

# Policy and technology status regarding Waste-to-Energy and the role of MBT in Korea

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## Abstract

The Ministry of Environment has established 'Comprehensive Master plan for Waste to-Energy' in response to high oil prices, greenhouse gas reduction, and control of ocean dumping of liquid organic waste. The goal of waste control policy has always been the safe and sanitary disposal of wastes; from now on, however, it will include the recovery of energy as well as the safe disposal of wastes. Specifically, energy recovery shall be promoted with 33,376 tons/day of combustible wastes for landfill and liquid organic wastes dumped into the ocean to achieve the 31% goal by 2012 and 100% goal by 2020. Likewise, 57 facilities shall be built including MBT facilities, RDF power plants, biogasification facilities, and power plants for 31% energy recovery by 2012. To carry out these measures, approximately USD 2.16 billion needs to be invested; thus generating economic benefits of USD 877 million per year beginning 2012, creating 17,000 jobs, and enabling Korea to respond to international treaties related to climate change.

## Keywords

Waste-to-Energy, Combustible wastes, Organic wastes, MBT, Biogasification, Energy recovery, Power plant

## 1 Background for Promotion

With the global consumption of resources and energy expanding due to the increase in economic activities, which in turn caused the increase in fossil fuel use and rise of BRICs, the whole world suffers from the environmental crisis involving resources such as the rapid rise in oil prices and climate change. Moreover, with international oil prices starting to swing upward rapidly beginning the latter half of 2007, we have been in the era of excessively high oil prices (exceeding USD 100 per barrel and continuing to increase since the start of 2008).

Table 1 Change in Oil Prices by Year

Year	'02	'03	'04	'05	'06	'07	'08	'09 (as of Mar. 6)
Unit cost (USD/barrel)	23.88	26.8	33.77	49.37	61.55	68.43	95.08	43.04

Note) Source: yearbook on energy statistics by the Korea Petroleum Association (based on Dubai oil)

Korea is the 10th biggest energy consuming nation in the world, importing 97% of energy. Therefore, developing plans for easing the dependence on import for energy by expanding the manufacture and spread of new & renewable energy that can serve as substitute for primary energy sources such as petroleum and coal is a matter of urgency. As of 2006, the ratio of gross domestic primary energy to new & renewable energy is only 2.24%. With the government working to increase the diffusion rate of new & renewable energy to 4% by 2012, Waste-to-Energy is emerging as the most efficient method for the diffusion and spread of new & renewable energy. This is because 76% of new & renewable energy output uses wastes. Its unit cost of production is also cheap (up to 10% of solar energy, 66% of wind energy).

Waste-to-Energy is emerging as a potent solution to climate change as well as excessively high oil prices due to the substitution effect for fossil fuel and high 'Global warming potential' (21 times carbon dioxide) of methane gas (biogas). Recently, international efforts to reduce greenhouse gas emissions have intensified through Waste-to-Energy including refuse derived fuel (RDF) from combustible wastes and biogasification of organic wastes. In the case of Korea, its greenhouse gas reduction obligations are expected to be fulfilled beginning 2013 with the ratification of the 'Kyoto Protocol (1997)'. Domestic carbon dioxide emission stood at 591 million tons as of 2005, increasing at an average annual rate of 4.7% since 1990; thus making Korea no. 1 among OECD nations.

In addition, according to the 'London Convention-1996 Protocol' that took effect in March 2006, reinforced control of ocean dumping is required worldwide. In the case of Korea, organic wastes including food wastewater generated in the process of food waste recycling, sewage, and wastewater sludge and animal excreta dumped into the ocean amount to about 20,000 tons/day (in 2006). For the conservation of the ocean environment and safety of marine products, dumping of sewage sludge and animal excreta into the ocean shall be prohibited beginning January 2012, and that of food wastewater, beginning January 2013; hence the urgency of measures for shifting to land disposal. Note, however, that the landfill processing of these wastes gives rise to problems of landfill safety and odor (bad smell). On the other hand, incinerating these wastes causes air pollution due to dioxin and incurs high disposal cost. Therefore, the productive disposal of new & renewable energy for greenhouse gas reduction through the biogasification of organic waste should be explored as an alternative land disposal method to landfill and incineration.

Amid the increasing interest in global warming and national energy security, EU presented a 'Greenpaper' on energy security in 2000. It prepared a roadmap aimed at further spreading new & renewable energy from 6.5% in 2005 to 12% in 2010. It also defined organic wastes including food wastes, animal excreta, and sewage sludge and

wood as 'Biomass' and pushed for their energy recovery while prohibiting the direct landfill of wastes whose energy recovery is possible through 'Landfill Directive '99'. Germany developed the world's first technology for separation and selection, producing more than 3 million tons of RDF from 5~6 million of combustible wastes using the best technology as applied to power plants exclusive for RDF and thermal power plants. In addition, it operates 3,700 individual farmhouse-type biogasification facilities using organic wastes. Japan has also promoted the construction of 'Biomass Town' together with the 'New Biomass-Nippon Comprehensive Strategy' in 2006 while actively promoting Waste-to-Energy by replacing small and medium-sized incinerators generating large amounts of dioxin with 57 MBT facilities and 5 RDF power plants since 2007. Since the development and spread of alternative energy in response to the depletion of fossil fuel and global warming are considered an urgent matter, wastes are regarded as new resources and used as in the case of developed countries. For the conversion of waste management systems for sustainable development and creation of Zero waste society in particular, Waste-to-Energy has recently been used as a useful policy means of addressing the complex challenges emerging in the present age such as the environment, economy, and global warming.

## 2 Current Status and Problems of Waste-to-Energy in Korea

A total of 5.23 million TOE of new & renewable energy was produced in Korea in 2006, with waste energy making up about 4 million TOE (including waste gases). The production of waste recovery energy excluding waste gases (including biogas) stands at 2.44 million TOE, accounting for 1% of primary energy and 61% of new & renewable energy. This is the amount that is mainly recovered from the remaining heat in the incineration facilities for solid wastes or waste landfill gas that cannot be regarded as the result of the active implementation of the Waste-to-Energy policy by the government.

Table 2 Current Status of Recovery and Use of Residual Heat in Incineration

Capacity of Facilities (tons/day)	Generation of Residual Heat (Gcal/year)	Uses of Residual Heat (Gcal/year)		
		Total	Power Generation	Heat Supply, Etc.
12,468	5,521,278	4,891,184	Subtotal: 1,133,708 Sales: 238,707 Own use: 895,001	Subtotal: 3,757,476 District heating: 2,133,360 Residents' support: 8,085 Benefit facilities: 42,377 Own use: 1,573,653

Table 3 Current Status of Recovery and Use of Waste Landfill Gases

Classification	Power Generation		Gas Supply	
	Places	Capacity (MW)	Places	Capacity (m <sup>3</sup> /day)
Total	11	80.83	4	917,280
Metropolitan areas	1	59.88(74%)	1	662,000(72%)
Non-metropolitan areas	10	20.95(26%)	3	255,280(28%)

Therefore, for more positive Waste-to-Energy, business fields including RDF production using combustible wastes as well as exclusive power generation, power supply, and refining use through the biogasification of organic wastes should be activated. As of 2007, however, only the MBT facility in Wonjoo City and 34 leading private RPF manufacturing facilities (37,000 tons/year) are being operated in the field of waste solid fuel and some MBT facilities and RDF power plants are being constructed. Biogasification using food wastes, sewage sludge, and animal excreta is carried out in part in the livestock wastewater treatment plant in Pajoo, Kyunggido, a landfill in Saenggok, Busan City, and some sewage treatment plants in Dongraegu, Busan City and Nam-gu, Ulsan City. The scale of facilities and business profiles leave a lot to be desired, however.

The low level of Waste-to-Energy in Korea can be attributed to the passive response of the government to energy recovery even as it has promoted a waste control policy centering on material recycling. As of 2006, the 83.6% waste recycling rate increased by 50% compared to 1996. In contrast, the landfill rate decreased to one-fifth due to the implementation of separate collection and application of Extended Producer Responsibility (EPR). Moreover, since the support of national treasury was concentrated on waste recycling and expansion of incineration and landfill fields, the budget for energy recovery was dismally small. The Ministry of Knowledge Economy, which is in charge of the development and spread of new & renewable energy, mainly supported the solar, wind power, small hydropower, and geothermal fields; general political and financial support for the waste field was sorely lacking, i.e., insufficient support for the development difference (the fixed rate is not set, and the floating rate is set low). In addition, the technology for the RDF from combustible waste in the field of energy recovery technology is currently being tested. In contrast, the biogasification technology for organic wastes is in the establishment and operation stages (first stage) at the pilot plant and is small in scale compared to developed countries. Thus, the conditions of the private market can be said to be very poor. Problems related to distrust in the waste solid fuel (RDF, RPF) quality, unstable market, and low supply unit cost also hinder the activation of private markets. The biogasification of organic wastes is another factor, considering

the excessive initial investment costs and uncertainty of success. The activation of recovery of residual heat in incineration is also restricted due to the absence of supply standards and remarkably low supply costs.

### 3 Promotion plan

#### 3.1 Promotion Goals

The Ministry of Environment established the 'Comprehensive Masterplan for Waste-to-Energy ('08~'12)' as a method for economic revitalization and in response to climate change. These measures have set the capacity for energy recovery to 12.18 million tons/year of combustible wastes for direct landfill and organic wastes dumped into the ocean (food wastewater, sewage and wastewater sludge, and animal excreta) among the generated wastes by 2020. They also target energy recovery of 3.8 million tons/year by 2012, focusing on public and general wastes whose actual energy recovery is possible. At the same time, a promotion goal for the recovery and use of 1.28 million Gcal/year of residual heat in incineration and 308,160 m<sup>3</sup>/day of landfill gases has been set. Note that these levels are deemed effective in terms of scale and economic efficiency.

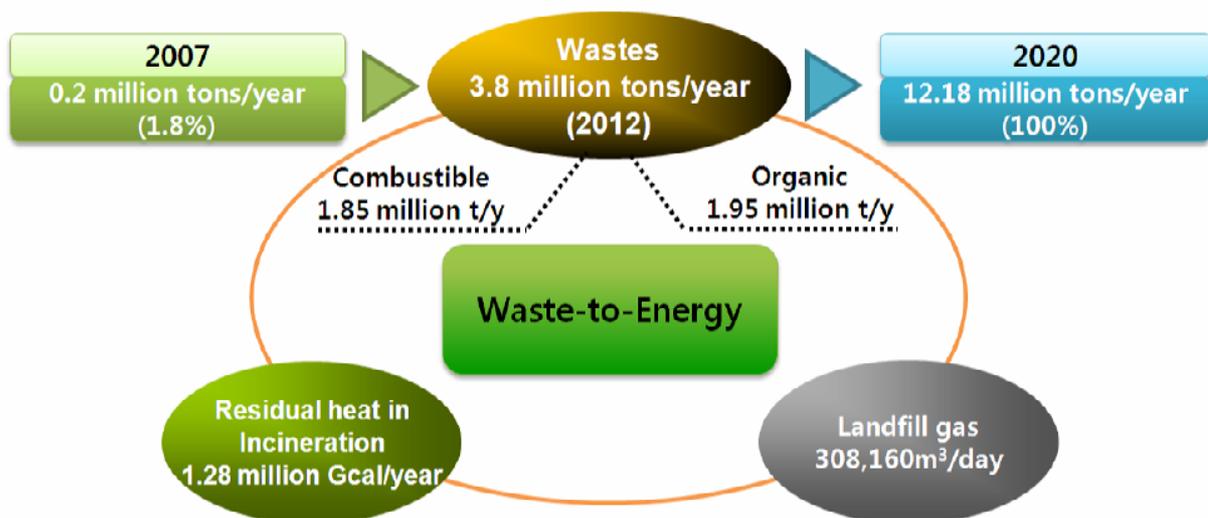


Figure 1 Promotion Goals

## **3.2 Promotion Contents**

### **3.2.1 Laying down the Foundation for Waste-to-Energy Promotion**

To support the effectiveness of these comprehensive measures and ensure smooth promotion, a 'Practice Plan for Comprehensive Master plan' was prepared on the end of 2008. It is expected to prevent waste factors in the national budget in advance by examining the appropriateness and economic efficiency by business field in detail and arrange the facilities expansion project by examining the actual demand related to the 'Waste-to-Energy project' by the local government in this practice plan. Discussion and settlement among local governments shall aim at the regionalization and concentration of energy recovery facilities and improvement of the system for the activation of Waste-to-Energy. An expert forum shall also be organized and operated; administration partnerships of city, county, and Gu shall be forged. A conference between the people and the government as well as policy tie-ups of the relevant authorities are also planned, thereby laying down the foundation for consultation on policy and technology, cooperation among local governments, collection of residents' opinion, and cooperation among the relevant authorities in the initial year (2008) based on the promotion of Waste-to-Energy.

For the political and systematic aspects of Waste-to-Energy, Waste-to-Energy facilities shall be expanded and converted instead of phased reduction and removal of the national treasury support as required for the establishment of landfills and incineration facilities of local governments. Fixed statutes for the reinforcement of waste landfill standards, imposition of landfill allotment, restriction on the establishment of simple incineration facilities, recovery of waste energy, and resetting of RDF quality standards shall also be pursued until 2010. Such will induce Waste-to-Energy actively by pre-examining waste solid fuel (RDF, RPF) use in the area of clean fuel use and through the acknowledgement of RDF (Fluff Type) that was not generated.

The side effects of individual facilities that are in disarray shall also be resolved, and economies of scale, ensured by promoting the regionalization and concentration of Waste-to-Energy facilities. The function of the market economy shall be stabilized and activated through the balance between supply and demand and by guaranteeing a reasonable supply unit cost. In addition, RDF markets shall be maximized through constant discussions with the Ministry of Knowledge Economy and by making efforts to set the fixed rate, increase the floating rate of RDF generation electricity, and actualize the supply unit cost of residual heat in incineration. Knowledge promotion will also be carried out among the people to establish a case of promoting the Waste-to-Energy policy in response to the high oil prices and climate change.

### 3.2.2 Promotion of Technology Development and Activation of the CDM Project

The Ministry of Environment started the 'Eco-Star Project Promotion Agency' in December 2007; it is planning to improve the technology level of Waste-to-Energy in Korea to the commercial scale of developed countries. This project will be promoted by 2014, aims at ensuring economically efficient, eco-friendly resources and activating the CDM project as well as promoting technology development in 14 fields including the use of fuel from combustible/organic wastes and biogasification technology by building organic connections and conducting joint research among industries, academe, institutes, people, and government. The Eco-Star Project will be linked and promoted together with the 'Comprehensive Master plan for Waste-to-Energy' being carried out to conform to the environment policy and ensure energy efficiency and environmental safety.

Meanwhile, the CDM project has been rapidly expanding worldwide (as of March 2009, 1,423 cases have been registered) since the Kyoto Protocol took effect in February 2005; 23 cases are registered, with 36 cases at validation in Korea. In particular, 2 cases are registered in the wastes field, and 10 cases are at validation. During the promotion of these Comprehensive Masterplan, the CDM project shall be actively supported through cooperation with local governments and affiliated organizations on the recovery of landfill gases, biogasification of organic wastes, RDF manufacture from combustible wastes, and recovery project for the residual heat in incineration.

### 3.2.3 Expansion Plan for Waste-to-Energy Facilities ('08~'12)

For the Waste-to-Energy of 3.38 million tons/year (9,260 tons /day) of public and general wastes by 2012, a total of 57 facilities (14,190 tons/day) including MBT facilities for combustible wastes and RDF power plants, facilities for the drying and solid recovered fuel of sewage sludge, biogasification facilities merging food wastewater and organic waste, and power plants shall be expanded.

Table 4 Expansion Plan According to the Waste-to-Energy Facilities

Classification		Total		Town		Individual		
Total (places)		14,190	(57)	7,180	(16)	7,010	(41)	
Facilities	MBT	5,840	(20)	2,400	(4)	3,440	(16)	
	Power plants	2,800	(10)	1,400	(4)	1,400	(6)	
	Organic	Use for fuel from sludge	1,280	(4)	1,000	(1)	280	(3)
		Biogasification of food wastewater	2,690	(11)	1,820	(4)	870	(7)
		Cogenerated gas	1,580	(12)	560	(3)	1,020	(9)

Note) One of the facilities is established as combination gasification facilities merging food wastewater in towns (total of 4 facilities).

On the other hand, for the 420,000 tons/year of wastes generated in the private sector, the establishment of MBT facilities with capacity of 370 tons/day and facilities for the drying and solid recovered fuel of wastewater sludge with capacity of 1,070 tons/day shall be pursued and bankrolled by a national treasury loan.

Moreover, support for the establishment of recovery facilities for landfill gases is planned to recover 214 m<sup>3</sup>/min (530,000 Gcal/year) of landfill gases from the 27 waste landfills in local governments. The development of 6 large-scale landfills (over 10N m<sup>3</sup>/min) shall be promoted as a development project, and 21 medium-scale landfills (over 2N m<sup>3</sup>/min), as an economic project. Such measure is expected to contribute to the early stabilization of landfills as well as recovery facilitation of landfill gases by promoting the Bioreactor Project with 14 medium-sized/large landfills. Moreover, a total of 1.28 million Gcal/year of residual heat in incineration including 630,000 Gcal/year from 42 general waste incineration facilities through the new establishment of or support for repair project for facilities for the recovery of residual heat by local governments are expected including 645,000 Gcal/year through the national treasury support for facilities for residual recovery in 27 private incineration facilities for industrial wastes.

Similarly, in establishing and operating facilities for Waste-to-Energy and MBT from combustible wastes, the biogasification for organic wastes and power plants should be integrated, connected, and clustered to enhance economic efficiency. A 'Environment-Energy Town' shall be constructed by sphere for such purpose. The Environment-Energy town construction project shall be promoted after dividing the entire country into 10 areas. Wide-area general waste landfills of local governments will be preferentially selected in the town site, and metropolitan area landfills in the middle region will be improved for the Environment-Energy town. For the remaining 9 areas, locations shall be provisionally selected through demand analysis by local governments; they shall be decided on and finally promoted through business public subscription, feasibility analysis, collection of residents' opinion, and consulting with the relevant local governments. On the other hand, facilities (ca. 5,780 tons/day) that can convert 4,748 tons/day of wastes into energy will be constructed in the town to treat approximately 50% of the total materials in the facilities expansion plan. Moreover, supply and demand relationships among small area-type individual MBT facilities in areas will be created through the establishment and operation of power plants in each town by area.

## 4 Requirements for Facilities Investment and Expected Effect

### 4.1 Requirements for Facilities Investment

Facilities investment of about USD 2.16 billion is required to recover energy from 3.8 million tons/year of organic and combustible wastes, 1.28 million Gcal/year of residual heat in incineration, and 308,160m<sup>3</sup>/day of landfill gases by 2012. Among these, the investment costs for facilities requiring national treasury support and loan are pegged at USD 658 million; private investments in the establishment of RDF and biogas power plants are estimated at USD 856 million.

Table 5 Estimation of Investment Need by Financing

Total (unit : USD million)	National Treasury (subtotal: 658)		Local Treasury	Investment by Public Enterprises	Private Investment
	Issued	Guaranteed			
2,161 (100%)	593 (27.4%)	65 (3%)	630 (29.2%)	17 (0.8%)	856 (39.6%)

Note) The basis of the calculation above is the present issue system for national expenditure. Note, however, that investment requirement by financing including national expenditure, local treasury, investment by public enterprises, and private investment can vary according to conditions such as the financial situation of the nation and local governments, conditions for business promotion, and private markets in the process of promotion of comprehensive measures.

In the business field, USD 877 million (40.6%) are expected to be required for the establishment of a Environment-Energy town, and USD 741 million (34.3%), for the RDF manufacture and power plant project for combustible wastes. Investment requirements by year are relatively small at USD 24 million (1.1%) in the initial year (2008) and USD 138 million (6.4%) in 2009. Note, however, that the required construction expenses for facilities establishment from 2010 to 2012 when the feasibility analysis and basic practice design are completed and establishment is commenced are expected to be equal to the average yearly income of USD 667 million.

Table 6 Estimation of Investment Requirement by Business

Total (USD million)	Establishment of Environ- ment Energy Town	Combustible Waste MBT, RDF power plant, etc	Organic Waste Biogasifica- tion, etc.	Recovery of Residual Heat	Technology Development, etc.
2,161 (100%)	877 (40.6%)	741 (34.3%)	324 (15.0%)	117 (5.4%)	102 (4.7%)

Table 7 Estimated Investment Requirement by Year

Total (USD million)	2008	2009	2010	2011	2012
2,161(100%)	24(1.1%)	138(6.4%)	536(24.8%)	851(39.4%)	612(28.3%)

## 4.2 Expected Effect

When all energy recovery facilities are completed and operated by 2012, a total of USD 892 million in annual economic effects including the reduction of cost of waste disposal is expected. Note that converting the petroleum substitution effect into the electricity output of energy in life yields 2,817GW per year or capacity average of 0.94 million for use by households in the city or 7.24 million Gcal when used for district heating (amount used by 460,000 households).

Table 8 Economic Effect of Waste-to-Energy

Total (USD million)	Reduction of Cost of Waste Disposal	Effect of Using Alterna- tive Fuel	Greenhouse Gas Reduction Effect
892	572	287	33
	Incineration/Landfill dis- posal cost	(petroleum: 4.92 million barrels)	(3.8 million tons CO <sub>2</sub> )

On the other hand, 17,000 jobs are expected to be created based on the employment effect resulting from the establishment and operation of Waste-to-Energy facilities in terms of the social aspect. In terms of the environmental aspect, the durability of landfills can be enhanced by up to 2.5~13 times as the amount of waste for landfill decreases to less than 20% of the current volume. The environmental load also decreases due to the reduction in leachate production. In addition, the establishment and operation of Waste-to-Energy facilities will help solve international problems such as fulfilling the obligation to reduce greenhouse gas emissions beginning 2013 and enable Korea to respond effectively to London Convention-1996 Protocol, which requires more reinforced control of ocean dumping.

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