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Biogas business strategy of OSAKA GAS

~Development of "Compact Biogas Production System"~

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Background

Biomass potential in Japan

Use of biomass has been promoted. In Japan, energy suppliers are required to promote renewable energy use by laws. Biogas is one of the most synergetic renewable energy for gas companies. So Osaka gas has been developing biogas related technologies.

According to the data in 2012[1)], there is about 35 million tons of carbon in Japan. The detail is shown in Fig.1. Japanese government set a goal of increasing the amount of biomass use to 26million tons of carbon by 2020. In point of energy use, 11million of biomass is set as a goal. This amount is about 10 Gm^3N/year as 45 MJ/m^3N city gas (natural gas).

In Fig.1, among these biomass, domestic animal waste and sewage have big potentials, but many of them are already used for composting and biogas. Woody biomass has also a big potential and partly used for materials and power generation. However food waste which includes in municipal solid waste and industrial waste, is hardly used. It is needed to be recycled by laws.

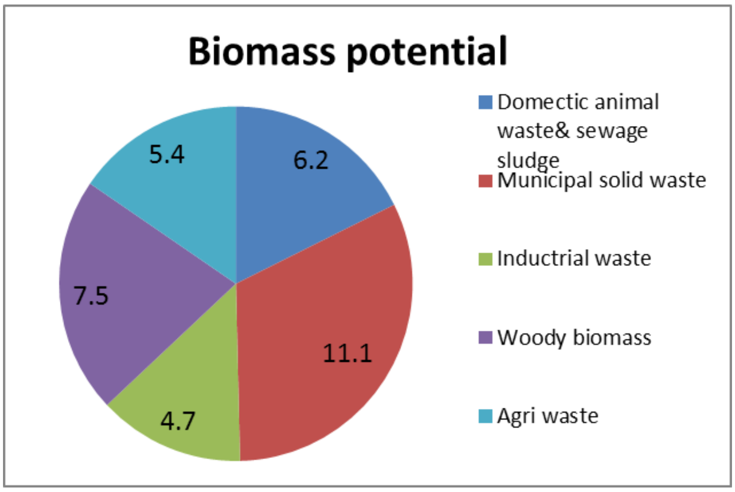

Fig.1 Biomass potential in Japan [million ton of carbon].

Biogas business strategy of OSAKA GAS

As our past approach to increase biogas use, we have developed technologies how to utilize biogas. Our developed main technologies are listed below.

- Purification: desulfurization and siloxane removal
- Gas storage: adsorption tank with activated carbon
- Utilization: biogas boiler and biogas engine

However, it is not enough only to utilize biogas. So we started developing biogas production technologies. We have been developing three biogas production technologies, such as methane fermentation using the hyper-thermophilic hydrolysis, UASB (upflow anaerobic sludge blanket) and the compact biogas production system. Through installing these technologies, we are aiming to spread the production and the use of biogas.

The hyper-thermophilic hydrolysis process is the combined system of hydrolysis at 80 degree-Celsius and the high temperature (55 degree-Celsius) methane fermentation. This system enables degradation of persistent organism and increase of biogas production. And the high disposal cost of the methane fermentation residue which is the main problem to enhance the installation of methane fermentation is decreased. Additionally, ammonia which is one of the main inhibitors in methane fermentation is vaporized in the hyper-themophilic tank because of high temperature[2)].

UASB is also one of biogas production technologies. It is able to use for the treatment of wastewater. Wastewater is treated in a reactor filled by granule of anaerobic bacteria and its degradation speed is much faster than conventional technologies. UASB technologies are widely used in the factories which are technically easy to install, and so we have been developing the system to spread UASB use. We has succeeded in establish the biogas production system from the soap factory's effluent which had been thought to be difficult to apply UASB treatment because of its high salinity and high alkaline[2)].

Although there are many small scale facilities which means the amount of discharged garbage is small, installing the methane fermentation system to them is economically difficult. We have been developing the new technology which is economically efficient for small scale facilities. The detail is below.

We established the technologies to make the biogas quality suit to all of standards (table 1) and has started to inject biogas into our pipeline. In case the location of the supply and the demand of biogas is far away, it is difficult to use biogas. In such case, it works on to transport the excess biogas from the supply site to the demand site through existing gas pipeline. In Japan, most of the city gas is imported as LNG and originally includes very less amount of impurities, so very strict standard is decided. Therefore, in order to inject biogas into the city gas grid, standards showed in Table 1 should be abided.

Table 1 Osaka Gas's standards for injection into city gas grid.

Component	CO_2 (vol%)	H_2S (mg/m^{3}N)	O_2 (vol%)	Calorie (MJ/m^{3}N)	Odrant (mg/m^{3}N)
Standards	<0.5	<1.0	<0.01	44.2-46.0	12-16

Biogas Production system for small scale facilities

We developed the new-type biogas production system for small scale facilities for that popular systems are difficult to be installed. Although the amount of generated biogas is small, it is efficiently used with the combination with city gas. In this paper, we introduce this system's development.

Food waste and garbage are needed to be recycled. However, biogas production is not so popular compared to fertilizer and livestock feed in Japan. One reason is that the popular biogas production system is economically inefficient for small amount of garbage. The existing biogas production system is designed on the assumption that it will be processing probably more than 10 ton/day of garbage. Also, there isn't enough space to install a popular biogas production system in small scale facilities. Additionally, in biogas production (methane fermentation), treatment of digested fluid is needed. Because the small scale facilities don't have enough capacity effluent treatment, the high disposal cost of digested fluid is a big problem.

Fig.2 shows the distribution of number of customers for each garbage discharge. The number of customers whose discharges are less than 1 ton/day (=365 ton/year) are majority. Additionally there are 300 general merchandise stores, which discharge approximately 1ton/day, in Kansai area (including Osaka, Kyoto and so on). However, almost all garbage discharged from small scale facilities is incinerated. Therefore, to spread biogas use, compact biogas production system is expected to be developed.

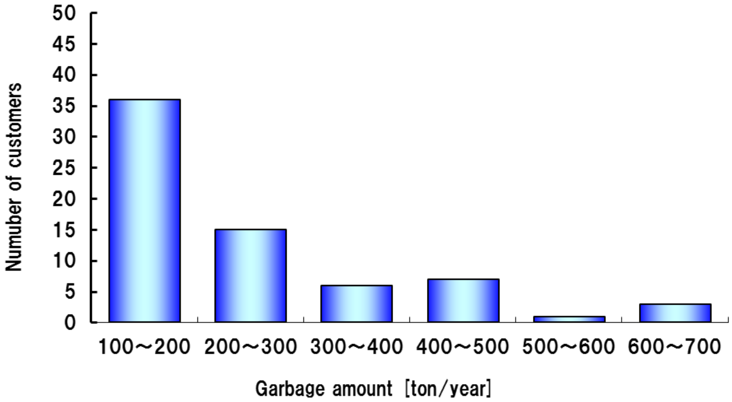

Fig.2 Distribution of number of customers for each garbage discharge in A-city.

Aim

With the aim of increase of biogas use in small scale facilities, we have been developing the compact biogas production system to digest below 1 ton/day garbage. Through mixed combustion of generated biogas and city gas using at the combined heat and power (CHP) system, generated electricity and heat can be used on site. So installing this developed system has the following advantages respectively.

- Customers: cost reduction of garbage treatment, and utilize renewable energy
- Gas company: spread city gas use (including fuel switch)

Methods&Results

3.1. Challenges of Compact Biogas System

In developing the compact biogas production system, there were problems to be solved as follows.

- Initial cost: cost reduction of commensurate with small scale
- Running cost: reduction of operating cost such as electric power for liquid transfer pumps
- Treatment of digested fluid: high cost of effluent treatment

To solve the problems, we incorporate the design of septic tank which stably treats wastewater without transfer pumps. Through this design, biogas production system is made in the septic tank factory. So it's initial cost becomes lower than on-site construction type.

As shown in Fig.3, this biogas production system is compact and integrating an anaerobic tank (anaerobic digesting) and an aerobic tank (effluent treating). Several tanks are provided in this system, and each tank is partitioned simply by wall boards. This system uses no transfer pump since solid and liquid of garbage are transferred from tank to tank basically by combination of sedimentating separation and overflows. Consequently, unlike the conventional biogas systems, the individual tanks in the compact biogas production system require no control systems of water in each tank levels and pumps. So we successfully reduced initial and running costs.

Additionally, sedimented garbage blocks effluent of anaerobic sludge in the separation tank. As integrating an aerobic tank, treated water including digested fluid from the anaerobic digesting tank is drained into sewage after purified. So the disposal cost of digested fluid isn't needed.

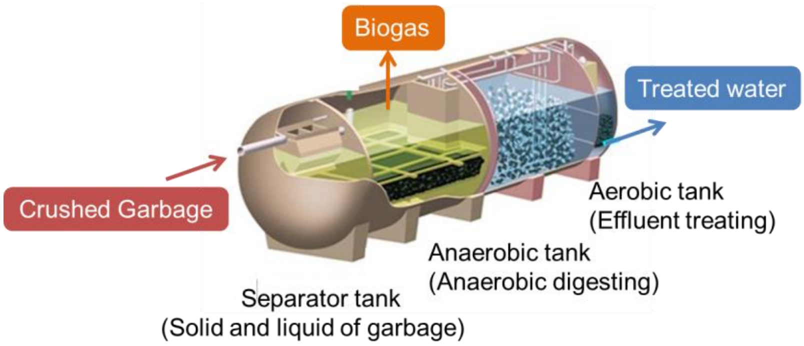

Fig.3 Figure of compact biogas production system

In small scale facilities, the amount of generated biogas is small and varying in volume and quality. Therefore as shown in Fig.4, heat and power can be generated efficiently through mixed combustion of biogas and city gas. Some generated heat and power are used for the system's consumption, and the excess of them are used in the system installation site.

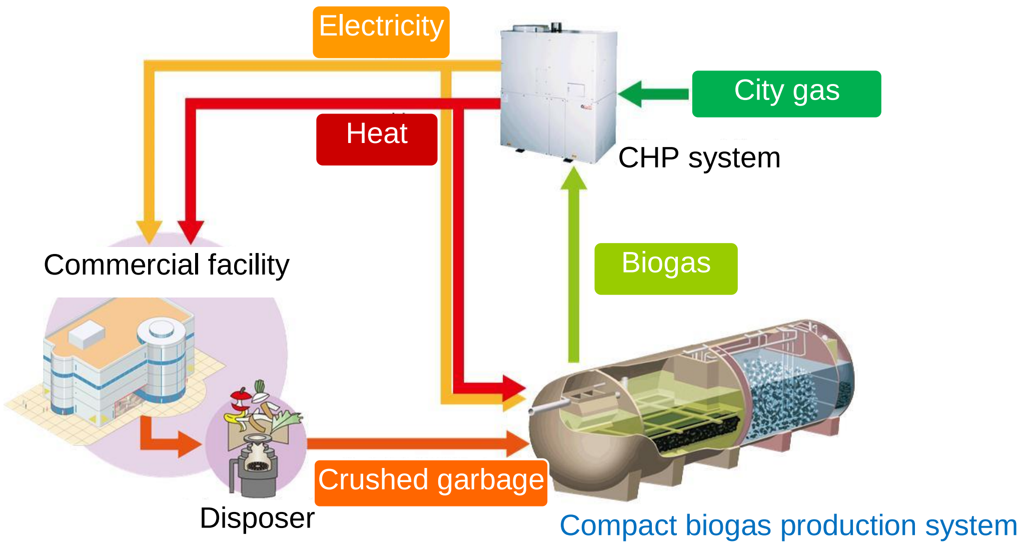

Fig.4 Production and utilization of biogas from garbage on-site.

3.2. Structure of "Compact Biogas Production System"

The individual tanks of the compact biogas production system feature the following functions and flow process, as shown in Fig.5

1) Reservoir: Receives crushed garbage.

   The reservoir allows impurities (bones, shell, etc.) contained in crushed garbage to sink and settle.

2) Separator: Separates crushed garbage into solid and liquid.

   The solid parts in the crushed garbage sink and settle in the lower part of the separator by sedimentation separation. The lower part of the tank has a slit led to the anaerobic digester. This tank has two parts.

   - The sedimented garbage blocks effluent of anaerobic sludge.

- Upward blown biogas transfers a certain amount of the solid parts of the garbage into the anaerobic digester. Meanwhile, the liquid parts are transferred from the upper part of the separator to the effluent treating tank.

3) Anaerobic digester: Converts the solid parts of garbage into biogas.

The anaerobic digester anaerobically converts the solid parts of the garbage into biogas at 55 degree-Celsius.

4) Effluent treatment tank:

The effluent treatment tank clarifies the effluent (liquid parts of garbage) from the separator by aeration and settling. Excess sludge produced through aeration is returned to the reservoir, mixed with the solid part of the garbage, and transferred to the anaerobic digester.

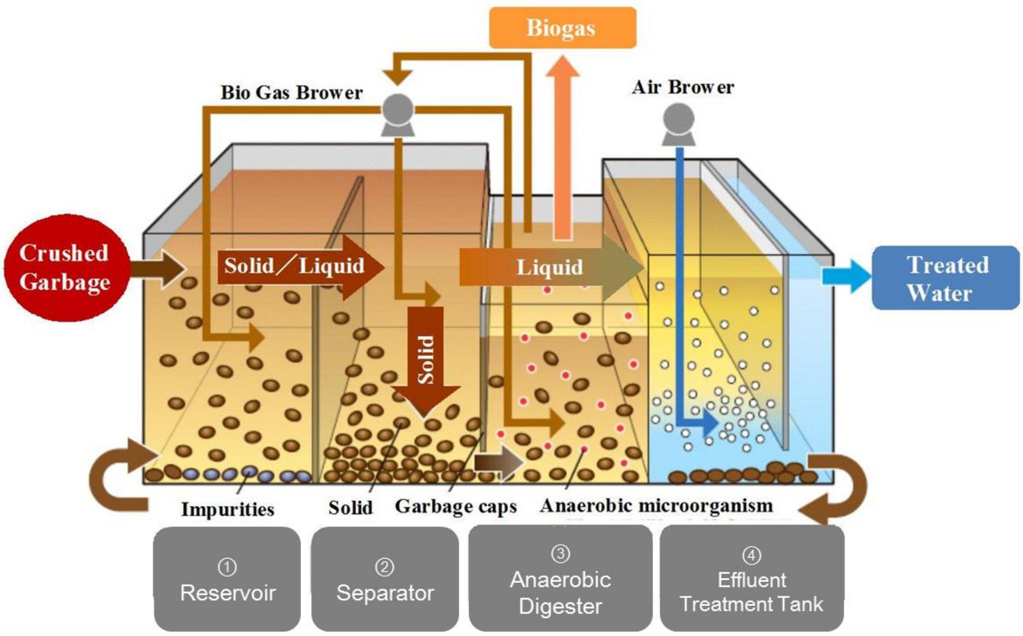

Fig.5 Flow chart of compact biogas production system.

3.3 Environmental Assessment

We compared greenhouse gas (GHG) emission in following three cases: 1) Using compact biogas production system (developed system), 2) Outsourced incineration, and 3) Outsourced compositing. Following contents were calculated for GHG emission. In one instance, GHG emission in the case of 50 kg/d garbage treatment (Fig.6) is shown in Fig.7.

1) Developed system: energy use of this system's consumption (CO_2, if more than the amount of biogas energy), heat and power generated from biogas (as a reduction of GHG), effluent treatment (N_2O) and incineration of excess sludge (N_2O).
2) Outsourced incineration: transportation(CO_2) and incineration (N_2O)
3) Outsourced compositing: transportation(CO_2), composting (CH_4 and N_2O) and reduction of manufactured chemical fertilizers (as a reduction of GHG)

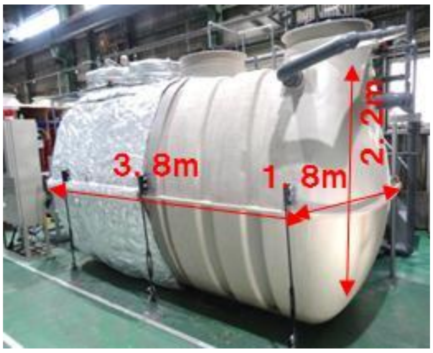

Fig.6 50kg model demonstrator

Additionally, CO_2 produced by methane fermentation, effluent treatment, incineration of garbage and compositing of garbage isn't calculated as a carbon-neutral gas. Following number are used to calculate GHG emission.

- Produced biogas rate is 71 L/kg-garbage (20% solids content equivalent) [3].
- The amount of heat and electricity daily used by the system (Fig.6) are 17.3 kWh/d and 12.2 kWh/d respectively[3].
- Generation and exhaust heat recovery efficiencies are 34% and 51% respectively.

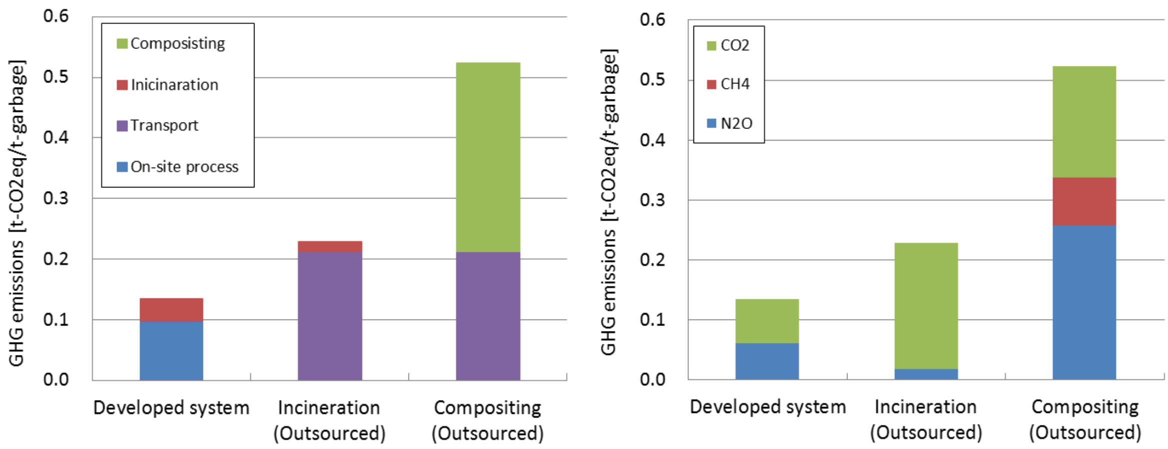

Fig.7 Greenhouse gas (GHG) emission in the case of treating 50kg/d garbage.

(Left: each process, Right: each GHG).

Compared three cases, using compact biogas production system was demonstrated to be the best process which can reduce GHG emission. However in this 50kg/d-type, the amount of produced biogas is less than that of energy consumption. So this development in ongoing to improve and verify the result. Additionally, we are also developing 400kg/d-type system which improves the energy balance.

Conclusions

We developed new-type biogas production system for small scale facilities for that popular system is difficult to be installed because there are no economically suitable equipment to apply for small scale facilities. In particular, we solved the problem including economical efficiency, space and treatment of digested fluid by incorporating the design of septic tank and combination of biogas production and effluent treatment. Generated biogas can be used efficiently by the mixed combustion with city gas. Additionally, installing this developed system was shown to contribute reduction of Greenhouse gas emission from outsourced incineration or compositing.

References

1) 4th biomass utilization promotion conference (Japanese-only): http://www.maff.go.jp/j/biomass/suisinkaigi/04/index.html

2) S. Osumi et al., "Development of innovative technologies for biogas production and purification", *25th World Gas Conference*, Kuala Lumpur, 2012.

3) M. Nakamoto et al., "Development of "Compact biogas system" to Generate Biogas from Garbage On-site", *International Gas Union Research Conference*, Copenhagen, 2014