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Energy Conservation in a Beer Plant by Utilizing Waste Heat from Gas Engine Power Generation Equipment

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◎ **Keywords: Waste heat recovery and usage**

◎ Outline of Theme

Kirin Brewery places a high priority on implementing efficient use of energy and CO_2 emissions reduction, and is aiming for a more than 35% reduction based on the 1990 figures for energy intensity, CO_2 overall emissions and emissions intensity. Following a switch of boiler fuel two years ago, a report is given of the recovery and use of waste heat from biogas engine type power generators that were able to realize a large effect in energy conservation and reduction of greenhouse effect gases.

◎ Implementation Period for the said Example

June 1, 2007 – June 30, 2008 Total 13 months

- Project Planning Period June 1, 2007 – October 31, 2007 Total of 5 months
- Measures Implementation Period Nov. 1, 2007 – March 31, 2008 Total of 5 months
- Measures Effect Confirmation Period April 1, 2008 – June 30, 2008 Total of 3 months

◎ Outline of the Business Establishment

- Items Produced Beer, low-malt beer (*happo-shu*), other mixed alcohols, and liqueurs
- No. of Employees 289 persons (As of July 10, 2008)
- Type 1 designated energy management factory

◎ Process Flow of Target Facility

Waste heat generated by the gas engines are recovered using the jacket cooling water, and is used for raising the temperature of the boiler supply water via a heat exchanger. Because there is still a surplus of waste heat, additional heat is recovered through heat exchange with water in hot water storage tanks. The stored hot water is supplied as heat energy to the beer manufacturing equipment in the plant, including being used as a heat source for raising the temperature of the can warmers (can heaters) and as a heat source for raising the temperature of the can pasteurizers (can sterilization heaters) in the packaging process. (Fig. 1)

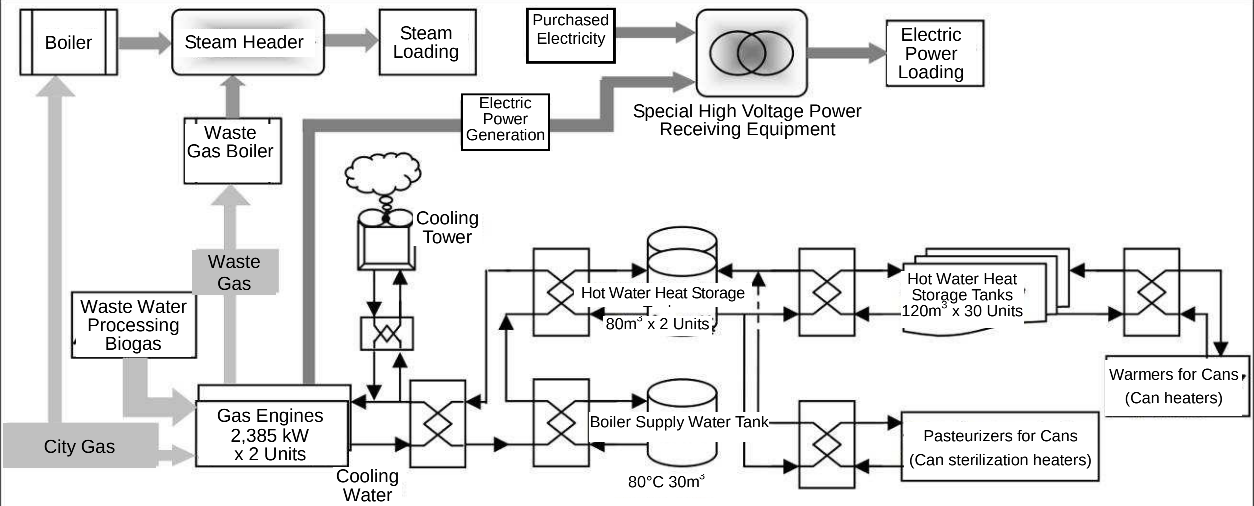


Fig. 1 Outline of the Process Chart of the Facility (Waste heat recovery and usage)

1. Reasons for Theme Selection

The Kirin Brewery Okayama Plant began operations in 1972, and in addition to beer, low-malt beer (*happo-shu*), and new genre main products, the plant also includes the complete “Kirin Chu-Hi Hyouketsu” low-alcohol refreshing drink production line and the entire company’s sole 135 ml can manufacturing line. It carries out manufacturing as Kirin’s base plant in Western Japan supporting its general alcoholic beverage business.

In this plant, by positively introducing manufacturing technology and natural resource-saving processes that are considerate to the environment to promote the reduction of adverse effects on the environment, energy conservation (of electricity, steam, and city water) and greenhouse effect gases (CO_2) emissions control activities are being continuously implemented as high-priority items for environmental management.

The theme this time is the plan to make effective use of heat realized by the efficient recovery and heat storage of waste heat from biogas engine type power generation equipment in an aim to realize energy conservation and CO_2 emission reductions.

2. Progress of Activities

(1) Implementation Structure

The 100% utilization of the waste heat recovered from the power generator will cause an increase in the gas engine power generating equipment overall efficiency, and it was believed this would result in a large reduction in the plant steam usage amount and reduction in the CO_2 emission amounts. Regarding the appropriate recovery and supply of the waste heat, a project was established and cooperation formed between the Energy Group of Kirin Engineering Company, Limited (known below as KEC) who supplies the energy, and the Packaging Manager, who uses the energy, to tackle the implementation.

The implementation structure is shown in Fig. 2.

The implementation actual results are shown in Fig. 3.

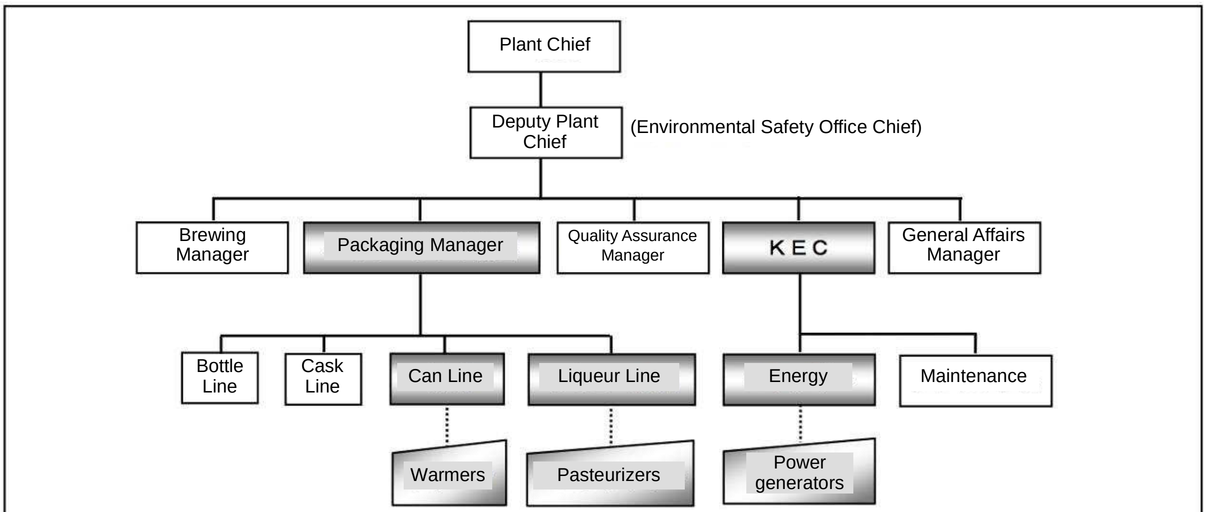


Fig. 2 Okayama Plant Organizational Structure (Shaded parts indicate divisions that were involved in the measures this time)

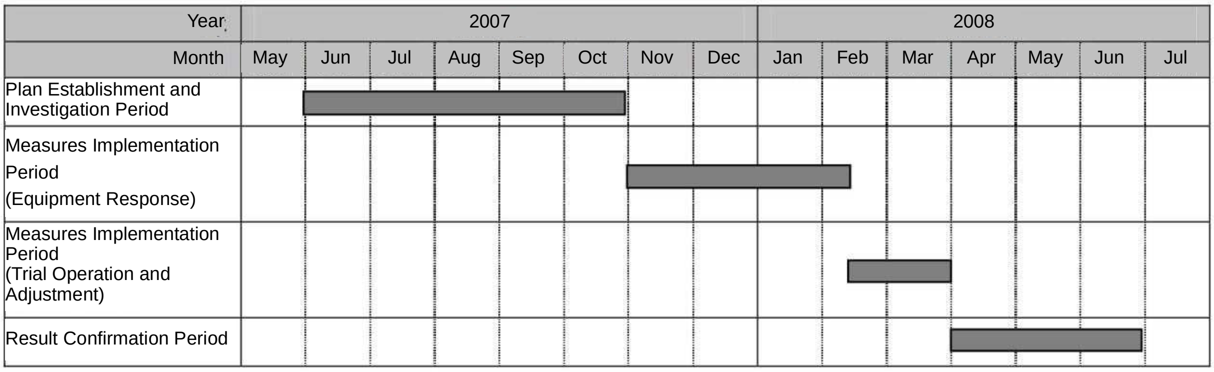


Fig. 3 Implementation Actual Results

(2) Understanding of Current Situation

Recent results of energy conservation and CO_2 emission reduction activities at the Okayama Plant have almost all been related to the energy supply equipment, as seen by the introduction of solar power generation equipment and the switching of boiler fuel.

In order to greatly improve the energy efficiency, it would be necessary to improve the flow of energy in the entire plant by tackling issues through linking together activities for the energy supply equipment and demand equipment.

(3) Analysis of Current Situation

Although steam is recovered from the biogas engine type power generation equipment using waste gas boilers (1,970 kg/h x 2 units) to recover heat from the waste gas, the engine jacket cooling water waste heat (225,000 MJ/day, or approximately 9,375 MJ/h) is being discharged into the atmosphere.

Fig. 4 shows the current situation of the cooling water flow diagram of the gas engine power generation equipment.

Table 1 shows the gas engine power generation equipment specifications.

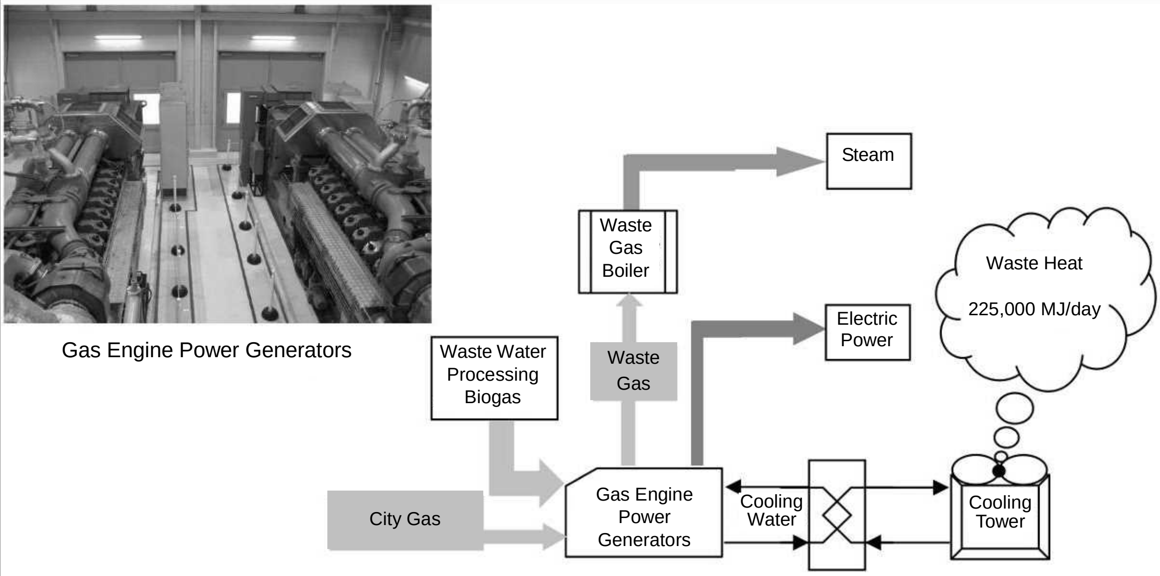
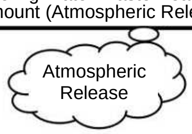


Fig. 4 Current Situation of Gas Engine Power Generation Equipment Cooling Water Flow Diagram

Table 1 Gas Engine Power Generation Equipment Specifications

Item		When Exclusively Burning City Gas (13A)	When Exclusively Burning Biogas
Generated Power Output	(kW)	2,385 x 2 Units	2,385 x 2 Units
Generated Power Efficiency	(%)	41.1	39.0
Fuel Gas Consumption Amount	(Nm^3/h)	502 x 2 Units	710 x 2 Units
	(MJ/h)	20,873 x 2 Units	22,031 x 2 Units
Waste Gas Waste Heat Generated Amount (Manufacture of Steam in Waste Gas Boiler)	(kg/h)	1,970 x 2 Units	2,014 x 2 Units
	(MJ/h)	4,960 x 2 Units	5,072 x 2 Units
Cooling Water Waste Heat Generation Amount (Atmospheric Release)	(MJ/h)	3,981 x 2 Units	4,716 x 2 Units



* Fuel gas lower heat generation amount: City gas (13A) 41.58 MJ/Nm^3, Biogas 31.03 MJ/Nm^3

(4) Target Settings

① Steam Reduction Amount 17,182 t/year

② CO_2 Emissions Reduction Amount 2,299 t/year

* Calculated from the actual manufactured amounts in 2006 and 2007.

(5) Problem Points and their Investigation

1) Problem areas

① The engine jacket cooling water waste heat (225,000 MJ/day) is being wastefully released into the atmosphere.

2) Investigation details

① Concerning the investigation of the usage destinations for the waste heat of the gas engine power generation equipment, investigations were carried out to identify equipment inside the plant where it could be used. The waste heat usage destination investigation diagram is shown in Fig. 5.

Among these destinations, the following three locations were found to be particularly distinctive.

a) The temperature of the water supplied to the boiler installed very close to the power generator is low (upstream temperature + approximately 10℃), and a large amount of fuel gas is being used for raising its temperature.

b) Although heat energy is being supplied from the hot water heat storage tanks to the can warmers on the can line, because an insufficient heat amount is being maintained by the hot water heat storage tanks, steam is being blown in to the warmers.

c) The steam usage amount of the can pasteurizers on the liqueur line is large at approximately 13,000 t/year, and this is being used in an almost steady amount on working days.

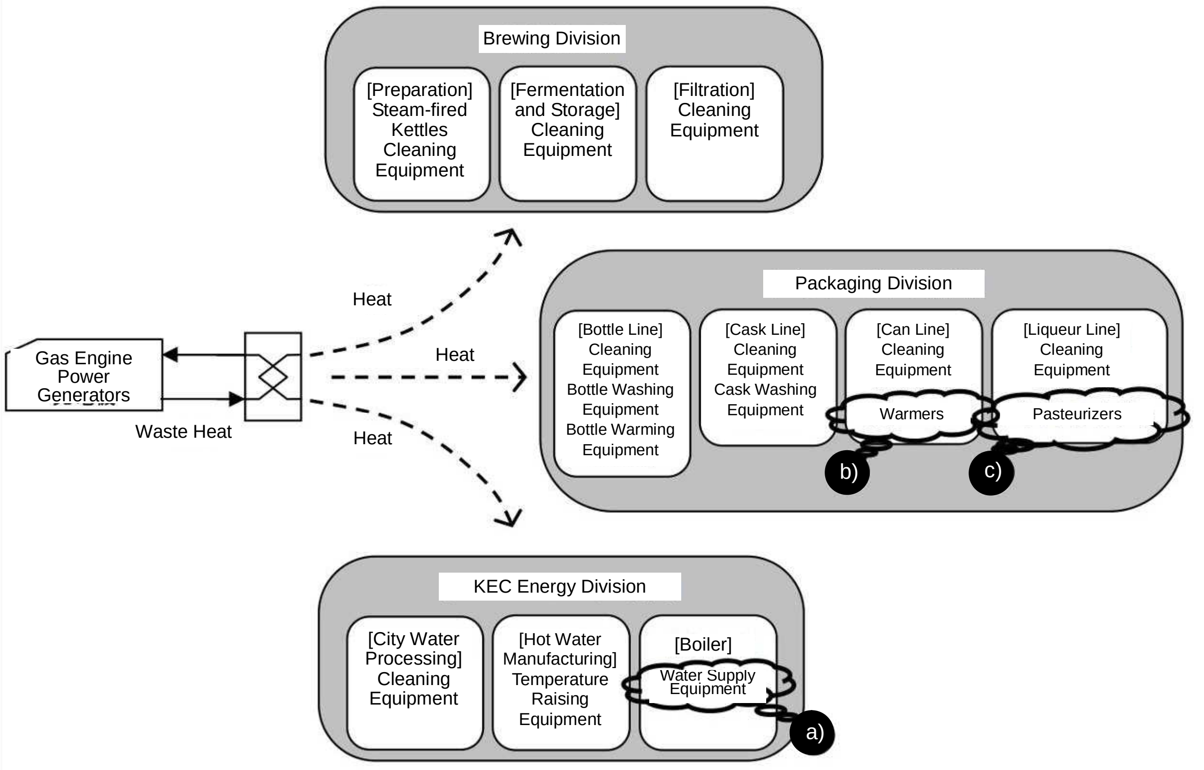


Fig. 5 Waste Heat Usage Destination Investigation

② An investigation was carried out into whether the waste heat could be effectively used as stored heat.

a) It is possible to store the engine cooling water waste heat in the high temperature hot water heat storage tanks.

b) It is possible to take water from the high temperature hot water heat storage tanks to supply heat energy to the can warmers and store the heat in the hot water heat storage tanks. The capacities of the heat storage equipment are shown in Table 2.

Table 2 List of Heat Storage Equipment Capacities

Equipment Name	Equipment Capacity
High Temperature Hot Water Heat Storage Tanks	75℃ 80m^3 x 2 units
Hot Water Heat Storage Tanks	65℃ 120m^3 x 30 units

③ An investigation was carried out into the waste heat recovery amounts. The waste heat recovery balance flow investigation diagram is shown in Fig. 6.

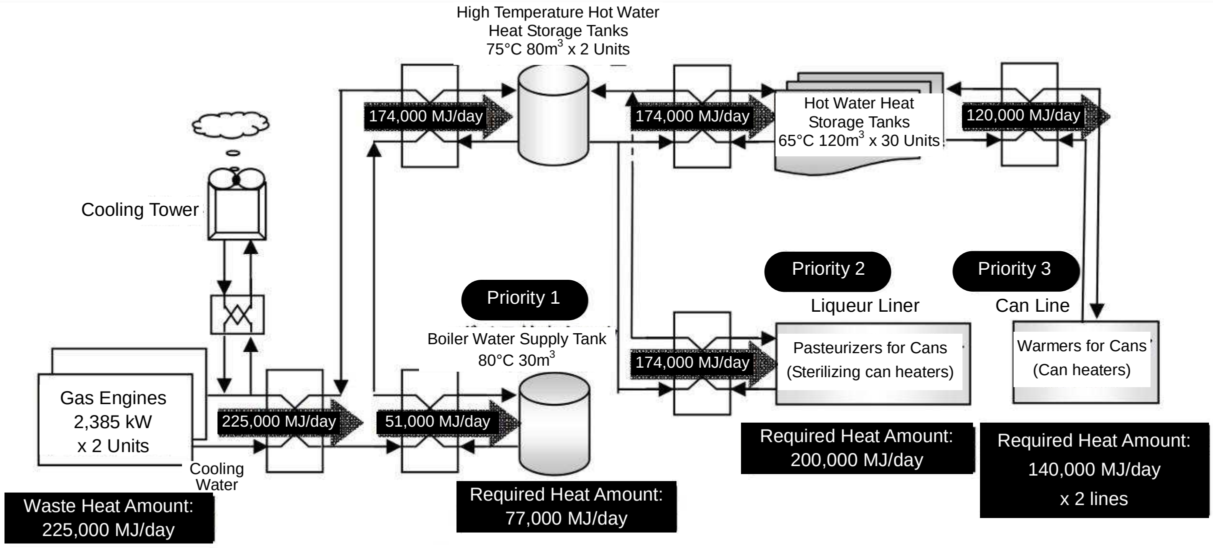


Fig. 6 Waste Heat Recovery Balance Flow Investigation Diagram

a) From the balance flow investigation, it was found that all of the waste heat generated by the gas engine power generation equipment could be used. However, because not all of the required heat amounts could be provided using this waste heat, it would be necessary to determine priorities for the heat supply.

b) Because the temperature of the water supplied to the boiler installed very close to the power generator is low (upstream temperature + approximately 10℃), and a large amount of fuel gas is used for raising its temperature, this is assigned the top priority.

c) It is not possible to supply all the heat amount required for the can pasteurizers and the can warmers on the liqueur line. Because the can pasteurizers on the liqueur line use steam steadily, these are given priority for the supply of heat. Accordingly, the can pasteurizers on the liqueur line are assigned second priority, while the can warmers are given third priority.

④ An investigation was carried out into the annual reduction amounts, taking the annual number of operating days of each equipment unit as approximately 200 days. The annual reduction investigation amounts are shown in Table 3.

Table 3 Annual Reduction Investigation Amounts

Equipment Name	Heat Amount (MJ/year)	Steam (t/year)	CO_2 Emissions Reduction Amount (t/year)
High Temperature Hot Water Heat Storage Tanks	37,482,450	13,565	1,815
Boiler Water Supply Tank	9,995,020	3,617	484

*The specific enthalpy of the saturated steam is 2,763 MJ/t at a pressure of approximately 0.7MPa.

(6) Details of Measures

1) Waste heat recovery of the engine cooling water

Fig. 7 shows the waste heat recovery flow diagram of the gas engine power generation equipment.

① Heat is recovered to the boiler water supply tank. Because this is located close to the power generating equipment, and there is always water being supplied to the boiler (loading), the heat recovery to the boiler water supply tank will have the smallest amount of heat loss due to radiation.

② Heat is recovered to the high temperature hot water heat storage tank. Heat that was not recovered to the boiler water supply is recovered to the high temperature hot water heat storage tank.

③ Heat is recovered to the hot water heat storage tank. Heat remaining from the high temperature hot water heat storage tank is recovered to the hot water heat storage tank.

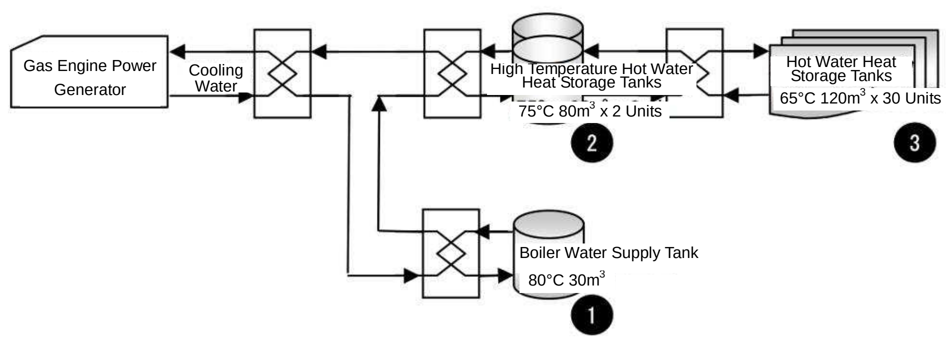


Fig. 7 Waste Heat Recovery Flow Diagram

2) Supply to the waste heat usage destinations

The waste heat supply flow diagram is shown in Fig. 8.

① Heat is supplied to the boiler supply water.

② Heat is supplied to the liqueur equipment pasteurizers from the high temperature hot water heat storage tank.

③ Heat is supplied to the can line warmers from the hot water heat storage tank.

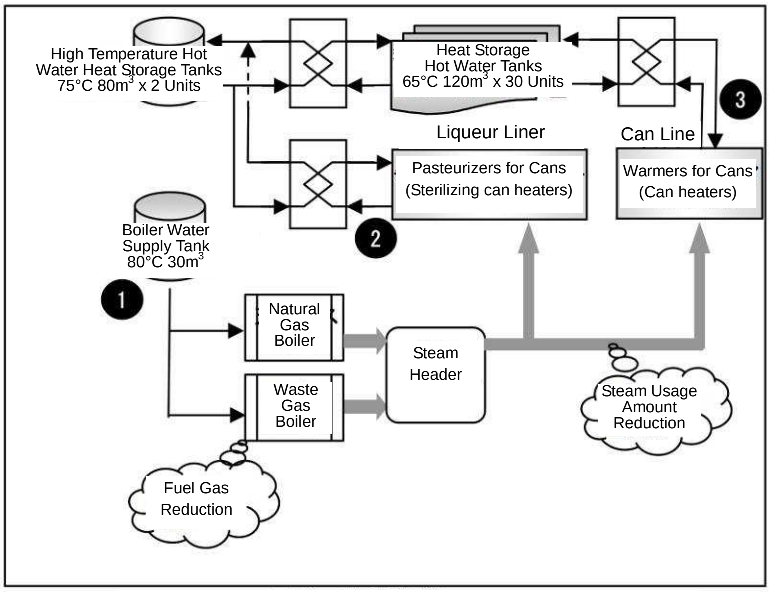


Fig. 8 Waste Heat Supply Flow Diagram

3) System overall flow diagram

The system overall flow diagram is shown in Fig. 9.

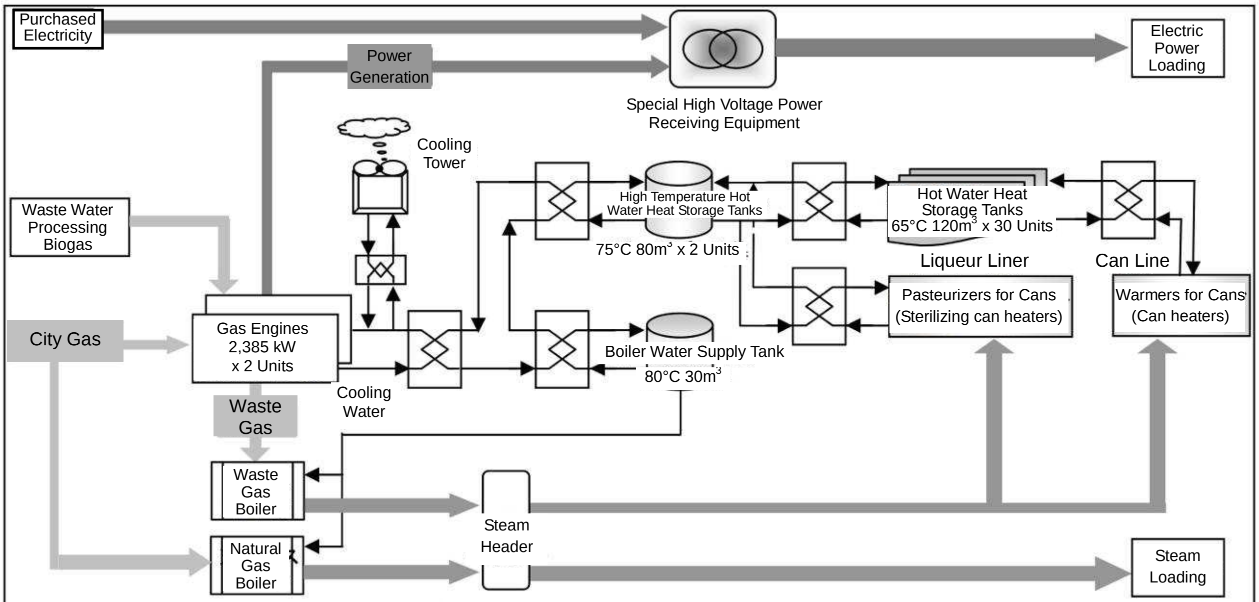


Fig. 9 System Overall Flow Diagram

(7) Effects Achieved after Implementing Measures

① A 45% reduction was achieved in the liqueur line steam intensity between April and June this year compared with the same period in the previous year. (Fig. 10)

② A 40% reduction was achieved in the can line steam intensity between April and June this year compared with the same period in the previous year. (Fig. 11)

③ The heating amount utilized for raising the temperature of the boiler supply water was converted to a steam amount. (Fig. 12)

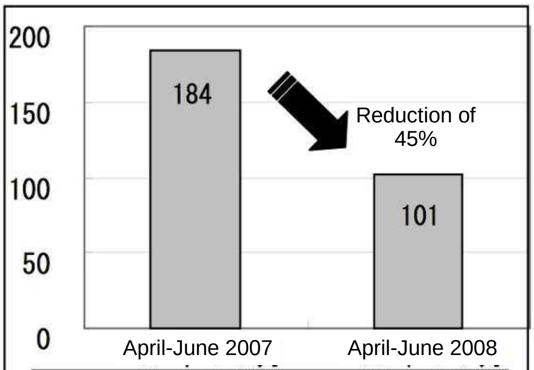


Fig. 10 Liqueur Line Steam Intensity (kg/kL)

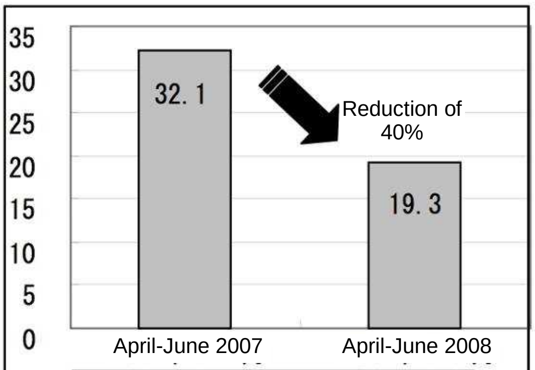


Fig. 11 Can Line Steam Intensity (kg/kL)

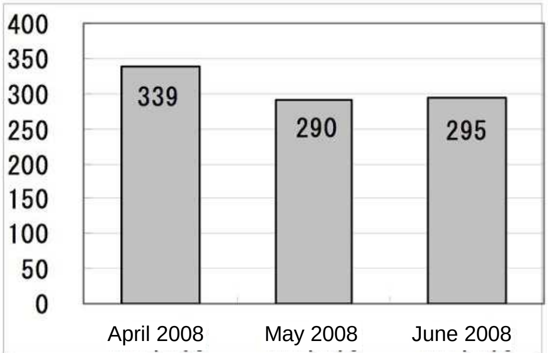


Fig. 12 Boiler Supply Water Recovered Heat Amount Steam Conversion (t)

④ A 27% reduction was achieved in the heat amount intensity for the whole plant between April and June this year compared with the same period in the previous year. (Fig. 13)

⑤ In addition, a 30% reduction was achieved in the carbon dioxide gas emissions intensity between April and June this year compared with the same period in the previous year. (Fig. 14)

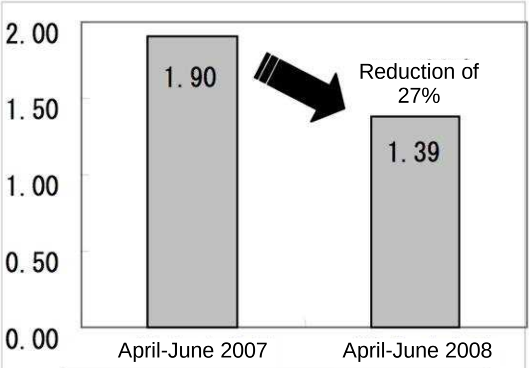


Fig. 13 Energy Intensity (GJ/kL)

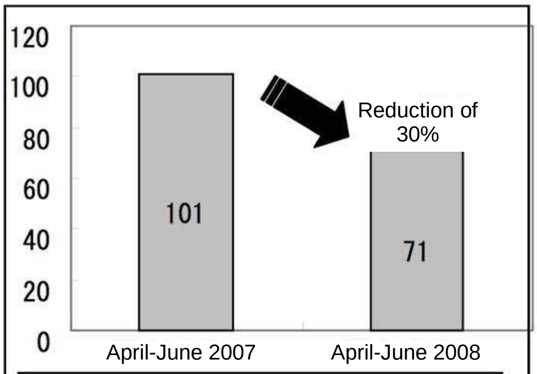


Fig. 14 Carbon Dioxide Gas Emissions Intensity (CO_2kg/kL)

⑥ The waste heat recovery effect is shown in Figure 4. The obtained results roughly realize the annual targets.

Table 4 Waste Heat Recovery Effect

Item		Annual Targets	Annual Actual Results	
Steam Usage Amount	(t/year)	17,182	14,372	83.60%
CO_2 Emissions Reduction Amount	(t/year)	2,299	1,935	84.10%

* The annual actual results were calculated for the full year using this year's actual results between April and June.

* Reference

・Energy Conservation Amount 1,024 kL/year (Crude Oil equivalent)

・Energy Conservation Amount in Yen ¥32,653,000/year

3. Summary

As a result of the collaboration between the Energy Division (Supply equipment manager) and the Packaging Manager (Demand equipment manager) to tackle the issues, it was possible to realize energy conservation and CO_2 emission reductions that roughly realized the target values. In addition, the activities also resulted in further increasing employee awareness of energy conservation and CO_2 emission amount reductions.

These measures are one model for biogas engine type power generation equipment waste heat recovery, heat storage and use, and we believe that it will be possible to develop this model to other locations and other fields. We hope that in the future this will prove useful in promoting further energy conservation activities.

4. Future Plans

Because a surplus will be created in the heat storage maintained amounts in the summertime and when the packaging lines are halted, in the future we would also like to enhance cooperation inside the plant to investigate heat energy usage destinations and contribute to further energy conservation.

The Okayama Plant makes use of the delicious water taken from a clear stream of the Yoshii River, and conducts its business in a natural environment surrounded by greenery. In the future we will continue to promote measures that consider environmental preservation taking great care to maintain this environment with which we are blessed in order to be able to pass it down to the next generation.