2005 Prize of the Chairman of ECCJ

Energy Conservation by Improving Chilling System and Introducing Gas Engine Cogeneration System

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Kyoto Brewery
Engineering Division

◎ **Keywords: Rationalization of cooling and heat transfer (Heating equipment, etc.) Rationalization of conversion to heat motive power (Cogeneration equipment)**

◎ Outline of Theme

This brewery, aiming to be an environmentally harmonious energy conservation factory (eco-brewery), has been actively promoting the energy conservation activities and, as far as CO_2 emission is concerned, it already achieved 17% reduction from 1990 level. From among the activities the brewery implemented, we, as identified, would like to report the improvement of the chilling system and the introduction of the gas engine cogeneration system which created a great effect in the energy conservation of electricity. As regards the improvement of the chilling system, we reduced the chilling electricity by dividing the chilling systems according to the temperature necessary for the load to efficiently make cold source. As regards the introduction of gas engine cogeneration system, we realized the energy conservation by reducing the electricity loss by using the high-efficiency private generation and by using the exhaust heat discharged by the power generation.

◎ Implementation Period of the Said Example

January 1998 – July 2005 Total 91 months

- Project Planning Period January 1998 – September 2003 Total of 69 months
- Measures Implementation Period October 1998 – November 2004 Total of 83 months
- Measures Effect Verification Period January 1999 – July 2005 Total of 79 months

◎ Outline of the Business Establishment

- Items Produced Beer, sparkling liquor, liqueurs, other alcoholic beverages [2]
- No. of Employees 369 (including people from cooperating companies)
- Annual Energy Usage Amount (Actual results for fiscal year 2004)

Heavy oil	519.2 kL
City gas	7,451,970 Nm^3
Electricity	27,792,099 kWh

◎ Process Flow of Target Facility

Fig. 1 shows the processes of beer production. In the brewing processes, steam is mainly used for the heating, and in the processes of fermenting, storing and filtering, brine is used for the cooling, using a great deal of energy of electricity and heat in all processes.

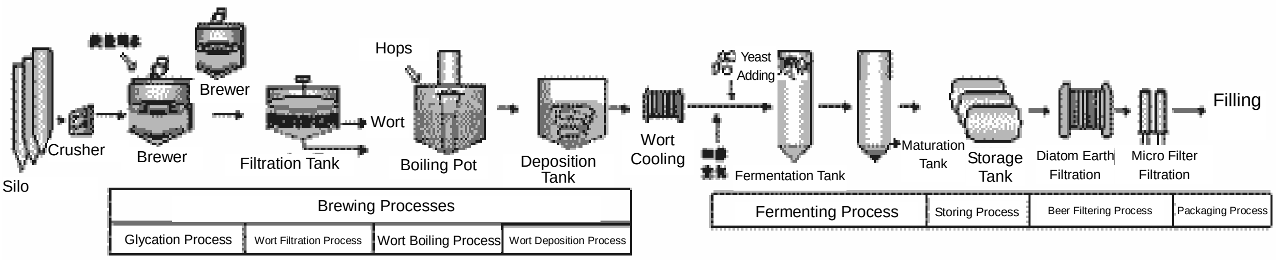

Fig. 1 Outline of Beer Production Processes

1. Reasons for Theme Selection

Kyoto Brewery was built in 1969 as the second brewery of the company. Since then, it has played an important role as a base factory to supply products to the demand in the western region of Japan. However, as the factory has operated for many years, aging of the equipment and inefficiency of the use of the utility became noticeable in recent years. It was time to renew the equipment. So when we were to renew the production equipment starting with the “scrap and build” of the brewing processes in 1999, we took the opportunity as a chance to realize big energy conservation by changing the existing utility supply system, and we began improving the chilling system and electricity supply system of the factory.

A. Improvement of Chilling System

2 (A). Understanding and Analysis of Current Situation

The flow of the chilling system before improvement is shown in the figure below. There were two systems for the chiller, i.e. the fermentation chillers and the driving chillers, and both systems were making -5℃ brine.

We found the following problems with the existing system.

- Aging of the fermentation chillers

Of five chillers, it was time to renew three chillers (25% of the total chilling capacity) because of aging.

- Deterioration of chilling capacity and intensity due to aging

・Capacity 1,530 JRt (Designed capacity: 1,773 JRt)

・Intensity 2.25 kWh/JRt (Designed intensity: 1.53 kWh/JRt)

The efficiency was much worse than the designed efficiency and it was likely that there was shortage of the capacity in the peak time (summer).

- Brine of fixed temperature was being supplied regardless of the temperature necessary for the load.

The temperatures necessary for each process are as follows.

・Wort cooling process: 5℃

・Fermentation process: 0℃

・Beer storing process: -5℃

・Filtering process: -5℃

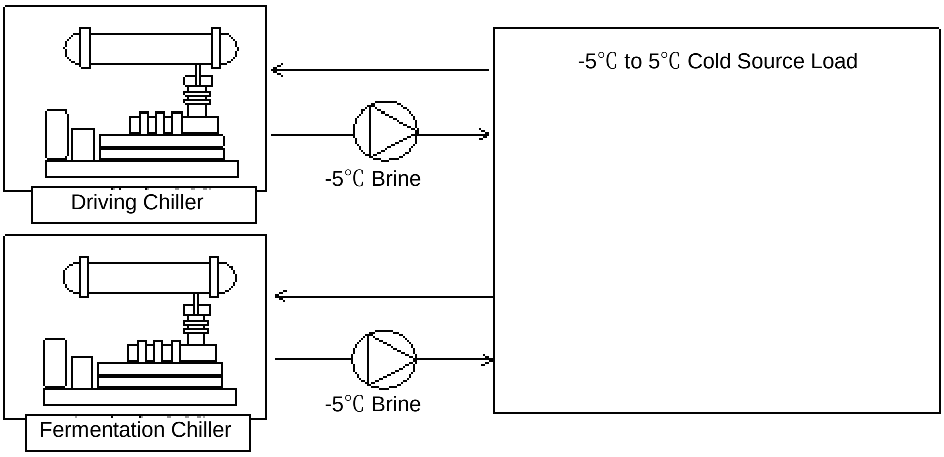

Fig. 2 Flow of Chilling System before Improvement

3 (A). Progress of Activities

(1) Implementation Structure

This factory is tackling the energy conservation on a daily basis by periodically holding the Energy Conservation Session composed of representatives of each division/process. To implement the theme of the said study, we worked with people concerned in each group centering around the driving group of the Engineering Division and technical staff members.

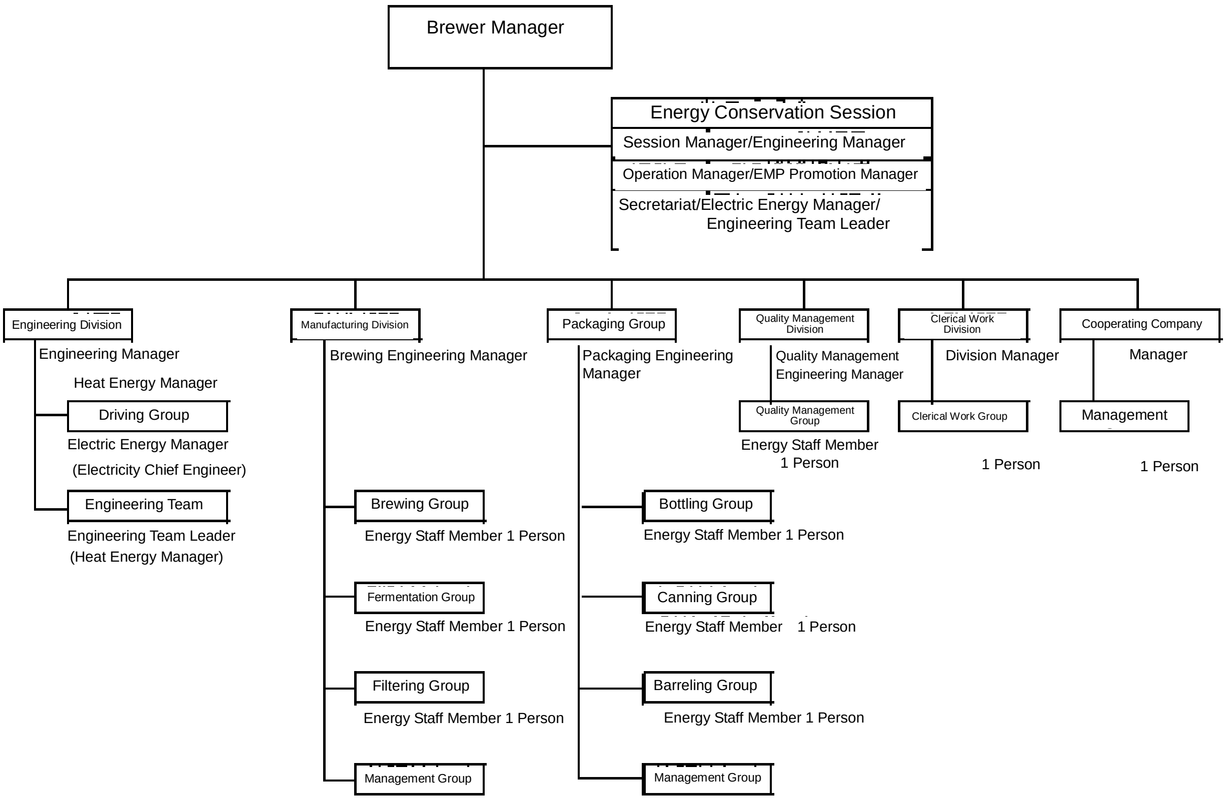

Fig. 3 Energy Conservation Session Organization Chart

(2) Target Settings

- Energy conservation amount　1,047 kL
- Energy conservation ratio　5.4 %
- CO_2 emission reduction amount　1,206 t-CO_2 (Total electrical source), 3,219 t-CO_2 (Average of heat power)

(3) Problem Points and their Investigation

There were problems that the efficiency of making chilling heat deteriorated due to the aging and because the brine of fixed temperature was being supplied to the loads whose temperature zone was different. So we studied the measures that could solve these problems. At the same time, we studied the way to realize energy conservation as much as possible.

4 (A). Details of Measures

- To enhance efficiency of chilling system

We divided the loads into three temperature zones according to the required temperature, i.e. -5℃ zone (for beer cooling, tank cooling, chilled room cooler), 0℃ zone (for fermentation tank cooling, chilled room cooler) and 5℃ zone (for making chilled water).
Here, the -5℃ cold source is made by the driving chiller, the 0℃ cold source is made by the fermentation chiller and the 5℃ cold source is made by the steam absorption chiller newly introduced.

- To enhance efficiency of electric driving chiller

・To dispense with chlorofluorocarbon, we introduced NH_3 chillers in the place of the fermentation chillers which had been to be renewed.
・By doing the low compression ratio operation by increasing the brine temperature, we reduced the chiller's compressing force (Fig. 4).
・We reduced the loss made by the chiller when making the cold source by increasing the temperature for sending the brine and increasing the temperature for returning the brine (to make the temperature difference bigger).

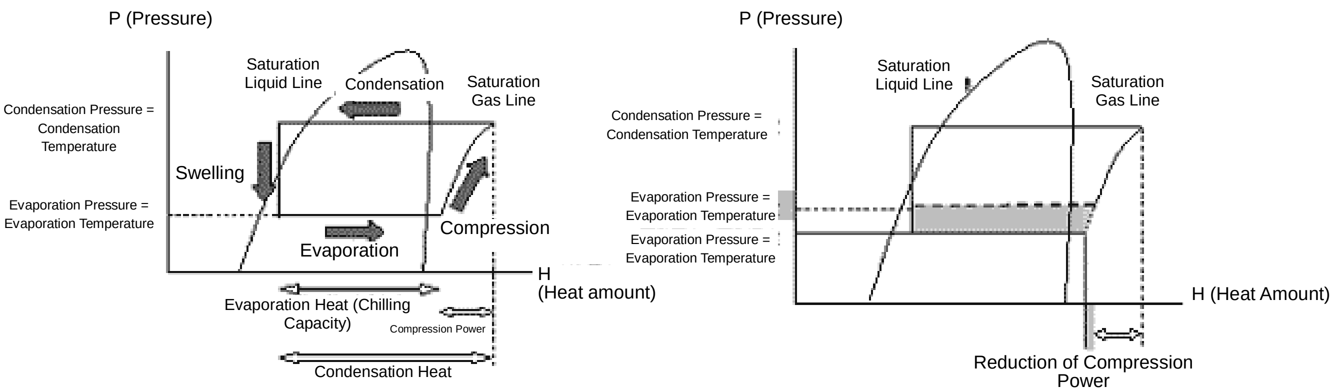

Fig. 4 Reduction of Chiller's Compressing Energy by Increasing Brine's Evaporation Temperature

- Reduction of energy for auxiliary machine

・We reduced the conveying energy by changing the cooling medium from brine to chilled water.

- Matching with cogeneration system

・To make the steam load stable for the gas turbine cogeneration system which had been introduced earlier, we introduced the steam absorption chiller.

The figure below shows the flow of the chilling system improved by the foregoing measures.

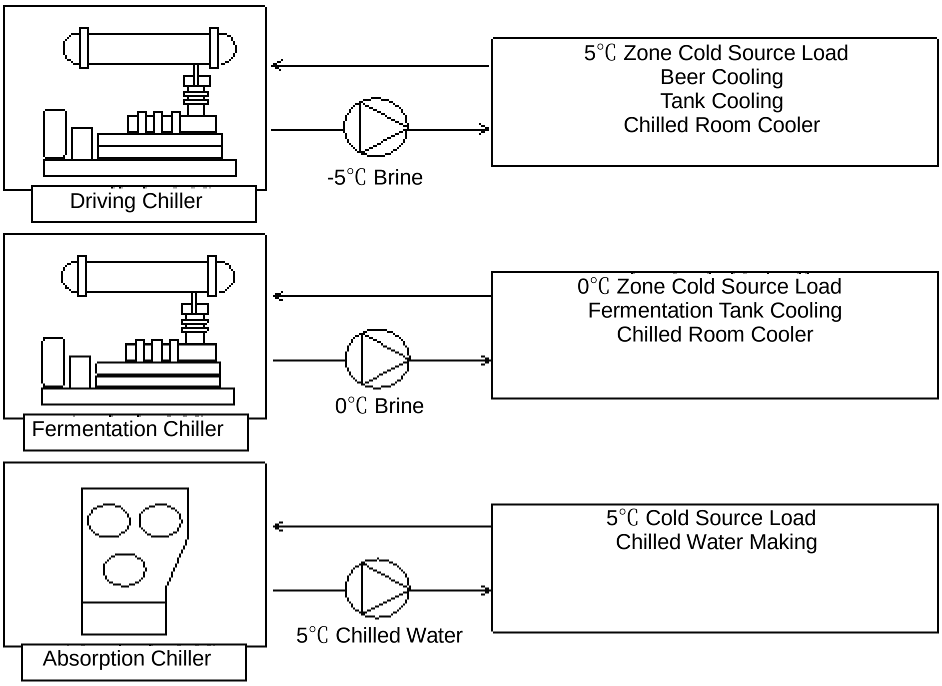

Fig. 5 Flow of Chilling System after Improvement

5 (A). Effects achieved after Implementing Measures

・Energy conservation amount	1,047 kL
・Energy conservation ratio	5.4 %
・CO_2 emission reduction amount	1,206 t-CO_2 (Total electric source),
	3,219 t-CO_2 (Average of heat power)

B. Introduction of Gas Engine Cogeneration System

2 (B). Understanding and Analysis of Current Situation

The following figure shows the energy supply flow before improvement, where the electricity generated by the 1,500 kW gas turbine and the electricity purchases were being supplied to the electricity load. As regards the steam load, 1.6 MPa high pressure steam generated by the waste heat boiler of the gas turbine was being first stored in the accumulator then depressurized to 0.8 MPa and supplied. If there was shortage, the steam generated at the rate of 20 t/h by the gas water-tube boiler was supplied. Meanwhile, 5℃ chilled water was produced by the steam absorption chiller.

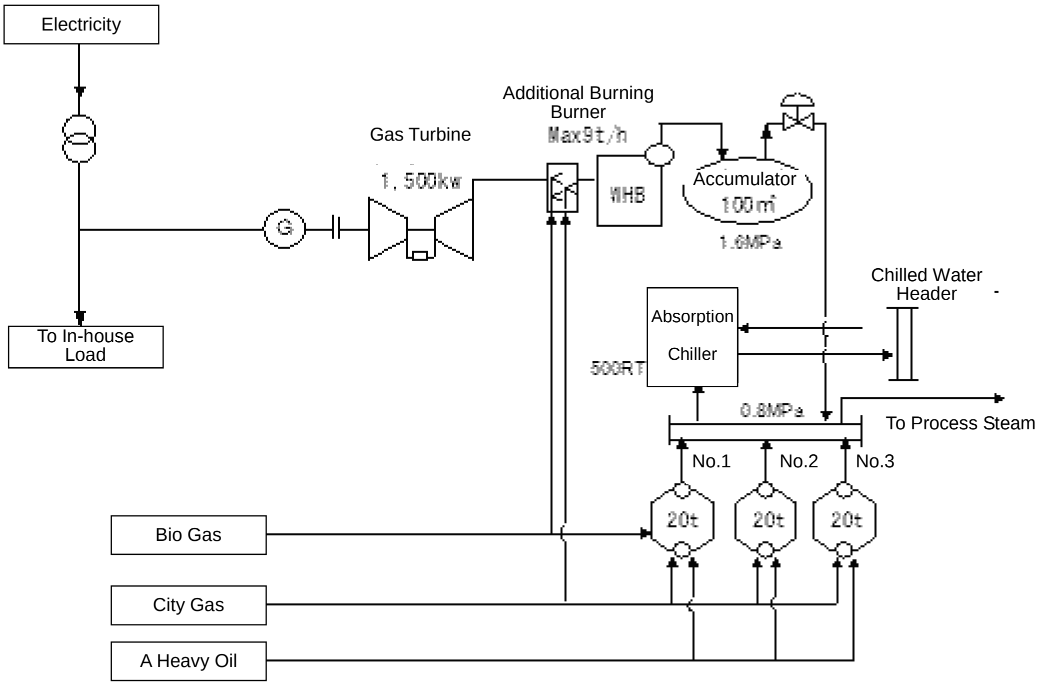

Fig. 6 Flow of Energy Supply System before Improvement

Then, Fig. 7 shows the electricity load and the steam load of a week of this brewery before improvement.

The gas turbine cogeneration system was being operated by the WSS method (weekly start and stop), but the power generation of the gas turbine generator was as small as 1500 kW against the momentary maximum electricity load. So as far as the electricity load is concerned, there was still room for introducing private power generation. As regards the steam load, the steam generated by the gas turbine steam generator almost coped with the base load (approx. 9 t/hh), so it was found that we could not afford to greatly increase the steam amount (no place to use).

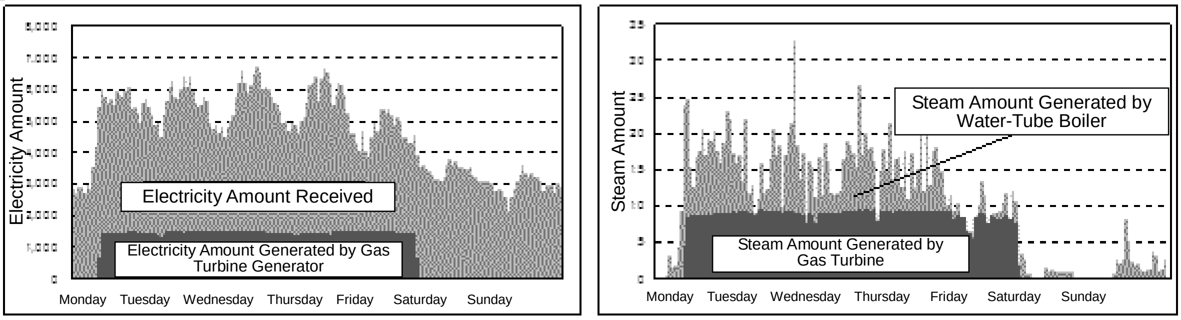

Fig. 7 Electricity Load and Steam Load (of a Week)

3 (B). Progress of Activities

(1) Implementation Structure

The same as A. "Improvement of Chilling System" above, based on the Energy Conservation Session of the brewery, we worked with the group members concerned centering around the Driving G of the Engineering Division and the engineering staff members.

(2) Target Settings

・Energy conservation amount	1,186 kL
・Energy conservation ratio	7.1%
・CO_2 emission reduction amount	535 t-CO_2 (Total electric source),
	5,055 t-CO_2 (Average of heat power)

(3) Problem Points and Their Investigation

It is of course very important to fully use the waste heat when introducing the cogeneration system. But it is also important to determine the generation capacity correctly based on the estimation of the operation in the future. We implemented detailed simulation of the estimated operation for these 2 points and examined the validity of the system.

4 (B). Details of Measures

(1) Problems and Study

There were mainly 3 problems to be studied as listed below.

- Selection of type and capacity of cogeneration system

As mentioned above, the waste heat generated steam amount of the existing gas turbine cogeneration system had been covering the base load of the steam, so even if the steam greatly increased to be supplied stably, there was no place to use it. So we decided to introduce a gas engine cogeneration system which was good in the power generation efficiency rather than in the waste heat recovery efficiency.

As regards the capacity of the generator, we looked for the model which could operate at 100% load for a long time (WSS) throughout a year, because partial load operation would worsen the power generation efficiency. So we finally selected a 2,385 kW gas engine whose efficiency was the highest in the 2,000 kW class gas engine generator.

- Efficiency of gas engine waste heat boiler

As regards the way to supply the steam generated by the gas engine waste heat boiler, there were tow possible ways, i.e. to send it to the existing accumulator (1.6 MPa) to prevent the decrease of the operation time due to the change of the load or to directly send it to the existing steam header (0.8 MPa). We found that in case of the former, the steam amount generated would be lower approximately by 7% than 0.8 MPa specifications because a high-pressure boiler was to be used. In case of the latter, as a result of the steam load simulation, we found that we could limit the operation loss to almost zero. So we decided to adopt the 0.8 MPa specifications.

- Use of gas engine waste hot water

Besides the waste gas, there was hot water of approximately 90℃ as the waste heat from the gas engine. We first thought of using it as hot water, but the existing waste heat recovery system had been working sufficiently so there were no places to use more 90℃ hot water. So we decided to use it for the hot water absorption chiller to reduce the chilling electricity. As a result of the simulation of the chilled water load, we confirmed that the waste hot water of the gas engine could be used 100%.

(2) Details of Measures

Based on the foregoing study, we decided to introduce the gas engine cogeneration system with the following specifications.

- Gas engine power generation equipment 2,383 kW
- Waste heat recovery steam boiler 1.85 t/h, 0.8 MPa
- Hot water absorption chiller 125 USRT

Fig. 8 shows the flow of the energy supply after the introduction of the cogeneration system.

To secure the space for installing the gas engine, No. 3 boiler was removed and the electricity generated by the gas engine was used for the in-house load. The steam generated by the waste heat recovery steam boiler is supplied to the steam header and used as process steam. The hot water absorption chiller produces 5℃ chilled water linked with the existing steam absorption chiller.

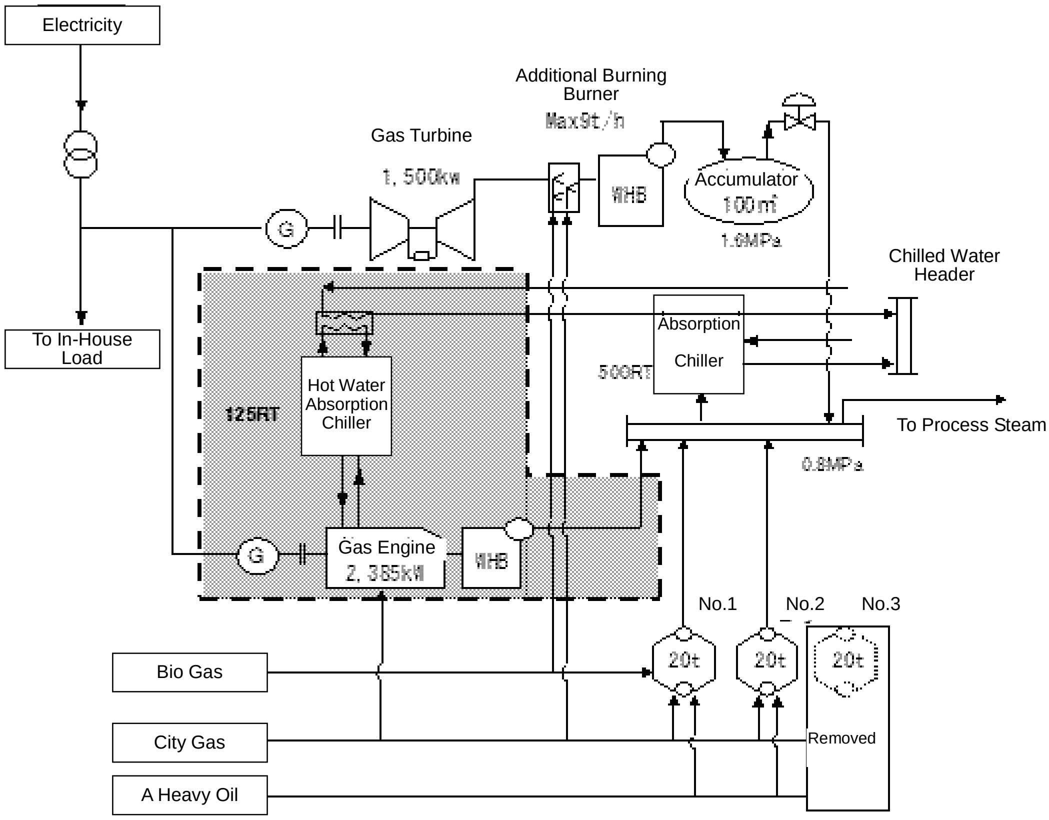

Fig. 8 Flow of Steam and Electricity Supply System after Improvement

(3) Situation after Implementing Measures

Fig. 9 shows the use of the energy after implementing the measures.

The WSS is working as planned and the operating time is expected to go as planned. As regards the use of the gas turbine, it is operated by the WSS the same as before the introduction and there is no decrease of the operating time. As regards the use of the waste heat, it is used almost 100% together with the chilled water of the steam and hot water absorption chiller.

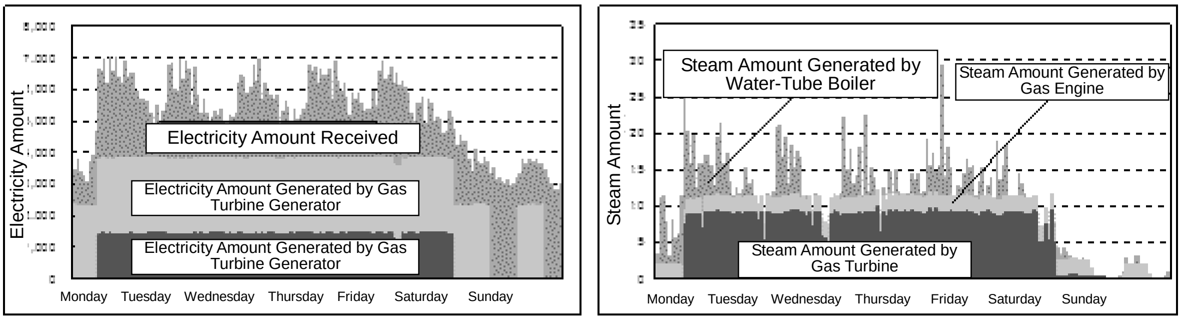

Fig. 9 Electricity Load and Steam Load after Implementing Measures (of a Week)

The heat balance measured after starting operation is as follows, which shows that the planned performance was obtained. We could reduce the loss associated with the generation and transfer of electricity by enhancing the efficiency of the private generation to approximately 42%. We also could enhance the total efficiency to approximately 75% by using the waste heat as much as possible. With the introduction of the gas engine cogeneration system, the ratio of the private generation in the total electricity use of this brewery was heightened up to 60%, which enabled us to realize the maximum energy conservation by doing the private generation and using its waste heat.

Heat Amount of Fuel Fed	Electricity Generated	Heat Amount of Steam Recovered	Heat Amount of Hot Water Recovered	Total Efficiency
kW	kW	kW	kW	%
5,624	2,355	1,401	434	
	41.9%	24.9%	7.7%	74.5%

Table 1 Gas Engine Heat Balance

5 (B). Effects achieved after Implementing Measures (Estimation of 2005)

- Energy conservation amount 1,186 kL
- Energy conservation ratio 7.1%
- CO_2 emission reduction amount 535 t-CO_2 (Total electricity source),
-

5,055 t-CO_2 (Average of heat power)

6. Summary

Using the opportunity to renew the existing production equipment as the chance to improve the system for supplying and using energy, we could achieve the energy conservation which accounted for 12.5% of the total energy use of this brewery. As the Kyoto Protocol was now put into effect, we hope that our activities which were effective in reducing the CO_2 emission are horizontally deployed to other factories.

7. Future Plans

We will continue to introduce energy conservation equipment when we renew the production equipment in the future. We are specifically studying the possibility to introduce energy conservation air conditioning systems. Meanwhile, in order to increase the use of the cogeneration system, we will establish a method for using it further efficiently and try to make the load even.