waste at Incineration Facilities: Before & After Joint Use Agreement**

|  | Before Joint Use Agreement |                               |                                       | After Joint Use Agreement             |                                       |
|--|----------------------------|-------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
|  | 1997                       | 2003                          | 2006                                  | 2010                                  | 2012                                  |
| Incineration Facility                              | Yangcheon<br>Nowon         | Yangcheon<br>Nowon<br>Gangnam | Yangcheon<br>Nowon<br>Gangnam<br>Mapo | Yangcheon<br>Nowon<br>Gangnam<br>Mapo | Yangcheon<br>Nowon<br>Gangnam<br>Mapo |
| Amount Incinerated at the 4 Facilities (tons, [1]) | 187,096                    | 162,795                       | 320,562                               | 740,287                               | 771,110                               |
| Landfill Waste (tons, [2])                         | 2,730,200                  | 1,866,096                     | 1,033,738                             | 527,790                               | 262,435                               |
| Incinerated + Landfill (tons, [3]=[1]+[2])         | 2,917,296                  | 2,028,891                     | 1,354,300                             | 1,268,077                             | 1,033,545                             |
| Landfill (%) [2]/[3])                              | 93.6                       | 92                            | 76.3                                  | 41.6                                  | 25.4                                  |
| Landfill (%) (Municipal Waste)                     | 61.9                       | 42.4                          | 24.8                                  | 14.4                                  | 7.8                                   |

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### Enhanced Productivity of the Incineration Facilities

After joint use began, use of the 4 incineration facilities quickly increased. In 2005, before joint use, the 4 facilities processed 253,561 tons of municipal waste; in 2012 (after joint use had begun) three times that number was processed (771,110 tons). The utilization rate rose from 37% in 2005 to 85% in 2012, and better utilization led to a reduction in operational costs. In 2005, operational cost (including labor, expenditures, general management, and profit for the commissioned operator) per ton of incinerated waste was KRW 90,508; in 2012, it was KRW 69,355, down by KRW 20,000. In the meantime, KRW 16.3 billion was coming from the city's budget to finance the operation of the incineration facilities. Fixed costs decreased due to the increased processing volume, but also due to the increased profits from the sale of incineration heat and other byproducts (e.g., scrap metal, incineration heat, recyclables), which were KRW 19,804 per ton before joint use but had risen to KRW 27,363 in 2012.

**Table 9 - Changes in Incineration Facility Productivity Before & After Joint Use Agreement**

| Category   | Before (2005) | After (2012) |
|--|---------------|--------------|
| Operation rate<br>(%, against normal operation days) | 37            | 85           |
| Operation cost<br>(KRW/ton of waste received)        | 90,509        | 69,355       |
| Sales of byproducts<br>(KRW/ton of waste received)   | 19,804        | 27,363       |

### Energy Recovery from Incineration Heat

The latent heat (lower heating value) of municipal waste brought to the incineration facilities in Seoul is 2,762 kcal per kilogram. Seoul's incineration facilities are capable of recovering 74% of incineration heat on average; some of the recovered heat is used for facility operation but is mostly sold to the district heating facilities in the adjacent facilities. Energy sales in 2006, before joint use, were of 561,411 Gcal; in 2012, after joint use had begun, sales went up 1.3 times to 1,269,336 Gcal. Before joint use, recovered heat was available to supply heating and hot water to 52,000 households. Joint use however helped the recovery rate grow, increasing the number of supplied households by more than 50,000. The main fuel used in city gas is LNG, meaning that incineration heat to supply heating and hot water results in less LNG being needed. In terms of the environment, it would mean less carbon dioxide and other greenhouse gas emissions from the use of LNG. The reduction of greenhouse gases before joint use (2006) was 27,000 tons but after joint use began in 2012, it was 60,000 tons. In terms of annual emissions by Seoul city buses, this reduction is tantamount to the annual emissions of 540 buses.

**Table 10 - District Energy Displacement Before & During Joint Use of the Incineration Facilities**

|   | Before (2006)                                   | During (2012)                         | Remarks  |
|---|---|---------------------------------------|--|
| Incineration heat sales (Gcal)                                      | 561,411<br>(10)                                 | 1,269,336<br>(2.3)                    | • Annual heating/hot water consumption per household: 10.9 Gcal  |
| City gas displacement (LNG m <sup>3</sup> )(Household)              | 59,597,770 m <sup>3</sup><br>51,506 house-holds | 134,749,045 m <sup>3</sup><br>116,453 | • LNG 1 N m <sup>3</sup> = 9,420 Kcal<br>• Annual heating/hot water consumption per household: 10.9 Gcal                         |
| Greenhouse gas reduction (tons CO <sub>2</sub> )(No. of city buses) | 26,725 tons<br>239 buses                        | 60,426 tons<br>540 buses              | • LNG 1 N m <sup>3</sup> = 2.23 kg CO <sub>2</sub><br>• Greenhouse gas emissions from Seoul city buses: 112 tons CO <sub>2</sub> |

## Significance of Seoul's Experience

### Waste, a Valuable Urban Energy Source

Cities generate a massive amount of waste. However, waste treatment facilities are not welcome in cities where land is needed for many other things, whether it is a treatment facility that requires a large area or an incineration facility that requires a relatively smaller area. Seoul chose the latter, as it does not require much land. Because it was in connection with land development programs, the city secured the site with relative ease and was able to use incineration heat as the source of district heating. Any remaining capacity at the incineration facilities was shared by adjacent districts, which limited the number of required incineration facilities and enhanced facility productivity. Today, Seoul's incineration facilities recover 74% of the latent heat from waste. What is not used by the facilities is sold to the district heating suppliers in the form of heat and electricity, sufficient to supply heating and hot water to 116,000 households.

Food waste however must be separated out as it works against energy recovery from other waste and generates odor – one of the principal reasons that nearby residents do not welcome incineration facilities. When recycled, food waste can be used as fertilizer or to produce bio-gas (i.e., methane).

### Accuracy in Waste Volume Forecast – a Must to Contain Facility Numbers & Resolve Conflicts

Both incineration and food waste facilities are designed for 10 – 25 years of use. The latest incineration facilities are equipped with cutting-edge incinerators, pollution-prevention facilities, and automatic controllers, and require a minimum of KRW 300 million per ton in investment. Operational costs are also prohibitive as the facility needs a skilled workforce, energy and chemicals, and parts replacement, etc. Upon making decisions on the size of an incineration facility, it was impossible to predict future policy changes and the city experienced considerable difficulties due to the unused capacity. It fortunately found a solution through joint use by adjacent districts, but social conflict and the waste of administrative resources were significant over time. Some of the most influential policies that helped Seoul reduce waste were: the volume-based waste disposal

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fee system that urged people to recycle; the Expanded Producer Responsibility; food waste recycling; and the decreased use of coal briquette ash due to changes in the choice of fuel. In the meantime, conflicts over landfill sites forced the city to process its waste within its own boundaries, making the demand for incineration facilities even higher. Such policy changes have a far-reaching impact on the volume of waste and how it is processed, and must be considered when projecting future waste volumes.

### **Reasonable Division of Responsibilities between the 25 Gu District Offices and the City of Seoul**

For the purpose of administration, large cities have administrative boundaries. Seoul is comprised of 25 gu districts for convenience. Such boundaries however are undesirable when it comes to securing facilities that are shunned by the people, such as a landfill or incineration facilities. Logically, it is better to have one for each district, but even if this were possible, conflict would be inevitable. Smaller facilities can mean installation and operation costs are higher.<sup>20</sup> Moreover, the reliability of pollution-prevention facilities may not be guaranteed. This is why many incineration facilities and landfills are installed and operated by larger administrative authorities, whether in Seoul, Tokyo, or Paris. Another similarity Seoul has with other cities is that district offices are in charge of collecting, transporting and recycling waste, as these offices are in direct contact with the people, making it easier to receive their cooperation in waste segregation and collection.

While the roles of the district offices and the higher level administrative authorities are clearly divided and defined, the opinions and demands of district offices should be the fundamental foundation when it comes to answering the demands for the facility or selection of the site. The facility size and location, especially locations for joint use, should be determined by the district, which is more likely to have an accurate picture of the waste management demand and to better understand resident opinions. The reason it took 7 years to build the Gangnam facility, from selecting a construction company to completing construction, is because conflict continued over facility capacity and location even after the construction contract had been awarded. Contrary to this, the Mapo facility had already worked out its capacity and location for joint use and site before awarding the construction contract, requiring 3.5 years to build.

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20. Generally, the ideal capacity for an incineration facility is 400 tons/day for economical installation and operation.

**Figure 7 - Bottom-up Approach: Procedure for Construction of an Incineration Facility**

|   |   |
|---|---|
| Request from district office for installation of a facility           | <ul style="list-style-type: none"> <li>· Facility capacity (400 tons/day or more, considering energy recovery efficiency)</li> <li>· Consent forms from joint users</li> <li>· Site(s) secured for facility</li> </ul>  |
| Development of a basic plan   | <ul style="list-style-type: none"> <li>· Area for joint use</li> <li>· Quality and quantity of waste</li> <li>· Division of roles between joint users</li> </ul>  |
| Announcement of plan for site selection; selection of potential areas | <ul style="list-style-type: none"> <li>· Site selection committee formed</li> <li>· Accessibility and location of residences examined</li> <li>· Site stability (size, earth type, risk of flooding, landslide, cracking, etc.)</li> <li>· Potential restrictions (historical heritage, school, military installation, height restrictions, protected water source area, etc.)</li> </ul> |
| Recruit candidate sites   | <ul style="list-style-type: none"> <li>· Propose possible assistance to local community and affected areas</li> <li>· Review environmental impact on site</li> </ul>  |
| Site selected & announced   | <ul style="list-style-type: none"> <li>· Consent obtained from residents in affected areas (2/3 consent in the case of the Hanam facility)</li> <li>· Consent obtained from residents in corresponding wider area when there are no specific affected areas (2/3 consent in the case of the Hanam facility)</li> </ul>  |
| Construction company chosen (basic design, impact assessment)         | <ul style="list-style-type: none"> <li>· Review of basic design</li> <li>· Assessment of technical and construction performance</li> <li>· Review of project cost</li> </ul>  |
| Information sessions for residents                                    | <ul style="list-style-type: none"> <li>· Details provided on basic design and impact assessment results</li> <li>· Opinions collected from residents</li> </ul>   |
| Detailed designs done & construction started                          | <ul style="list-style-type: none"> <li>· Incorporate resident opinions</li> <li>· Areas identified that will be affected within 2 years of waste processing facility installation, resident council organized, environmental impact evaluation</li> </ul>   |
| Pilot & pre-performance tests conducted                               | <ul style="list-style-type: none"> <li>· Have the resident representatives or designated organizations to be present</li> <li>· Follow-up on any abnormalities found</li> </ul>   |
| Construction completed & operations started                           | <ul style="list-style-type: none"> <li>· Facility performance tests conducted</li> <li>· Dioxin levels measured</li> <li>· Environmental impact assessment</li> </ul>   |

### Efforts to Win the Trust of Local Residents

Local residents are sensitive about incineration facilities because they can lead to lower property values, emission of pollutants from incineration, damage to the environment and health, and traffic congestion from the number of garbage trucks going to and from the facilities.

Property values do tend to decrease. The effect is more pronounced when conflicts, such as protests, are

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known on the outside; without conflict, the effect on property value dissipates. Even so, the possibility for lower property values is a potential anxiety for residents, and is seen as one of the burdens caused by the incineration facilities. Seoul has therefore provided compensation through financial assistance with heating, housing maintenance, leases, fees for public-use facilities, and medical checkups. From 1996 to 2013, the Resident Assistance Fund accumulated per household is KRW 13.56 million.

Seoul has some measures in place to protect areas near the facilities from pollutant emissions. First of all, waste is monitored by resident representatives to ensure it does not include water, food waste, or toxic materials before going to the incinerators. If any are found, the waste is rejected, and the corresponding truck may be denied access for a specific period of time. Emissions are measured in real time and displayed to the public. Any chemicals such as dioxin that cannot be measured in real time are collected for 3 or more months with the appropriate device. Since 2000, Seoul has held health impact assessments to identify impact on the environment and health. As of 2014, the 10th survey is underway.

These measures are in place, not because the facilities are problematic, but to earn the trust of the residents, and can be applied to food waste processing facilities and landfill as well.

### **Improvement to the Legal Framework**

Various laws, ordinances and agreements are in place so as to ensure that incineration facility sites are selected in a logical manner, that a fund is created to provide assistance to local residents, and that the residents in turn take active part in the operation of incineration facilities.

In South Korea, the installation of incineration facilities is pursuant to the Promotion of Installation of Waste Disposal Facilities & Assistance, etc. to Adjacent Areas Act, which stipulates the requirements for waste processing facility plans in various large-scale development projects; the procedure for site selection; the process of securing the facility site and construction; matters to be negotiated with local residents; assistance for residents; and methods of operation, etc.

The City of Seoul Ordinance on the Promotion of Resource Recovery Facility Installation & Assistance for Surrounding Areas contains information on operation of the incineration facilities, such as waste handling and receiving fees; utilization of the Resident Support Council and the Resident Monitoring Agents; and commissioned operation of the incineration facilities and facilities for public use.

The City of Seoul Ordinance on the Assistance Fund for Areas Adjacent to Resource Recovery Facilities also stipulates how the fund is to be created and used in compensation to the residents of affected areas, among many other things, to ensure transparent and objective use of the fund.

As for matters besides installation and operation of the incineration facilities and assistance to residents in the adjacent areas, the City of Seoul and the Resident Support Council reach agreement before decisions are made. Examples of what they deal with include joint use area of the incineration facilities, restrictions on waste receiving, standards, and time.

Incineration facilities are expensive to build and operate. If operated incorrectly, they can harm the environ-



ment and health, but they are undeniably critical to any city. These facilities require laws, ordinances and regulations on installation, operation, and resident assistance to be able to function well.

Important matters can also be determined by way of agreement with residents.

**Table 11 - Legal Framework for Municipal Waste Incineration Facilities in Seoul**

| Legislation Etc.   | Description  |
|--|--|
| Promotion of Installation of Waste Disposal Facilities & Assistance, etc. to Adjacent Areas Act                    | <ul style="list-style-type: none"> <li>· Installation of the waste processing facility is to be reflected in the development of plans pursuant to the Framework Act on National Land.</li> <li>· The plan for site selection is to be developed when installing/operating the waste processing facility.</li> <li>· A site selection committee is to be organized when desiring to construct a waste processing facility.</li> <li>· Compensation to be given and restrictions imposed on the waste processing facility site.</li> <li>· The scope of the affected areas.</li> <li>· Organization and functions of the Resident Support Council.</li> <li>· Creation of the Resident Assistance Fund.</li> <li>· Assistance from the head of the wider area administrative authorities for the installation of waste processing facilities.</li> </ul> |
| City of Seoul Ordinance on Promotion of Resource Recovery Facility Installation & Assistance for Surrounding Areas | <ul style="list-style-type: none"> <li>· Waste handling and receiving fees are to be collected.</li> <li>· Management and operation of the incineration facilities can be commissioned.</li> <li>· Resident Support Council/Resident Monitoring Agent.</li> <li>· Eligible users of the public-use facilities, commissioned facility operation.</li> </ul>   |
| City of Seoul Ordinance on the Assistance Fund to Areas Adjacent to Resource Recovery Facilities                   | <ul style="list-style-type: none"> <li>· Creation of the Resident Assistance Fund.</li> <li>· Use of the Resident Assistance Fund.</li> <li>· Target area of the Resident Assistance Fund.</li> <li>· Management and operation of the Resident Assistance Fund: council, meetings, etc.</li> </ul>   |
| Agreements between the City of Seoul and the Resident Support Council  | <ul style="list-style-type: none"> <li>· Waste receiving area.</li> <li>· Permitted waste properties; consequences for violations.</li> <li>· Waste receiving hours.</li> </ul>  |

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