2004 Prize of the Chairman of ECCJ

Efforts to Reduce Electric Consumption of Effluent Treatment Blower and Brine Chillers

Kirin Brewery Company, Limited
Hokuriku Plant
Environment Office

◎ **Keywords: Rationalization of heating, cooling and heat transfer (Air conditioning facilities, hot water supply facilities, etc.)
Rationalization of conversion of electricity to motive power and heat (Lighting systems, elevators, office equipment)**

◎ Outline of Theme

We have improved effluent treatment and operation of brine chillers that consume a lot of electrical energy and reduce electric consumption. For effluent treatment, we have changed the balance of water volume in a combination of anaerobic treatment and aerobic treatment (activated sludge method) and reduced electric consumption of aeration blower.
For chillers, we have changed superheating degree and reduced temperature measurement error to reduce electric consumption.

◎ Implementation Period of the said Example

January 2002 – August 2004

- Project Planning Period January 2002 – June 2002 Total 6 months
- Measures Implementation Period March 2002 – December 2003 Total 22 months
- Measures Effect Confirmation Period January 2004 – August 2004 Total 8 months

◎ Outline of the Business Establishment

- Items Produced Beer, Low-malt beer
- No. of Employees: 190 (including cooperative firms)
- Annual Energy Consumption (Actual results for fiscal year 2003)
  Heavy oil: 2,556 kL (A heavy oil LSA)
  Electricity: 9,674 MWh

◎ Progress Flow of Target Facility

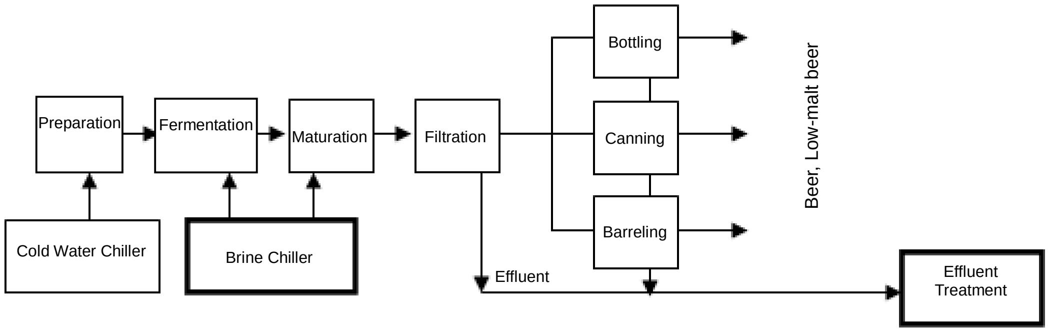


Fig. 1 Process Flow of the Target Equipment (Indicated by Bold Frame)

1. Reasons for Theme Selection

In this brewery, water used to cleanse tanks and pipes in the beer manufacturing process is sanitized and released to a river. Effluent is treated by a combination of energy-conserving anaerobic treatment and highly sanitizing aerobic treatment (activated sludge method), but electric consumption of this process accounts for 13% of that of the entire factory (actual result for 2001). Therefore, we set a theme (target) to establish an operation method that is more energy conserving.

On the other hand, beer requires to be cooled in the process of fermentation and maturation. Electrical energy consumed by chillers that serve as a cold source accounts for 19% of that of the entire factory (actual result for 2001), so we chose to improve the operation method of chillers as a parallel theme (target) since 2003.

Fig. 2 shows electric consumption by major processes in 2001.

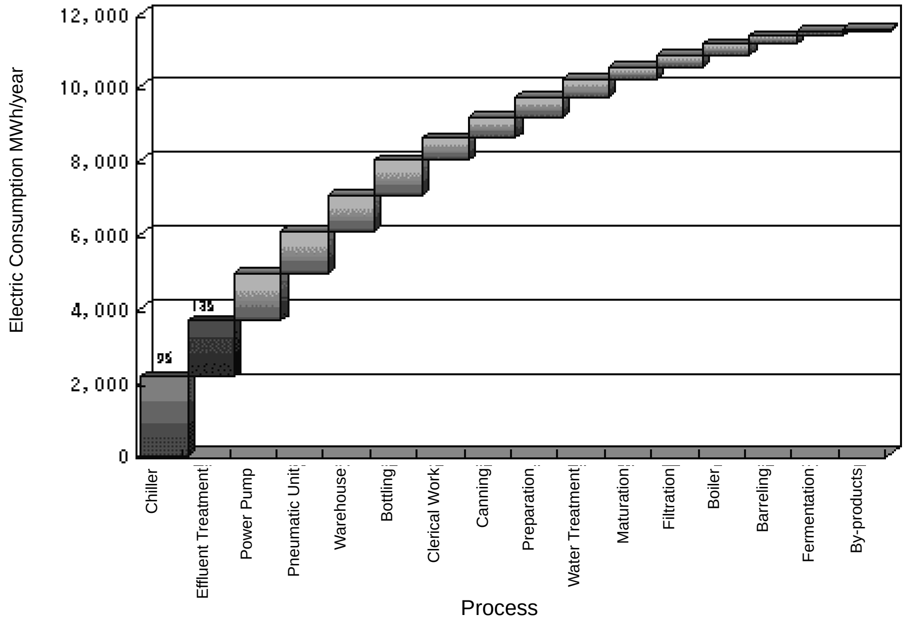


Fig. 2 Electric Consumption by Major Processes

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

1) Effluent treatment

The anaerobic treatment in effluent treatment conserves energy because it can be operated at high load and does not require aeration, but its sanitization effect is low. On the other hand, effluent sanitized by aerobic treatment (activated sludge method) can be released to rivers, but aeration requires a lot of electric energy. By combining benefits of anaerobic treatment and aerobic treatment (energy conservation and quality of sanitized water), energy-conserving effluent treatment can be realized.

2) Chiller

The temperature of beer is controlled at 5 to 10℃ in the fermentation process and at -1 to 0℃ in the maturation process.

The cold source for this is PG (propylene glycol) brine chillers. This is an important unit in the process, and at the same time, is the most energy consuming unit in the factory, so the effects expected from energy conservation activity is also significant.

(2) Analysis of Current Situation

1) Effluent treatment

Basically, anaerobic treatment and aerobic treatment is processed in series. In current anaerobic treatment, however, nitrogen is hard to remove, so N/BOD ratio (nitrogen: biochemical oxygen demand) becomes high, resulting poor water quality after sanitization. To solve this problem, about 30% of the original effluent is bypassed to aerobic treatment to make the ratio close to the most appropriate balance for common activated sludge, BOD : N : P = 100 : 5 : 1. The structure of effluent treatment is shown in Fig. 3.
Effluent treatment capacity: maximum 3,500 m^3/day, normally 2,800 m^3/day, two aeration blowers, 30 kW and 55 kW each

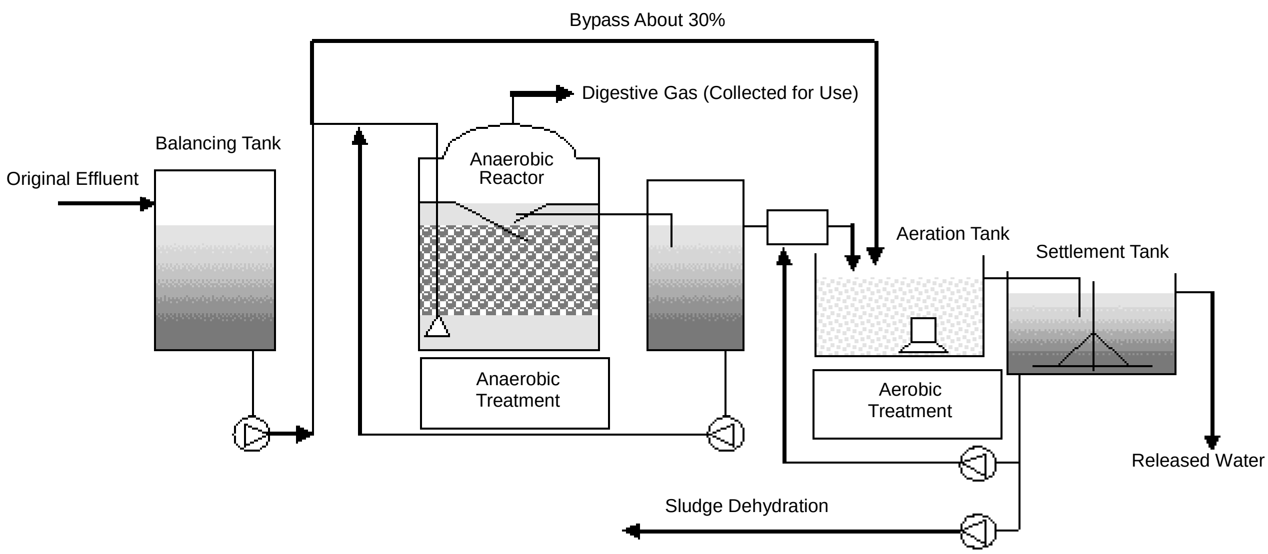


Fig. 3 Structure of Effluent Treatment (Before Improvement)

2) Chiller

Two PG brine chillers (chilling capacity: 800,000 kcal/h, method of compression: screw type, main electric motor drive: 300 kW) operate 24 hours a day simultaneously or alternately. One chiller is almost enough for the cold heat load in usual fermentation and maturation processes, but in summer, the second one repeatedly starts and stops after short operation. Although these chillers are the same model, their cooling capacities (outlet temperature of the secondary refrigerant of the evaporator) were different, indicating that they were not operating as designed.

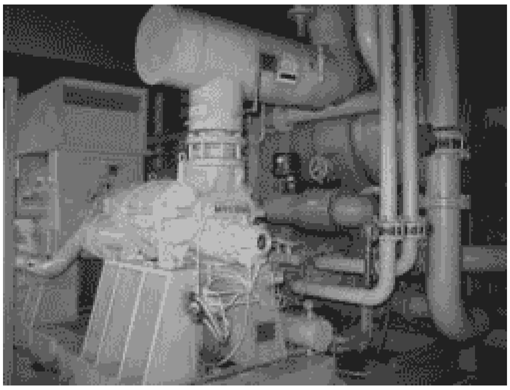
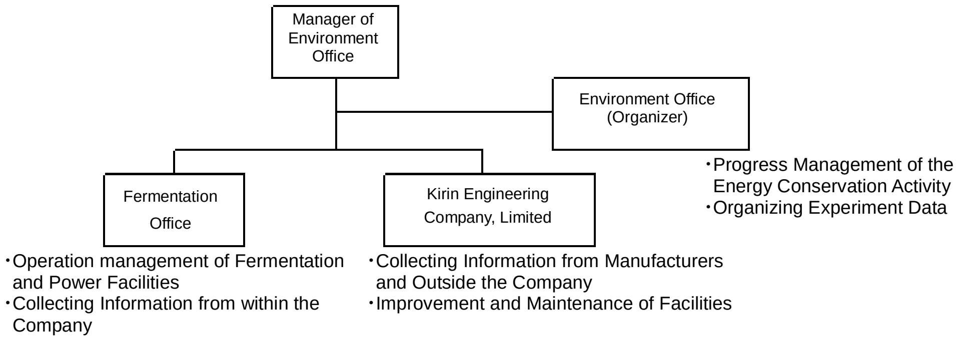


Photo 1 PG Brine Chiller

3. Progress of Activities

(1) Implementation Structure

This energy conservation activity was enforced by a team whose leader was the manager of Environment Office and members were Environment Office (organizer), Fermentation Office and Hokuriku Plant Division of Kirin Engineering Company, Limited.



(2) Target Settings

Target of the Entire Factory - To reduce specific electric consumption (kWh/kL) in 2004 by 3% compared to the actual result of 2001.

Target of Effluent Treatment - To build a method to treat all effluent by anaerobic treatment (elimination of bypassing original effluent to aerobic treatment)
To decrease the load of aerobic treatment to reduce electricity for aeration blower

Target for Chillers - Continuous operation of one PG brine chiller
To Increase the chilling capacity to reduce electricity when the second one is started.

(3) Problem Points and their Investigation

1) Effluent treatment

Although anaerobic treatment and aerobic treatment are combined,, electric consumption by aeration blowers used in aerobic treatment accounts for the major part of electric consumption of effluent treatment because about 30% of the original effluent is bypassed to the aerobic treatment. The fact that it is the most energy-conserving method to treat all original effluent by anaerobic treatment has been known, so we tried to treat all effluent by anaerobic treatment in 1993 when the factory opened. However, the quality of water sanitized by aerobic treatment was not good enough. Then, after trial and error, an operation method to bypass 30% of the original effluent to balance good sanitization and energy conservation was established. This activity is a retry of the activity in 1993 from a fundamental standpoint. Since 2002, we have repeated mini plant tests through cooperation with Manufacturing Technology Division of the headquarters, and then established new theories and method to control operation.

<u>Cleansing Method That Can Keep Quality of Water Treated by Aerobic Treatment Even When N/BOD Ratio is High</u> Aeration is stopped at a fixed time interval during treatment of activated sludge to promote nitrate respiration. When decomposed activated sludge performs nitrate respiration, it absorbs organic substances in the effluent and the decomposed sludge flock is repaired. At the same time, nitrate ion (nitrate-nitrogen) dissolved in the activated sludge compound liquid is denitrified and nitrogen is removed. This effluent treatment method is the new "anaerobic treatment and intermittent aeration of all effluent".

2) Chiller

The second PG brine chiller repeatedly starts and then stops shortly after. This is the problem. The challenge is to increase the capacity of one chiller so that chilling load can be covered by one chiller that operates continuously.

We explored the following measures to increase the chilling capacity:

(i) To remove dirt on a condenser and an evaporator (to increase heat-transfer efficiency)

(ii) To fill appropriate amount of refrigerant and lubricant.

(iii) To set the superheating degree lower.

For (i), open inspection of the condenser and evaporator during a regular inspection revealed no dirt that may have harmful effects.

For (ii), we checked the filled amount during a regular inspection and found no problem.

For (iii), the value is set to a constant value since 1993, when the factory started, and has never changed. We decided to work on changing this setting of superheating degree.

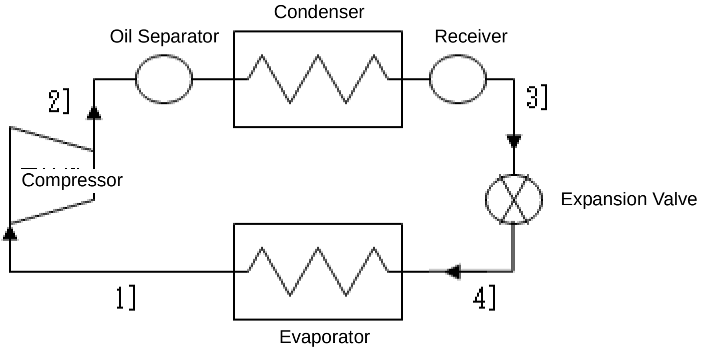


Fig. 4 Structure of the Chiller

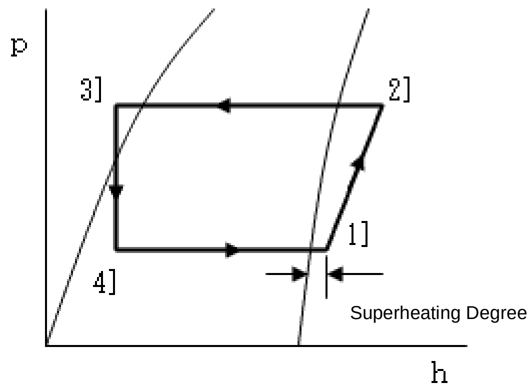


Fig. 5 Mollier Diagram

Fig. 4 shows the structure of a brine chiller and Fig. 5 shows the Mollier diagram.
In these figures, the chilling cycle is shown as 1] -> 2]: compression, 2] -> 3]: condensation, 3] -> 4]: expansion, and 4] -> 1]: evaporation.
The difference of temperatures between superheated steam and dry saturated steam in the state 1] is called superheating degree.
Flow rate of the refrigerant is controlled by an electronic expansion valve so that the superheating degree is kept constant. If the superheating degree is too high, the specific volume becomes large (density becomes low) and the circulation of refrigerant decreases, causing lower chilling capacity.
In contrast, if the superheating degree is too low, some refrigerant may remain in the liquid phase during the low load and may cause compression of liquid.

4. Details of Measures

(1) Effluent Treatment

Bypass feed to aerobic treatment was eliminated and all effluent was treated by anaerobic treatment and intermittent aeration.
Comparison of specific operation is shown in Table 1.

Table 1 Comparison of Operation Methods

	<Before Measure> Bypass Rate of Original Effluent:	<After Measure> Anaerobic Treatment and Intermittent Aeration of All Effluent
Bypass Rate of Original Effluent (%), Normal Time	30	0
Bypass Rate of Original Effluent (%), Low-load Time	30～100	0 (Supply of original effluent is completely stopped.)
Load of Anaerobic Treatment (kgCOD／kgVSS・d)	0～0.3	0～0.3
Aeration Method in Aerobic Treatment, Normal Time	Continuous Aeration	Intermittent Aeration (Aeration Interval *1)
Aeration Method in Aerobic Treatment, Low-load Time	Continuous Aeration + Effluent Bypass Rate 30 - 100%	Completely Stopped (Only sludge return pump is
MLVSS	7000～8000	4000～5000
MLVSS Load, (kgCOD／kgVSS・d) Normal Time	0.25～0.50	0.25～0.30
MLVSS Load, Low-load Time	0.25～0.38	0

*1 The interval of intermittent aeration is changed based on the NO_3 ion concentration in the aeration tank.

When the NO_3 ion concentration exceeds 20 ppm, operation goes one step down, and when it falls below 5 ppm, operation goes one step up.

Step Up ⇕ Step Down

Aeration for Four Hours and Stop for 30 minutes
Aeration for Three Hours and Stop for 30 minutes
Aeration for Two Hours and Stop for 30 minutes
Aeration for One Hour and Stop for 30 minutes

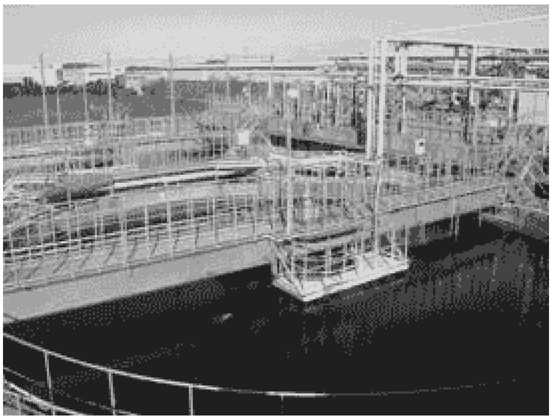


Photo 2 Full View of the Effluent Treatment Plant

(2) Chiller

The setting value of superheating degree of the brine chillers was lowered in stages to 5℃. Load control was performed so that chilling load of fermentation and maturation processes does not rapidly get low.

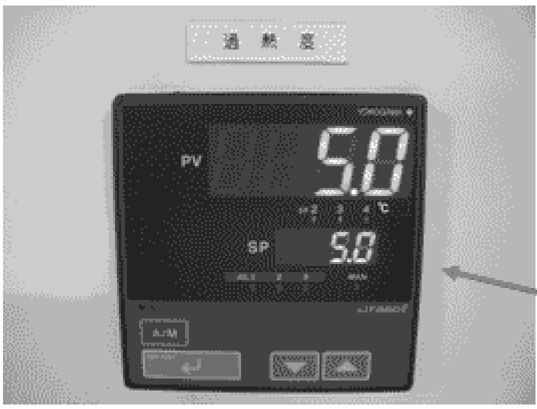


Photo 3 Superheating Degree Indicator

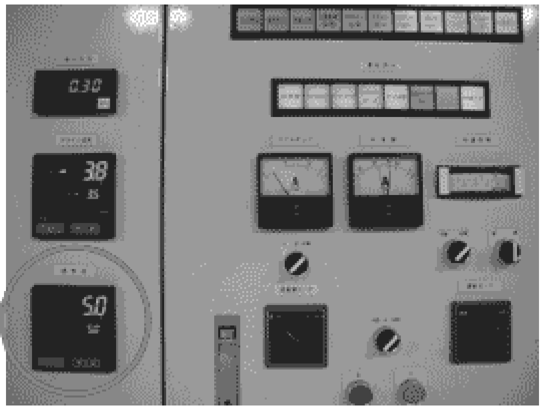
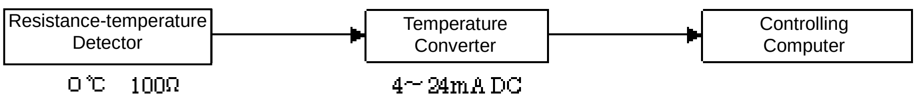


Photo 4 Chiller Operation Panel

Loop check of the resistance-temperature detector that detects the outlet temperature of the secondary refrigerant of the evaporator was performed to improve the accuracy of temperature measurement to start/stop the chiller.

Ultimately, temperature deviation of 0.2℃ was corrected.



5. Effects Achieved after Implementing Measures

(1) Effluent Treatment

In fiscal year 2004, specific electric consumption used in the effluent treatment process was decreased by 33% compared to fiscal year 2001.

Reduced electric consumption was 500 MWh/year and is equivalent to 4.5 million yen/year.

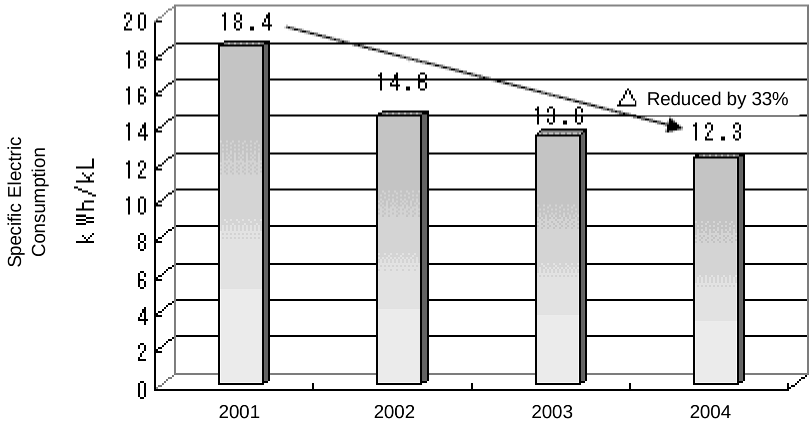


Fig. 6 Specific Electric Consumption of the Effluent Treatment Process

(2) Chiller

In fiscal year 2004, specific electric consumption used by the chillers was decreased by 23% compared to fiscal year 2003. Reduced electric consumption was 350 MWh/year and is equivalent to 3.2 million yen/year.

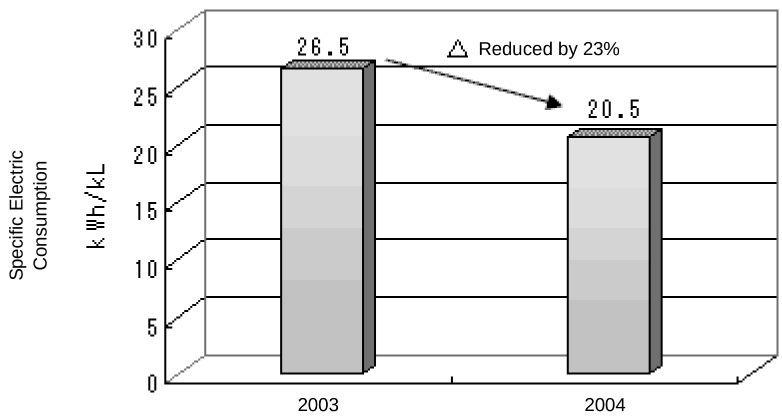


Fig. 7 Specific Electric Consumption of Chiller

6. Summary (PR Point of Verified Effects)

(1) Effluent Treatment

A method to control operation of anaerobic treatment of all effluent was developed to reduce electric consumption, and the following derived effects were obtained adding to reduction of electric consumption:

- Increase in the volume of digestive gas produced by the anaerobic treatment (it is used as boiler fuel: 5.4 million yen/year
- Reduction of excessive sludge produced by the aerobic treatment (Reduction of waste treatment cost: 3.4 million yen/year)

(2) Chiller

Superheating degree control using chiller electronic expansion valve is common recently, so this improvement can be easily developed to other establishments, even other companies that use similar chillers.

7. Future Plans

(1) Effluent Treatment

We plan to continue anaerobic treatment of all effluent to store and analyze data. By doing so, we plan to establish the most appropriate operation method and improve the quality of the water released after effluent treatment.

Currently, the digestive gas produced by the anaerobic treatment process of effluent is burned in boilers to be collected as thermal energy. When the factory is closed, however, we have excess thermal energy, so we plan to investigate methods to convert digestive gas to electrical energy.

(2) Chiller

We plan to investigate reduction of electric consumption by controlling the number of fans in operation of cooling tower with the wet-bulb temperature to lower the refrigerant condensation temperature (pressure).