

# Smart Waste Management in Seoul: Resource Recovery

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## Issues

Until the 1990s Seoul's waste management method was predominantly landfill, but this could not continue forever. With expansion of the city and its economy, securing available sites for landfill became more and more difficult. With the Nanjido Landfill Site almost filled to capacity and the increased difficulty of finding new sites, incineration surfaced as an alternative. As an intermediary treatment method before landfill, it was expected to extend the life of landfill sites by reducing the amount of solid waste.

The new state-of-the-art incinerators are called 'Resource Recovery Facilities', and burn solid urban waste at 850-950°C to recover the heat (above 400°C) produced in the process. The high-pressure steam produced is used as an alternative source of energy that provides heat for nearby communities. This is why resource recovery facilities are conceptually different from traditional incinerators. The Seoul Metropolitan Government (SMG) first considered building resource recovery facilities in the early 1990s; the subsequent construction of four major resource recovery plants was carried out over two decades. Only four districts house their own resource recovery facilities.



**Figure 1 Location of Resource Recovery Plants in Seoul**  
 (Source: Seoul Metropolitan Government)

Figure 1 Location of Resource Recovery Plants in Seoul

## Solution

As mentioned above, there are four resource recovery facilities in the Seoul area (Nowon, Yangcheon, Gangnam and Mapo) as seen in Figure 1. The first resource recovery facility in Seoul opened in Yangcheon-gu in 1996, with a capacity of 150 tons per day. Since then, Seoul has acquired three more resource recovery plants in Nowon-gu (1997) Gangnam-gu (2001) and Mapo-gu (2005). Together they process an average of 2,850 tons of household waste every day. The Mapo Resource Recovery Plant converts 750 tons of waste into power every day, and this is shared with five administrative districts in northwest Seoul, namely Mapo-gu, Yongsan-gu, Jung-gu, Jongro-gu and Seodaemun-gu. The Nowon plant, sharing with the northeast districts of Nowon, Jungnang, Seongbuk, Gangbuk, Dobong and Dongdaemun, has been in operation since 1997 and treats 800 tons of waste every day. The Gangnam plant, in operation since 2001, treats 900 daily tons of waste from seven districts in the southeast of Seoul, while the Yangcheon plant, established in 1996, takes 400 tons of waste per day from southwest Seoul. In all, the four resource recovery plants in Seoul are shared with 21 administrative districts (SMG Climate &

Environment Headquarters, 2012).

Because there are only four resource recovery plants in Seoul, the city government decided to share them with districts without such a facility. This decision met strong opposition from residents who lived near a resource recovery plant due to negative associations with an incineration plant. The city conducted public hearings and briefing sessions and provided financial incentives for residents in the affected areas. By showing its intention to ensure public safety and safe operation of the facilities, the SMG was able to persuade residents of the necessity of its plans.

As a consequence of joint use, the operating rates of the plants jumped from 33% in 2006 to 82% in 2010, while the residents in the nearby areas receive subsidized heating and other incentives. In addition, some of the profits from the resource recovery facilities go to a community support fund. Sharing the resource recovery plants produced technological, economic and societal benefits such as extending the life of the Sudokwon Landfill, reducing air pollutants, and lowering the cost of heating and waste transportation (SMG Resource Recovery Facility).

## 2.1. Planning

In April 1991, the SMG announced a comprehensive plan for waste management, signaling a transition in related policy from landfill to resource recovery. This decision encountered strong resistance and opposition from residents against siting such facilities in their area, with the resultant increase in the amount of waste treated in their neighborhood. An amendment was made to the original plan so that every district would have its own incineration plant, which later turned out to be inefficient and unfeasible, as half of the districts just did not have any available space. There was also a concern that building 11 incineration plants would worsen air pollution. As a solution, the city decided that three to four districts would jointly use and operate these needed but unwanted facilities (Choi, 2000).



**Figure 2 | Community Facilities**

## 2.2. Implementation

### 1) Negotiation with Residents

The SMG strove to find ways to encourage public support for the joint use of resource recovery facilities through more than 320 public meetings since 2001. As part of these efforts, related city ordinances were revised twice to reflect discussions with residents. According to the amendments made, residents who lived within 300 meters of the plants received a discount of up to 70% on their electricity bills as a means of compensating for their inconvenience and discomfort. In addition, the tipping charge of the resource recovery plants was lowered to prime cost to encourage cooperation among the authorities in the districts where the plants were located. With regards to the intake of waste from other districts, consultation was needed to meet requirements as set out by the three stakeholders, namely the SMG, the district head and the citizens' council. Proceeds from the community support fund would be spent to subsidize apartment management fees, medical costs and recreational facility use for residents in the region (SMG Resource Recovery Facility).

- Negotiation Process: Construction of the Nowon Resource Recovery Plant

The construction of the Nowon plant provoked intense opposition from the local residents, who feared the dioxin emissions from incinerators and the negative impact a nearby incinerator would have on their property values. To resolve these issues, the Korean and Seoul Metropolitan Governments conducted an

information process to address local concerns and communicate to residents the necessity of these societally-required facilities. The project finally earned public support and was given the go-ahead when residents realized the social benefits of resource recovery and accepted the government's promise to cut the amount of emissions and provide compensation for their inconvenience (Lim, 2013).

- **Negotiation Process: Joint Use of the Mapo Resource Recovery Plant**

The plan for the joint use of the Mapo Resource Recovery Plant, aimed at increasing its operating rates, was not welcomed by the Mapo-gu citizens. Even so, the conflict in this district was relatively easy to settle. The consultation process began with a council established in 1996, made up of officers from the involved districts and community representatives. In 1997, the council agreed to include Jung-gu in the coverage of the Mapo plant. To compensate for the inconvenience from the increased amount of waste processed in the existing facility, Mapo-gu requested that the city invest in public amenities such as cycling lanes in their ward. On December 31, 1997 after two days of consultation, Yongsan-gu was also approved to join, when agreement was reached with Mapo residents (Lee, 2000).

- **Negotiation Process: Joint Use of the Yangcheon Resource Recovery Plant**

The Yangcheon Resource Recovery Plant was built as part of a major housing development in Mok-dong Yangcheon-gu. Originally, the plant was used exclusively by Yangcheon-gu, and this was the reason behind its low operating rate. Joint use of the Yangcheon plant was first discussed in July 1998 when Seoul Metropolitan Government decided to address the low operating efficiency of the Yangcheon plant. Stakeholders from different sectors, including civic groups, residents and involved authorities, were invited to workshops, plant tours and round-table talks. In 2010, the city government finally gained approval from the local residents, after four years of effort to resolve conflicts and misunderstandings among the interested parties. During those four years a variety of strategies were initiated, such as 560 public meetings between local representatives and city authorities. The city government, to combat public fears, also presented data which proved the safety of the resource recovery facility.

According to the agreements made, Gangseo-gu and Yeongdeungpo-gu would donate KRW 1,000 for every ton of waste they discharged to the Yangcheon plant, and subsidize the apartment management fees of residents living within 300 meters of the facility, along with investments in neighborhood improvement (e2news, 2010; Newsis, 2010). In addition, some of the proceeds from increased heat production from the joint use would go to the residents, providing a discount of 8.8% on their heating bills. Since 2000, the city government has also conducted health impact assessments on the operation of the facilities. In addition, to relieve residents' concern over dioxin emissions, standards were raised for emissions, which are now ten times more stringent than national standards. Residents are able to monitor the concentrations of pollutants through an automated monitoring system (Newsis, 2010).

## **2) Citizens' Council**

The city government allowed residents in the area to create a citizens' council that would consist of

community representatives, members of the district council, and specialists in environmental sciences recommended by residents. The council is entitled to appoint a research institute to conduct environmental impact assessments of the resource recovery facility and monitor whether the facility operates in an environmentally-responsible manner. They represent the community's interests by ensuring adequate compensation for the inconvenience of having unwanted facilities (SMG Resource Recovery Facility).

### 2.3. Finance

#### **1) Operation Costs and New Revenues**

The construction of the Nowon Resource Recovery Plant cost a total of KRW 62.7 billion, entirely financed by city budgets; its operating costs are also borne by the SMG. Back in 2006, before the joint use agreement, annual operating costs were KRW 6.1 billion, with revenues from waste collection and heat production a mere KRW 2.1 billion, incurring a deficit of almost KRW 4 billion every year. The Yangcheon plant also used to find itself in deficit, with annual operating expenses of KRW 4.5 billion and revenues of just KRW 2.4 billion. As of 2009, it was operating at about 81% of its designed capacity, a dramatic jump from 33% in 2006 (The Hwankyong Sisa Ilbo, 2006).

Converting waste into energy to provide electricity and domestic heating replaces KRW 104.1 billion of energy imports every year, while cutting down greenhouse gas emissions by 594,608 tCO<sub>2</sub>. The four resource recovery plants in Seoul, equipped with SCR catalyst systems, save annual LNG costs of KRW 5.8 billion, thus reducing the city's annual greenhouse gas emissions by 15,000 tCO<sub>2</sub>. The shortened travel distance from waste to treatment facilities is responsible for reducing transport costs by KRW 5 billion every year (The Energy Economic News, 2011).

#### **2) Community Support Fund**

Under city ordinances, a community support fund was created from the revenues generated from operation of the resource recovery facilities. Used for improving the living environment in the affected areas, the fund receives 10% of the revenues from tipping charge collection (with an extra 10% on waste from the user districts), and contributions from the user districts. Under the Enforcement Decree to the Promotion of Installation of Waste Disposal Facilities and Assistance to Adjacent Areas Act, the proceeds from the fund are spent to subsidize heating bills, apartment management fees, medical expenses and other community welfare-related projects and services approved by the fund management committee.

According to the joint use agreement, Gangseo-gu and Yeongdeungpo-gu are to contribute KRW 21,000 per ton of waste discharged to the Yangcheon Resource Recovery Plant and subsidize the heating bills of 3,413 households residing within 300m of the facility. Ten percent of the revenue from tipping charge collection, including an extra 10% levied on waste from the user districts, goes toward the community

support fund, which ensures that residents get some of their living expenses subsidized, including heating bills and apartment management fees. Likewise, Mapo-gu received contributions from Jung-gu (KRW 6.6 billion) and Mapo-gu (KRW 4.8 billion), which are responsible for submitting 20% of the tipping charge to the Mapo Development Fund in return for sharing its resource recovery plant (Lee, 2000).

## 2.4. Challenges

The Mapo Resource Recovery Plant is the only one which was built under the joint use plan. The other three plants originally only served the district where they were located and struggled with low operating rates of 20~30%. To address this low rate of efficiency, making these plants available to neighboring districts was considered necessary in order to extend the life of the Sudokwon Landfill Site. Yet the city government's decision to increase waste management efficiency was met with strong resistance from residents who did not want any increase in the amount of waste treated at the facility in their district.

To settle this resistance, Seoul Metropolitan Government strove to find ways to encourage public support through over 320 public meetings, beginning in 2001. Relative city ordinances were revised twice to reflect discussions from talks with residents. According to the amendments made, residents who lived within 300 meters of the plants were to receive a discount of up to 70% on their electricity bill as a means of compensating for their inconvenience and discomfort. The tipping charge was lowered to prime cost to encourage cooperation among the authorities in the districts where the plants were located. As for the intake of waste from other districts, consultation would meet the requirements set out by the three parties, namely the SMG, district head and the citizens' council. Proceeds from the community support fund would be used to subsidize apartment management fees, medical costs and recreational facility use for residents in the region (SMG Resource Recovery Facility).

# Results

## 3.1. Output

### **1) Improved Operation Efficiency of Resource Recovery Facilities**

This partnership has effectively maximized the use of the facilities to meet demand. In addition to creating more opportunities for the respective districts, sharing four resource recovery facilities between 21 administrative districts within Seoul has led to a positive impact in reducing greenhouse gas emissions and replacing energy imports.

The method of waste treatment has undergone substantial changes. In order to manage the limited

national land efficiently, the government has widened the policy scope towards waste management and away from a heavy reliance on landfill. Consequently, the expected life of the Sudokwon Landfill Site has been extended.

Due to the increased sharing of incineration, the expected life of the Sudokwon Landfill Site has now been extended to 2044 (e2 news, 2010). The joint use system led to a huge improvement in the operating rates of the plants, jumping from 33% in 2006 to 82% in 2010. Moreover, surplus heat from the incineration process is also utilized as an alternative energy source.

|                                       | Yangcheon   | Nowon   | Gangnam  | Mapo  |
|---------------------------------------|---|---|--|---|
| Region                                | Southeast   | Northeast   | Southeast  | Northwest                                       |
| Capacity                              | 400 t/day<br>(200 t/day ×2<br>incinerators)       | 800 t/day<br>(400 t/day ×2<br>incinerators)                       | 900 t/day<br>(300 t/day ×3<br>incinerators)                          | 750 t/day<br>(250 t/day ×3<br>incinerators)     |
| Construction<br>Period                | 1992.12~1996.2                                    | 1992.12~1997.1  | 1994.12~2001.12  | 2001.12~2005.5                                  |
| Joint-use<br>Agreement<br>Date        | 2010.5.10   | 2007.6.30   | 2007.5.7   | 2009.2.10                                       |
| Site area (m <sup>2</sup> )           | 14,627  | 46,307  | 63,813   | 58,435  |
| Construction<br>Cost (KRW<br>million) | 31,815  | 74,279  | 101,080  | 171,166   |
| Sharing<br>Districts                  | Yangcheon-gu<br>Gangseo-gu<br>Yeongdeungpo-<br>gu | Nowon-gu<br>Jungnang-gu<br>Seongbuk-gu<br>Gangbuk-gu<br>Dobong-gu | Gangnam-gu<br>Seongdong-gu<br>Gwangjin-gu<br>Dongjak-gu<br>Seocho-gu | Mapo-gu<br>Yongsan-gu<br>Jung-gu<br>Seodamun-gu |



|                               | Yangcheon | Nowon         | Gangnam                  | Mapo      |
|-------------------------------|-----------|---------------|--------------------------|-----------|
|                               |           | Dongdaemun-gu | Songpa-gu<br>Gangdong-gu |           |
| Amount of Waste Burned (2005) | 131 t/day | 147 t/day     | 212 t/day                | 443 t/day |
| Amount of Waste Burned (2012) | 345 t/day | 614 t/day     | 835 t/day                | 635 t/day |
| Operating Rate (2005)         | 32.8%     | 18.5%         | 23.6%                    | 59.1%     |
| Operating Rate (2012)         | 86%       | 77%           | 93%                      | 85%       |

Figure 3 Joint Use Statistics

## 2) Economic and Environmental Benefits of Resource Recovery

Seoul's recovery facilities have burned 740,000 tons of solid municipal waste and recovered 1.76 million Gcals of environmentally-friendly energy. That is enough to provide heating for 200,000 households (approximately 15% of Seoul's apartments) for one year, assuming an annual heating figure of 9Gcal for each apartment.

Behind such remarkable improvement was the doubled recovery rate compared to that of 2006 (Energy Economic News, 2011). The recovered energy can also substitute oil imports that amount to KRW 104.1 billion every year. In addition, by recycling waste that would otherwise become landfill, 594,608 tons of CO<sub>2</sub> emissions are reduced annually.

### 3.2. Outcomes

#### **1) Reduction of Greenhouse Gas Emissions**

By employing an SCR catalyst system, Seoul's resource recovery plants have saved annual LNG costs of KRW 5.8 billion, thereby cutting the city's annual greenhouse gas emissions by 15,000 tCO<sub>2</sub>. Such accomplishment in reducing greenhouse gas emissions has gained wide praise, with the Nowon Resource Recovery Plant being formally recognized as 'a government agency which contributes to the reduction of greenhouse gas emissions' at ECO-EXPO KOREA 2013 (Voice of the People, 2013). Converting waste into energy to provide electricity and domestic heating replaces KRW 104.1 billion of energy imports every year and cuts 594,608 tCO<sub>2</sub> of greenhouse gas emissions. The four resource recovery plants in Seoul, employing SCR catalyst systems, save annual LNG costs of KRW 5.8 billion. The shortened travel distance from waste to treatment facilities is another contributor, reducing transport costs by KRW 5 billion every year (Energy Economic News, 2011).

#### **2) Increasing Public Awareness of Waste Treatment Facilities**

The Yangcheon Green Environment Education Center focuses on Seoul's environmental policies such as contemporary waste-to-energy facilities, air pollution management, car-sharing services and a future waste management system called Dust Bot. It also offers hands-on learning experiences to help people understand the facility's waste treatment process, as well as running a variety of educational programs to foster a better understanding of the environment and the resource recovery facility itself (Seoul Times, 2012). The SMG runs a citizen-monitored system and supports citizens' councils to resolve public distrust, while making continuous investments in community facilities. As a consequence, there has been a remarkable change in understanding and trust on the part of the public. In addition to employing personnel to monitor fraudulent activities, honorary citizen monitors were also appointed. They were educated in ways to help guide citizens toward adapting to the new method of waste disposal.

## Lessons Learned

#### **1) Overcoming NIMBY ("Not in my backyard") through Community Support**

Regarding the installation or joint use of resource recovery plants, the SMG showed sufficient capacity to facilitate agreement among residents, and promoted ways to engage them by arranging a civic council and citizen monitors. In addition, a community support fund was established for community improvement, and residents' needs were promptly reflected through communication with community representatives. All this hard work resulted in increased local trust and awareness of the benefits of resource recovery facilities.

## **2) Improving Maintenance and Operation**

As to overcoming public distrust in the authorities' ability to provide safe services, openness turned out to be the key. Presenting data on facility operations, stipulating and reflecting residents' requests, and establishing a resident-monitored system were all conducive to building a climate of trust. In order to overcome persistent negative associations with resource recovery plants and possible disruption to residents, the city still needed to make further investment in facilities such as anti-pollution systems, green space, and exterior design.

## **3) Circular Economy via Waste-to-Energy Initiatives**

Unlike regular incinerators, resource recovery plants utilize surplus heat from the combustion of waste at a temperature between 850°C and 1100°C to provide heating in the region. Waste-to-energy initiatives are Seoul's way of paving the path to a circular economy. Seoul's experience has proven to the world that retrieving energy from waste can not only substitute reliance on fossil fuels and landfill, but can also become a source of revenue.