4-2-1 The basic energy plan for sewerage works of Tokyo “Smart plan 2014”

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Abstract: Sewerage works of Tokyo consumes 9.8 hundred million kWh annually, which is approx. 1.1% of total power consumption in Tokyo, 86.0 billion kWh. Moreover, energy consumption is predicted to increase as sewerage system service improves. In addition to expand the use of renewable energy, it is necessary to promote energy saving of each process and of entire system. The Bureau of sewerage, Tokyo Metropolitan Government should contribute to the reduction of the total energy consumption as well as reduction of GHGs emissions. Therefore, the Bureau made the basic plan for sewerage works of Tokyo “Smart plan 2014”, which is the first master plan to enhance energy efficiency and promote energy management. The Bureau aims to expand the amount of renewable energy and energy saving to more than 20% of total energy consumption within 10 years. For example, renewable energies such as much as solar power and power generation with the heat of the incinerators are further utilized and obtain as possible energy. Sludge thickeners and dehydrators of energy-saving type are installed and further energy saving equipment is devised. Also the Bureau will introduce the self-sustaining incinerator to save the energy of sludge treatment.

Keywords: energy measures plan; renewable energy; energy saving; self-sustaining incinerator

Introduction

Tokyo sewerage system is an important urban infrastructure which supports the lives of 13 million living people and urban activities. The Bureau of Sewerage, Tokyo Metropolitan Government (the Bureau) manages sewers with the total length of approx. 16,000 kilo-meters in 23 wards area and Tama area as well as an enormous number of facilities including 20 wastewater treatment plants (WWTPs) and 86 pumping stations. It contributes to the improvement of living environment, prevention of floods, and water quality conservation of public water bodies. In order to provide those high-quality sewerage services, the Bureau uses a huge amount of energy. It is about 9.8 hundred million kWh electricity, which is more than 1% of the annual electricity consumption of Tokyo (Approx. 86.0 billion kWh), and about 20 million m³ fuels in city gas equivalent. They are respectively equivalent to the electricity consumption of about 270,000 general households and the city gas consumption of about 52,000 households.

The Bureau is one of the biggest energy consumer and has a great responsibility in reducing energy consumption. In reconstructing facilities and equipment, we have actively worked on the utilization of renewable energy and energy conservation efforts to enhance energy efficiency.

Due to the Great East Japan Earthquake on March 11, 2011, power plants suffered damage from the tsunami-disaster and we were forced to respond to planned blackouts and restriction on electricity use during the summer. In addition, the confusion of distribution network and the stagnation of fuel supply posed an obstacle to securing of electricity in an emergency. Moreover, the shutdown of nuclear power plants caused a major increase in electricity charges and affected the sewerage
management. Facing on these difficulties, we are pressed to make a major shift in its energy policy.

On the other hand, it will be necessary to actively advance the efforts including enhancement of flood control, improvement of combined sewer system (CSO) and introduction of advanced wastewater treatment. Therefore, the energy consumption is expected to increase with the implementation of those projects.

Furthermore, in the Tokyo Olympic and Paralympic Games 2020, the Bureau needs to actively advance preventive measures against road subsidence due to aged sewers, further improvement of water quality in public water bodies, and response to heavy rain during summer time, etc.

In light of these circumstances, the Bureau has to actively advance the utilization of renewable energy, the energy-saving efforts in individual facilities and equipment, the comprehensive operational management in the whole plant from water treatment to sludge treatment and the energy management from broad-based perspective to reduce energy consumption. Additionally, we also need to work on an enhancement of crisis management for sewerage functions to cope with emergencies.

In order to ensure the implementation of these efforts and stable supply of sewerage services, the Bureau decided to plan, a basic energy plan, “Smart plan 2014”.

**Energy Use of Sewerage works**

(1) Current Situation of Energy Use

The sewerage works uses the energy in the 3 facilities mainly shown Figure 1.

![Figure 1](energy_use_tosw.png)

**Figure 1** Energy use of Tokyo sewerage works in FY2013

(2) Electricity and Fuel Use

The sewerage works uses a great volume of fuel (city gas, etc.) as well as electricity. The annual energy consumption with electricity and fuel combined is 4,620 TJ (Tera-joule) as shown in the figure 2. We have to reduce the whole energy, both electricity and fuel.
(3) Increase in Energy Consumption
Promoting flood measures and improvement of CSO increases the amount of rainwater pumped in heavy rain and the amount of wastewater to be treated, especially dirty wastewater at the early period of rainfall, which increases the energy consumption. Furthermore, the expansion in the introduction of advanced wastewater treatment, which improves the effluent quality, also needs additional facilities and increases the energy consumption. In order to respond to the energy consumption increased by these efforts to improve sewerage services, we need to continue the energy reduction measures and introduce new measures.

**Strategy of Smart Plan 2014**
Based on the current situation and issues of energy use for the sewerage works, the following four effort policies are to advance the energy use and optimize the energy management.

(1) Expansion of renewable energy utilization
The Bureau will make further use of renewable energy, such as solar power generation (Figure 3) and new power generation with the heat of the incinerators, to secure energy by ourselves as much as possible in the sewerage works.

(2) Further promotion of energy saving
By development/introduction of new advanced wastewater treatment technologies and Self-sustaining incineration system, etc., the Bureau will promote energy conservation further to reduce energy consumption.

(3) Optimization of energy through the treatment process of the whole facility
The Bureau will introduce energy smart management to optimize energy use through the treatment process from wastewater treatment to sludge treatment in the whole facilities and to improve the efficiency of operational management between several facilities from a broader perspective.

(4) Improvement of energy crisis management
By expanding emergency power-generation facility, introducing dispersed power system and passing fuels between facilities to operate the emergency power-generation facility, the Bureau will enhance energy crisis management to maintain sewerage functions at any time.
Goal of Smart plan 2014

In order to ensure the implementation of efforts set forth in Smart plan 2014, the Bureau will work on to accomplish the goal, planning period and the idea of energy reduction.

(1) Target Value

The Bureau aims to expand the amount of renewable energy and energy saving to more than 20% of total energy consumption by FY2024 (Figure 4).

(2) Planned Period

From FY2014 to FY2024

(3) Actions of Energy Reduction

The energy used in the sewerage works is expected to be increased by the promotion of projects such as flood measures and improvement of CSO. Therefore, it is important in sewerage management to work on the expansion of renewable energy use, further promotion of energy saving and to reduce the volume of purchasing energy.

In this plan, the total energy consumption should be the volume of purchasing energy plus the volume of renewable energy and saving energy. The idea of energy reduction is to increase the ratio of renewable energy and saving energy to the total energy consumption.

Total energy consumption in the future and efforts on renewable energy, etc.

The total energy consumption in FY2013 was 4,620TJ and, among the volume, the renewable energy volume was 230TJ (the ratio is 5% to the total energy consumption). In the future as well, the Bureau will work on the improvement in sewerage services, including the enhancement in the level of flood measures and the improvement of CSO. The volume of purchase energy is expected to increase to 4,930TJ in FY2024.

Therefore, we will work on the expansion of renewable energy use and the further promotion of saving energy and, as in the table, based on the reference year FY2013, we will reduce the purchase energy in FY2024 to 4,060TJ (3,620+440), aiming to make the ratio of renewable energy, etc. to the total energy consumption to be more than 20% (Figure 5).

Main Efforts in the Future: Renewable Energy, etc.

In addition to the expansion of renewable energy efforts including solar power generation and the utilization of thermal energy of sewerage, which have been implemented so far, the Bureau will further utilize usable energy with new power generation using the low temperature waste heat at the time of incinerating unused sludge, etc. By these new measures, the volume of renewable energy will be expanded in FY2024 to 350TJ. And then, the volume of saving energy will be expanded in FY2024 to 750TJ by introducing the new advanced wastewater treatment technology and the development/introduction of self-sustaining incinerator, etc (Table 1).
Figure 5 Change the energy consumption of Tokyo sewerage works in the future

Table 1 Main measures for renewable energy (left) and energy saving (right)

<table>
<thead>
<tr>
<th>measures</th>
<th>renewable energy (TJ)</th>
<th>saving energy (TJ)</th>
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</thead>
<tbody>
<tr>
<td>Solar power generator</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Power generation from low temperature heat</td>
<td>9</td>
<td>-</td>
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<tr>
<td>of incinerator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-sustaining incinerator</td>
<td>41</td>
<td>-</td>
</tr>
<tr>
<td>Wastewater heat</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>Solar heat</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Sludge drying by waste heat of incinerator</td>
<td>43</td>
<td>-</td>
</tr>
<tr>
<td>Micro hydraulic power generator</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sludge carbonization furnace</td>
<td>-</td>
<td>60</td>
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<tr>
<td>Power generation by digest gas</td>
<td>-</td>
<td>82</td>
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<tr>
<td>Waste heat recovery steam generator</td>
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<tr>
<td>amount</td>
<td>120</td>
<td>230</td>
</tr>
<tr>
<td>amount</td>
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</tr>
</tbody>
</table>

Representative Examples of Our Efforts

Specific examples of efforts in this plan are shown in the following.

(1) Development/introduction of self-sustaining incineration system (Figure 6)

The Bureau developed the energy self-sustaining incineration system which generates electricity from emitted heat and dewatered sludge. In addition, we developed new dehydrator which enables to produce super low water content sludge. By the system which is a combination of these, fuel and electricity are unnecessary. Moreover, GHGs emissions from sludge incineration can be reduced in approx. 50%. This system will be introduced in 2019 at Shingashi-WWTP.
(2) Introduction of semi-advanced wastewater treatment system (Figure 7)

Effluent quality (T-N and T-P) by semi-advanced wastewater treatment system is slightly poorer than the advanced (A2O-method). But, this system can be implemented in short time by modifying the existing structures. It has been introduced in accordance with the reconstructing.

Energy consumption of semi-advanced system is also equivalent to the normal activated sludge process.

(3) Energy management by the whole facility in WWTPs

The Bureau uses effectively the energy of sludge from wastewater treatment to reduce the volume of fuel by sludge treatment facility. In addition, we promote improvement of operation method and technical development to reduce the energy of the whole facilities even if the energy of the wastewater treatment is increased.
(4) Introduction of dual fuel type power generator (Figure 8)

In preparation for the traffic disruption caused by the earthquake, the Bureau introduced a power generator with a combination of kerosene and city gas. It was introduced in 2016 at Nakagawa-WWTP, and in the future it will plan to expand the introduction.

![Image of dual fuel type power generator](Figure 8)

**Conclusion**

By advancing various efforts set forth in this plan, the ratio became over 9% as of the end of FY2015, and seems able to achieve the target value 20% by 2024. On the other hand, it is required to reduce GHGs emissions. The Bureau has already planned a global warming prevention plan in the sewerage works "Earth plan 2010" in 2010, aiming to reduce the volume of GHGs emissions to more than 25% from FY2000 by FY2020. As Measures of Smart plan 2014 also lead to reduce GHGs emissions, we will enhance our efforts to achieve both plans.

In having Tokyo Olympic and Paralympic games 2020, the Bureau should contribute to advanced urban environment. Furthermore, we will not only promote energy management but also drive further development to accomplish Smart plan 2014.

**Reference**