2007 Prize of Director General of Agency for Natural Resources and Energy

Reduction of fuel consumption by tuning sewage sludge combustion furnaces

Arakawa Left Bank South Branch, Saitama Sewage Corporation
Arakawa Water Circulation Center, Sewage for Arakawa Left Bank South Basin, Saitama

◎ **Keywords: Rationalization of fuel combustion**

◎ Outline of Theme

Arakawa Water Circulation Center is one of the four biggest sewage treatment plants in Japan, which treats sludge (capacity: 935,000m^3/day) discharged from 6 cities in the watershed of South Saitama. Reducing fuel consumed by the sludge combustion furnaces in this treatment plant and promoting energy conservation will significantly contribute to reducing pressure to the global environment.
This document reports the result of energy conservation activities.
Saitama Sewage Corporation concurrently makes efforts such as obtaining ISO 14001 (certified on March 3, 2000) and 310 challenge plan (cost reduction plan, 2005 - 2007) to boost up promotion of energy conservation.

◎ Implementation Period for the said Example

- Planning period — May, 2005 - August, 2005 (total 5 months)
- Implementation period — October, 2005 - March, 2007 (total 18 months)
- Effect verification period — November, 2005 - July, 2007 (total 21 months, ongoing)

◎ Outline of the Business Establishment

- Business description: Terminal treatment plant of watershed sewage (type 1 designated energy management factory)
- Number of employees: Prefecture and corporation staff: 28, contractor staff: 115, total 143
- Annual energy use: City gas 5,249,638m^3, crude oil equivalent 6,230KL (record in 2004)

◎ Process Flow of Target Facility

The treatment process of the sludge combustion furnaces in the target facility is as shown in (Fig. 1).

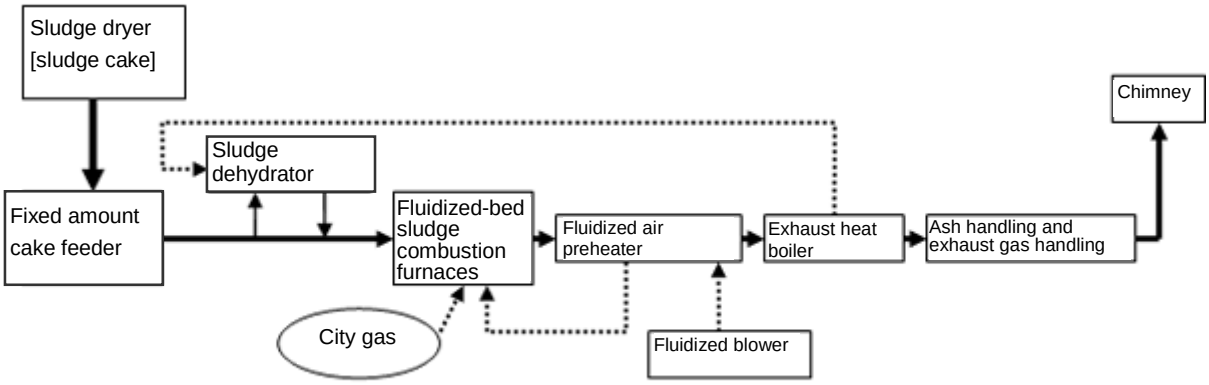


Fig. 1 Flow chart of the target equipment

1. Reasons for Theme Selection

Arakawa Water Circulation Center is specified as type1 designated energy management factory by the Energy Conservation Law, and consumes 19,195 KL of electricity and 6,294 KL of heat (crude oil equivalent) annually.

Most city gas consumed in this center is consumed by the sludge combustion furnaces.

The fuel consumption intensity (Table-1) is decreased 1% compared to the previous fiscal year, but the energy efficiency of the sludge combustion furnaces installed in this center is not very good compared to sludge combustion furnaces installed in other water circulation centers in Saitama Prefecture. However, we set fuel reduction plan in “Environment Management Program” according to ISO 14001 to work on energy conservation activities and achieved the result to be described. That is why we chose this case.

Table-1 Fuel consumption and intensity

	FY 2002	FY 2003	FY 2004
Fuel consumption (m^3/year)	5,235,872	5,410,633	5,249,638
Amount of sludge cake (t/year)	166,636	174,836	172,494
Intensity (m^3/t)	31.4	30.9	30.4

2. Understanding and Analysis of Current Situation

(1) Understanding of current situation

Every day, 450 t of sludge cake (moisture content 80%) is produced during the process of sewage treatment, all of which is treated by the fluidized-bed sludge combustion furnaces.
In this center, four sludge combustion furnaces that can treat 200 t/day are installed.
First and Second combustion furnaces have sludge driers (two driers/furnace). However, because this center is in near in a residential zone, we had decreased sludge drier use by half in consideration of diffusion of reek.
Third and Fourth combustion furnaces are direct input system without sludge dehydrating equipment as an anti-reek measure.
Normally, three of these four combustion furnaces are operated.

(2) Analysis of current situation

To deploy energy conservation activities on sludge combustion furnaces, it was necessary to resolve the following issues:

[1] Good water quality must be maintained without adverse effects to water treatment facilities.

[2] Sludge cake is produced about 450t/day, so when three sludge combustion furnaces are operated, one of them must be operated intermittently, which makes the intensity worse.

[3] Sludge driers installed in first and second sludge combustion furnaces cause odor.

[4] With only one sludge drier operated, self-driving combustion operation was not enabled.

3. Progress of Activities

(1) Implementation Structure

The energy management frame work in Arakawa Water Circulation Center is as shown in (Fig. 2).

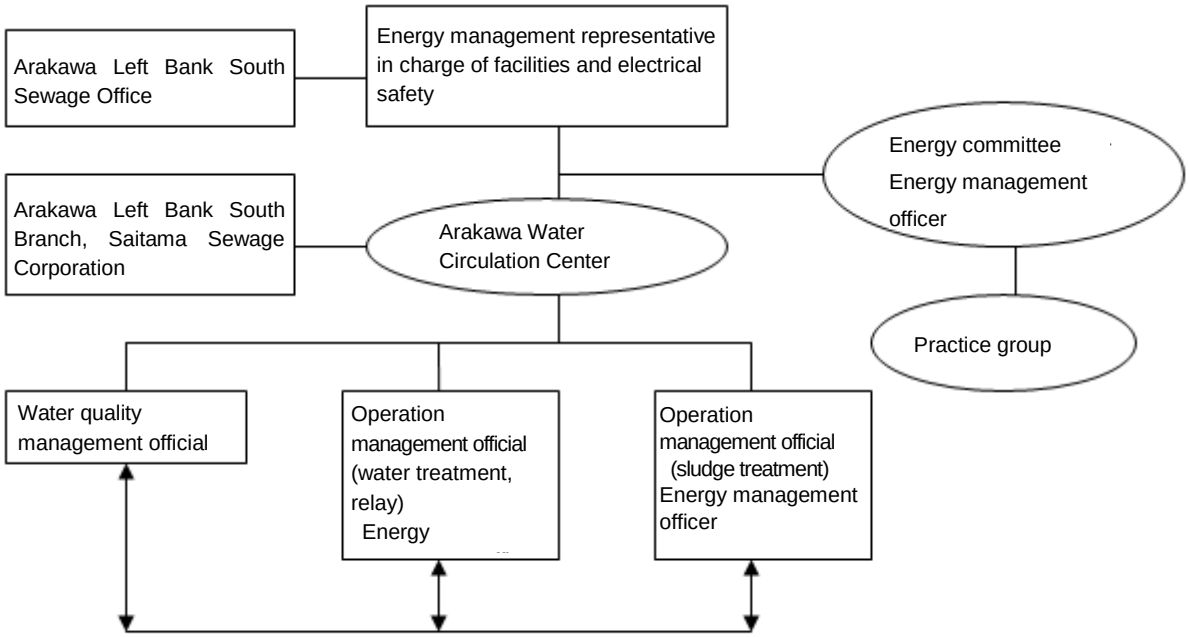


Fig. 2 Organization chart of energy management

(2) Target settings

When the energy conservation activity was started, it was very difficult to estimate how much could be reduced. Therefore, we set the goad to reduce 1% or more compared to the previous fiscal year based on the evaluation criteria of the Energy Conservation Law.

[1] Goal in FY 2005: To reduce 1% or more compared to the previous fiscal year. (intensity 30.4m3/t => 30.0m3/t)

[2] Goal in FY 2006: To reduce 1% or more compared to the previous fiscal year. (intensity 30.0m3/t => 29.7m3/t)

(3) Identification of problems and investigation result

To fully promote energy conservation activity from 2005, we identified and reviewed problems as follows:

[1] To reduce number of times of intermittent operation of 3rd combustion furnace and improve intensity

Third combustion furnace is operated intermittently, so its temperature frequently rises and drops; a lot of fuel is consumed especially when temperature rises. Therefore, we retained sludge cake in the emergency sludge cake storage tanks (500m^3 x 4 tanks) to store the

amount of sludge cake so that the furnace can be operated continuously and made a research of reducing intensity.

[2] To identify location of reek leakage of the sludge driers in first and second sludge combustion furnaces

To prevent generation of reek, we identified the location of reek leakage of the sludge driers

[3] To improve intensity by operating two sludge driers

By suppressing reek, we operated two sludge driers in first and second combustion furnaces instead of one unit operation and researched the decrease of intensity.

As a result of review, by utilizing emergency sludge cake storage tanks, we made continuous operation time of third combustion furnace longer and improved intensity.

We found that when two sludge driers of each of first and second combustion furnaces are operated, the moisture content of the sludge cake decreased and self-driving combustion operation was available in these furnaces.

Then, we identified locations that generate reek from sludge driers, which is a problem for peripheral residents, including reek ducts, access holes, and casing joints.

Self-driving combustion operation means an operation status where the treated sludge cake itself serves as fuel and no city gas is used at all. This operation status can significantly reduce fuel consumption and can significantly reduce intensity.

4. Solving the Problem

(1) Reek suppression measures

To suppress reek, the following measures were implemented:

[1] Clean and check reek ducts to recover deodorizing performance.

[2] Increase air tightness by using heat-resistant silicon packing to the access holes of the sludge driers etc., which leak reek.

[3] In dried cake transfer conveyer, reek leaked from the casing joints, so we used air-tight packing to the joints and we performed caulking after assembly to increase the air tightness.

[4] Enclosed the sludge driers with fire-retardant boards to prevent diffusion of reek.

[5] For the reek within the enclosure, we installed new reek fan and duct to lead the reek to fluid air of the third and fourth sludge combustion furnaces to perform combustion deodorization.

(2) Measures to maintain self-driving combustion operation

We enforced measures to maintain self-driving combustion operation in the first and second combustion furnaces. (Fig. 3)

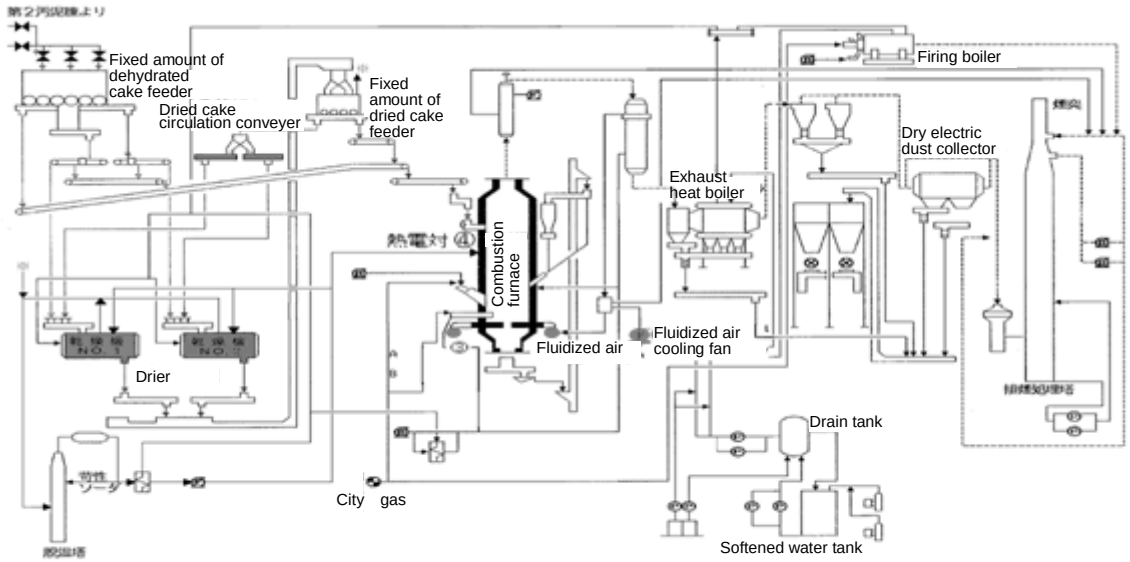


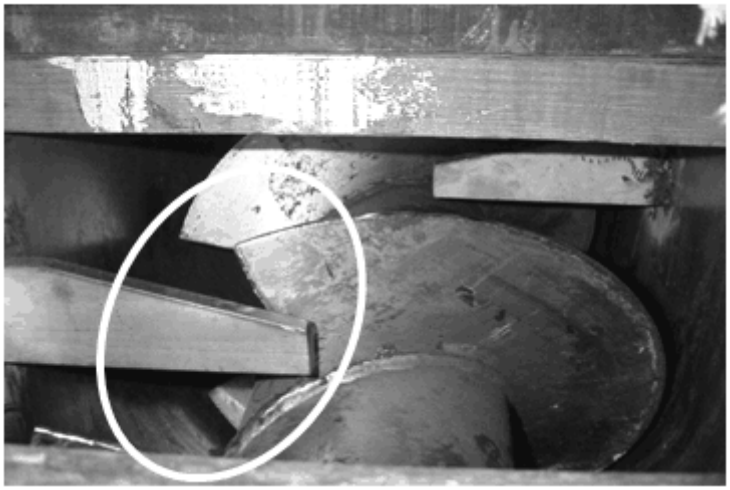
Fig. 3 Flow chart of the first and second sludge combustion furnaces

1) Prevent adhesion of dried cake to the dried cake circulation conveyer

The reason why self-driving combustion operation could not maintained was that not enough dried cake is supplied into the sludge drier and not enough circulation cake is returned to the drier.

Because dried cake adheres to the screw blades of the uniaxial type screw conveyer in the dried cake circulation line, so the adhered dried cake was removed manually during operation. Therefore, we installed scratcher and baffle plates on the existing conveyer. (Photo-1) As a result, adhesion of dried cake was prevented and checking became safer and easier. By this improvement, the input of circulation cake into the sludge driers increased.

Photo-1 Measure on the conveyer



2) Increase sludge cake input to the sludge drier

Maximum design capacity of the sludge driers is 2.0t/hr. However, sludge cake is input 1.0 - 1.5t/hr and the amount of produced dried cake is not enough, so self-driving combustion could not be maintained.

Because the moisture content of sludge cake is high (80%), sludge cake adhered to the paddle blades in the sludge driers and prevented heat exchange, which lead to inefficient drying process. As a countermeasure against this, we increased the amount of circulation of dried cake to suppress adhesion of sludge cake to the paddle blades. Combined with the measure on the conveyer described above, we succeeded to input the design capacity of the sludge driers, 2.0t/hr.

3) Change of fluid air volume

Fluid air is supplied from fluid blower via fluid air preheaterand distribution pipes to the sand layer of the combustion furnaces. As a result of investigation, we found that the air volume is too large that the sludge cake was burned out on the sand layer and heat was not efficiently transferred to the free boards of the combustion furnaces.

As a countermeasure against this, we changed the fluid air volume from constant 9,500 m^3/hr to 8,500 - 9,000m^3/hr to retain optimal combustion status.

4) Effect of temperature on the thermocouples

Self-driving combustion operation requires freeboard temperature of 830℃ or higher, sand layer temperature of 730℃ or higher, and gas flow rate 35m^3/hr or less for five minutes. However, the freeboard temperature did not become 830℃ or higher. Therefore, the

position of the two thermocouples was rotated 90 degrees and the temperature in the furnace was checked. As a result, we found that the air from the reek duct (for combustion deodorization of sludge drier), whose temperature is low (about 100℃) had an impact on the thermocouples and the temperature of the freeboard was not accurately measured.
As a countermeasure against this, we reconnected the reek duct and unused secondary combustion air duct so that the air does not affect on the thermocouples. As a result, appropriate temperature control became available.

5) Change of operation conditions of fluid air cooling fan

Fluid air cooling fan is designed to start operation, to prevent furnace temperature from rising, when self-driving combustion is detected. When this fan is operated, fluid air is cooled and the temperature in the furnace is lowered more than necessary, making a condition for self-driving combustion hard to maintain.
As a countermeasure against this, we changed the condition of operation order of fluid air cooling fan from detection of self-driving combustion to detection of furnace temperature (furnace temperature 870℃ - 850℃).

5. Effects of Countermeasures and Cost-Benefit Performance

(1) Trend of self-deriving combustion operation

Self-driving combustion operation rate of the second sludge combustion furnace (Fig. 4) was initially 9%, but as a result of the measure, it improved to 97%.
Fuel consumption (Fig. 5), which was initially 71,000m^3/month, was decreased to 2,000m^3/month; intensity was also decreased from 12.4m^3/t to 0.3m^3/t.

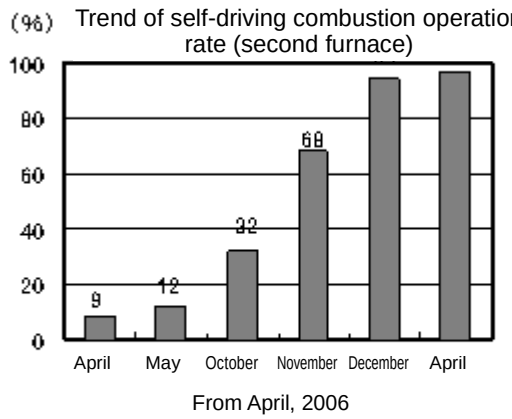


Fig. 4 Trend of self-driving combustion operation rate

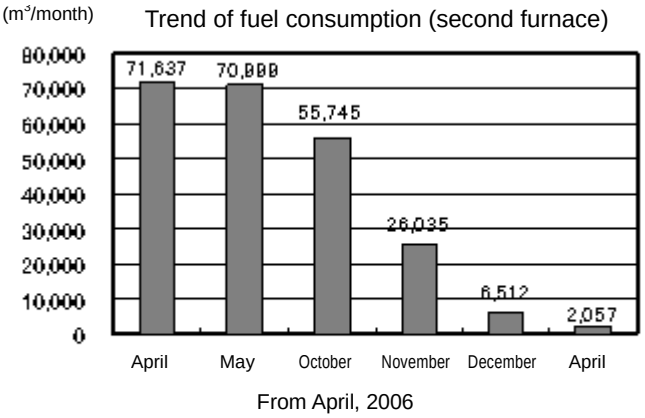


Fig. 5 Trend of fuel consumption

(2) Energy conservation and cost performance

Energy conservation volume in fiscal years 2005 and 2006 compared to 2004 are shown in table-2.

Table-2 Energy conservation

	Fuel consumption (m^3/year)	Fuel conservation (m^3/year)	Crude oil equivalent (KL/year)	CO2 reduction (t CO2/ year)
FY 2004 (base)	5,249,638			
FY 2005	4,422,865	826,773	981	1,924
FY 2006	4,058,987	1,190,651	1,382	2,711
Total		2,017,424	2,363	4,635

Fuel conservation was 2,017,424m^3 during the two years. Using the current unit price 54 yen/m^3, it is equivalent to about 180 million yen. The cost for modifying the facility to suppress reek and maintain self-driving combustion operation was about 160 million yen, which is expected to be recovered in three years.

This is 2,363KL of crude oil equivalent in two years and represents type2 designated energy management factory by the Energy Conservation Law (1,500KL - 3,000KL).

We also reduced 4,635t-CO2 emission in two years and contributed to solve global warming problem.

The intensity (Fig. 6) of the overall sludge combustion furnaces is 26.0m^3/t in FY2005 (decreased 14% compared to FY2004) and 23.2m^3/t in FY 2006 (decreased 23% compared to FY2004), which significantly exceeded the goal. The value for 2007 is a target value.

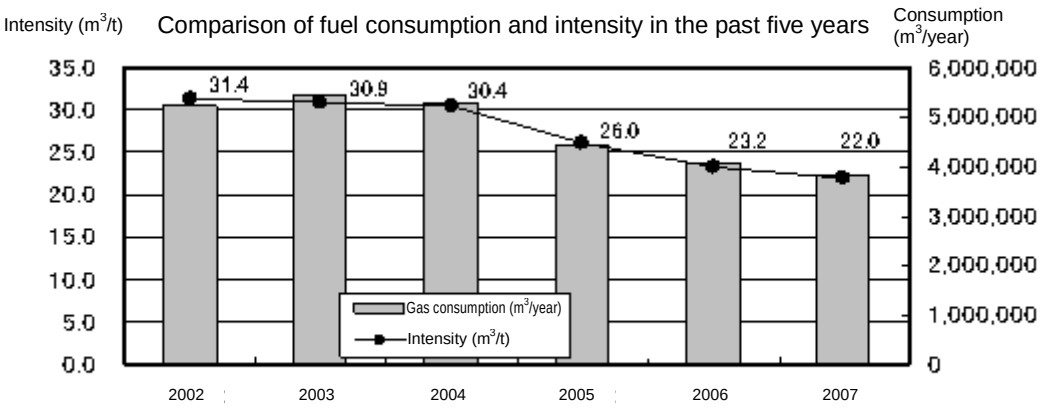


Fig. 6 Comparison of fuel consumption and intensity

(3) Suppression of dinitrogen monoxide

Sewage emits a lot of greenhouse gases during the course of its treatment. Among them, dinitrogen monoxide that is generated during the sludge combustion treatment process has great greenhouse effect, so urgent effort to reduce emission is required. Ministry of Land,

Infrastructure, Transport and Tourism actively promotes advanced sludge combustion (combustion temperature 850℃ or higher), so we verified reduction of dinitrogen monoxide by advanced sludge combustion.

As a result of verification of sludge combustion furnace operation (Fig. 7), monthly average temperature of the furnace kept 854℃ while maintaining self-driving combustion operation and concentration of dinitrogen monoxide in the exhaust gas decreased from 70ppm to 18ppm.

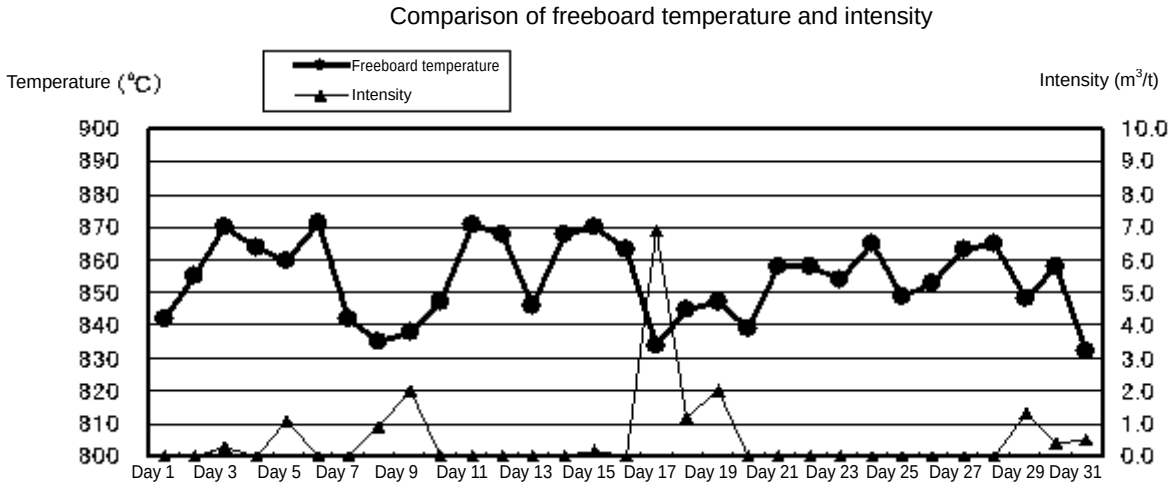


Fig. 7 Comparison of freeboard temperature and intensity

6. Summary

As a result of this energy conservation activity, significant reduction (city gas 2 million m^3 and CO2 emission 4,600t-CO2) was achieved by maintaining self-driving combustion operation. We could contribute to prevention of global warming, as well as the viewpoint of cost reduction.

As measures to prevent diffusion of reek, installation and improvement of reek duct etc. required investment, but it is expected to be recovered in a short period of time. Along with problem consciousness of staff was raised, the effect of environmental measure was extremely high.

7. Future Plans

Because there is confluence, the properties of sludge cake changes due to flow of dirt when it rains in Arakawa Water Circulation Center. Therefore, combustion may become difficult in the combustion furnaces sometimes. In the future, we would like further to investigate heat

value and moisture content etc. of sludge cake to establish appropriate operation of sludge combustion furnaces.

In addition, we also would like to review energy conservation of direct input type third and fourth sludge combustion furnaces.

The Sewage Corporation continues to aim for improvement of maintenance and management technologies, proactively conduct investigative researches, and promote further energy conservation.