2007 Prize of the Chairman of ECCJ

Energy Conservation Considering In-House Environment of Public Hospital

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Hospital Management Office, Hospital Management Department
Sapporo City General Hospital, Energy Conservation Promotion Group

◎ Keywords: Energy management system for each equipment

◎ Outline of Theme

Sapporo City General Hospital has tried to reduce the costs paid for lighting, heating and water as one of the activities to improve the management of the hospital. However, it was difficult to darken the light in the hospital or change the room temperature because it would worsen the in-house environment. Therefore, we, as identified above, did the energy conservation in the software aspect eliminating the operational waste and improving the operational efficiency of the equipment. We also implemented the energy conservation in the hardware aspect by introducing the ESCO business. As a result, we could reduce the use of primary energy by 34% and utility costs by 42% in 7 years.

◎ Implementation Period for the said Example

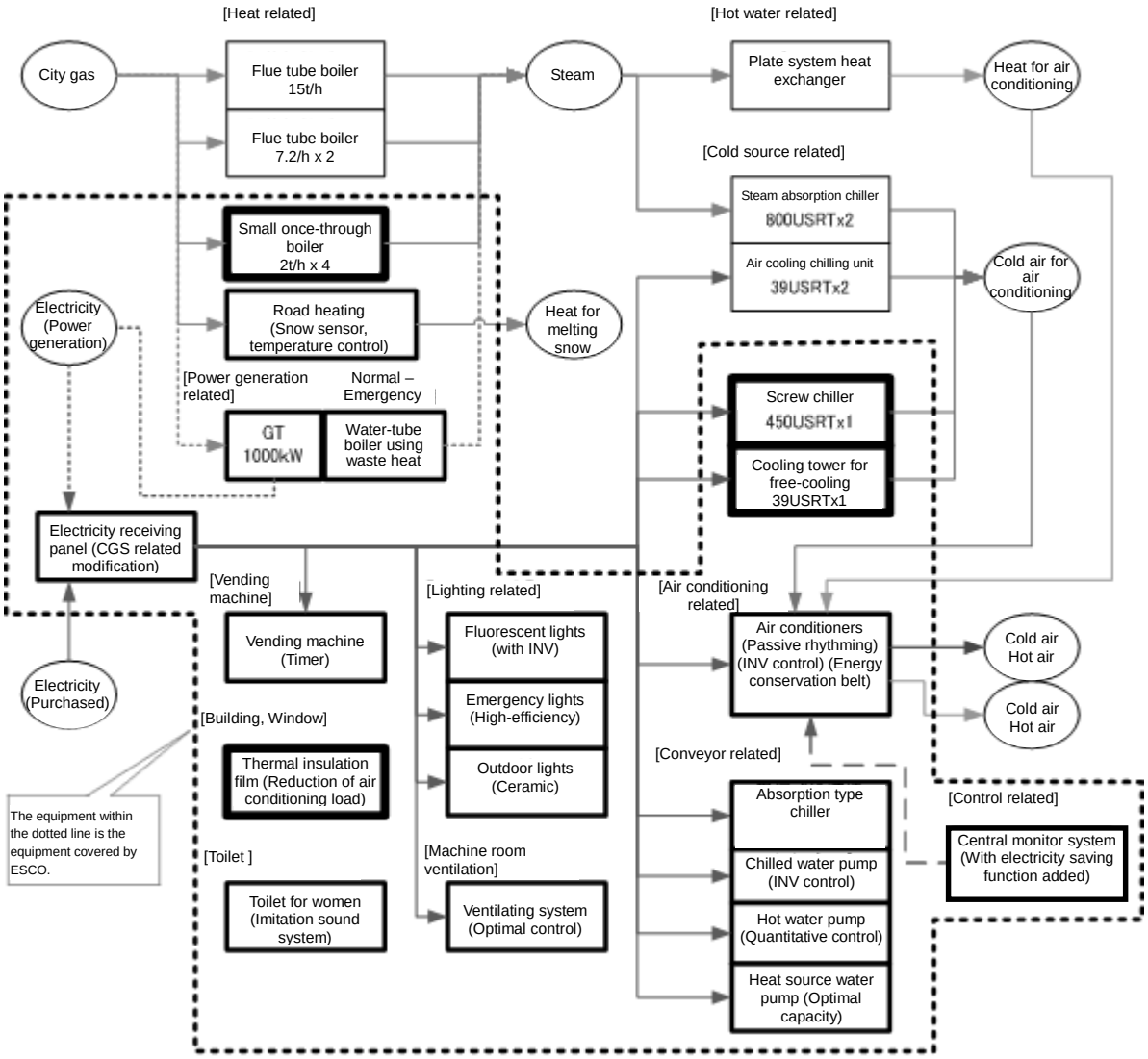
June 2000 – March 2007

- Project Planning Period June 2000 – August 2005
- Measures Implementation Period August 2000 – March 2006
- Measures Effect verification Period August 2000 – March 2007

◎ Outline of the Business Establishment

- Medical services 818 beds
- No. of Employees Approximately 1,000
- Type 1 designated energy management factory

◎ Process Flow of Target Facility



1. Reasons for Theme Selection

(1) Sapporo City General Hospital moved to the current location in 1995 and it was newly built as a general hospital consisting of 2 stories underground, 10 stories on the ground and 2 stories on the roof with 57,318 m^2 total floor area. The hospital provides not only general medical services but also critical medical services such as emergency medical treatment, pregnancy care, psychiatric care, pediatric medical practice corresponding to the demand of the era and contributing to the health and medical safety of the citizens. To provide safe and reliable medical service of high quality which the citizens can trust not only now but also in the future, the hospital needs to build a sound and stable base

for its operation. So the cut of the costs for utility is one of the important activities toward the improvement of the hospital operation.

Meanwhile, Sapporo City was qualified for ISO14001, the international standard for the environment management system, on November 22, 2001 for the first time as a government ordinance designated city. Since then, the city has been implementing not only its own measures for reducing environmental load based on its environment policy but also measures for encouraging business organizations in the district to have concern for the environment.

(2) To progress the energy conservation activities at a hospital, it is important to maintain the adequate environment for the medicine and hygiene and consider the comfort of the patients. For example, if fluorescent lights are thinned out inadvertently to reduce electricity, it would cause trouble for the weak-sighted patients in walking. Meanwhile, the heating and cooling temperature must be comfortable throughout a year to create medical effects and the air conditioning must maintain adequate cleanness of the hospital air according to the classification of the cleanness of each area in the hospital to prevent in-house infection.

So we cannot do energy conservation measures which worsen our medical environment for 2,000 outpatients every day and 700 inpatients. It is absolutely important not to damage the in-house environment when we are to do the energy conservation activities.

(3) So we focused on the energy conservation which complete operational improvement without damaging the in-house environment and spending a lot of money. Those activities included the elimination of operational waste and improvement of equipment efficiency. We have repeated the improvement of the hardware aspect since 2000 by introducing the ESCO business and we could achieve a great deal of energy conservation by additionally implementing the measures.

2. Understanding and Analysis of Current Situation (Analysis of energy consumption in 2000)

To start the energy conservation activities, we took the “energy conservation audit service” of the Building-Energy Manager’s Association of Japan in fiscal year 2000, and its evaluation of our energy consumption was as follows.

(1) Understanding of Current Situation

- The consumption of the primary energy in fiscal year 1999 was 244,000 GJ, the electricity purchased was 126,713 GJ (51.9%), the consumption of gas was 117,288 GJ (48.1%). Of the gas, 57% was consumed by the boiler and 43% was consumed by the cogeneration system.
- The energy consumption specific unit was 4.35 GJ/m^2 a year and it was 24% greater than 3.53 GJ/m^2 of yearly average value for all hospitals. However, as a hospital becomes bigger exceeding 30,000 m^2, its energy consumption specific unit becomes greater. So, it can be said that present specific unit was slightly above the average value.
- The hospital is in a cold region. Considering the necessity of energy consumption for the road heating, etc, it was thought that we were consuming energy efficiently.
- The energy consumption specific unit decreased by 268 MJ/m^2 (5.8%) in 4 years after the opening of the hospital and it was thought to be the result of our energy conservation activities taken up in the entire hospital.

(2) Analysis of Current Situation

- It is necessary for us to recover and use waste heat maximum and improve the total efficiency in the operation of the cogeneration system.
- Therefore, when operating the cogeneration system, we should use the waste heat boiler rather than the flue tube boiler.
- As regards the efficiency of the flue tube boiler, No. 1 boiler (15 t/h) is likely to operate with light load worsening the efficiency because its capacity is big. Considering the fact that No.2 and No. 3 boilers (7.2 t/h) can sufficiently cope with the load in normal cases, we decided to use No. 1 boiler, which is currently used throughout a year, as a spare boiler in seasons other than winter from now on.
- To deal with the road heating load, we should establish a method of operation and control which does not cause excessive consumption.
- As there are some circulation pumps in the heat source and air conditioning system which are not equipped with the inverter and there are also some air supply and discharge fans which are not equipped with the inverter, we should study the possibility to introduce the inverter for them. The equipment with an inverter is, especially when it is operated for 24 hours, very efficient, even if initial cost is high.
- Because it is not long after the hospital was opened, the main energy conservation directed toward operational and managerial improvement. Presently, it might be

necessary to study the improvement of the hardware aspect including buildings and equipment.

3. Progress of Activities

(1) Implementation Structure

Sapporo City General Hospital moved to the current location and newly opened in 1995, and it has been operating its facilities stably overcoming the initial trouble. In this process, the facility maintenance company for the maintenance and management of our facilities were closely tying up with us through the QC activities and had meticulously studied the way to prevent equipment from trouble and reduce the operation cost. As a result of the measures studied and implemented together, we could reduce the energy consumption specific unit.
At the same time, we took the “building energy conservation audit service” provided by the Building-Energy Manager’s Association of Japan, and studied active energy conservation measures. The hospital facility management division had implemented them. Meanwhile, Sapporo City introduced ISO14001, the international standard of the environment management system (EMS), in fiscal year 2001 and established our own environment policy. In order to reduce the environmental load according to the EMS, we repeated the PDCA cycle to reduce the use of energy by 1% every year and, accordingly, reduced the emission of CO_2. Meanwhile, since there is financial limitation if the hospital acts alone and it is necessary for the hospital to learn the various methods., Therefore we appealed to the public for ESCO business proposals in fiscal year 2004 and applied for the subsidy of the NEDO in fiscal year 2005, implemented the construction and started the ESCO service in fiscal year 2006.

(2) Target Settings

In the environment management system of Sapporo City, each bureau (district) repeats the PDCA cycle and implements measures for reducing the environmental load following the procedures of a manual called EMS rules. In this activities, each bureau aims to reduce the use of energy 1% every year. Meanwhile, when introducing the ESCO business, we made a baseline based on the energy amount used in FY2001 to FY2003 and made a target to reduce the use of primary energy approximately 19%.

(3) Problem Points and their Investigation

When implementing the energy conservation measures, it is necessary for us to understand accurately the operation efficiency of the equipment, etc. We had been tallying up the daily or monthly data for a long time. Then, in fiscal year 2000 when office computers began spreading, we started to input daily use of utility into the spreadsheet software of an office computer to manage and analyze the amounts of power generation, gas use, steam generated and the efficiency of the cogeneration system and boilers. By visualizing the data and comparing them with those of foregoing years, it became easy to confirm the efficiency of the equipment operated and compare the energy amount used before and after changing the operation system of the equipment.

4. Details of Measures

(1) Implementation of Improvement Measures for Management and Operation

To improve the management and operation, we implemented the following measures one after the other. We could expect improvement effect from every measure with small investment. We hereby recount the main ones written below.

- Reduction of heat loss by continuous cooling operation.
- In case of chillers for freezers in the kitchen, reduction of the well water usage by recovering the well water for cooling.
- Improvement of operation efficiency of the waste heat boiler by heating the combustion air for the cogeneration system.
- To shorten the operating time of air conditioners and fan coil units.
- To use the waste heat boiler preferentially by reviewing the setting pressure of the flue tube boiler and the waste heat boiler.
- Improvement of the flue tube boiler’s efficiency by changing the operation of No. 1 boiler (15t/h).
- To change the garden lights to the energy conservation type, i.e. electrode-less bulb fluorescent lights.
- Reduction of city water amount by using water saving frames.
- Reduction of heat loss and water amount by reviewing the blow amount of the flue tube boiler and the waste heat boiler.
- Reduction of the well water amount by reviewing the back-washing interval of the well-water filter.

- To expand the operation period of the total heat exchanger by means of the bypass damper control.
- Reduction of the electricity by using natural cold energy of the closed cooling tower for the heat source water.

A. Reduction of heat loss by continuous cooling operation. (Implemented in fiscal year 2000)

Since this region is relatively cool, we had tried to reduce the cooling energy in the middle season (May, June, September and October) by stopping the fan coils for the cooling in correspondence to the outside temperature. However, when the cooling was stopped, room temperature would increase and people would open the windows. Even when we changed the cooling to continuous operation, this state was unchanged. So we prohibited people from opening the windows and compared the heat amount used with the data of the previous year. As a result, we found that the heat loss from the windows was larger than our estimation. So we changed the cooling to the continuous operation in September and October and the result was that the heat amount used during these months was approximately 22% lower than that during the same period of the previous year.

Of course, there is influence of the outside temperature, so it cannot be said that everything was caused by the difference of the operation system. But, we realized that stopping the fan coil while operating the machine out of adjustment did not have sufficient energy conservation effect in spite of sacrificing the in-house comfort. So we changed the way to conducting continuous cooling operation throughout the summer and the middle season from fiscal year 2001.

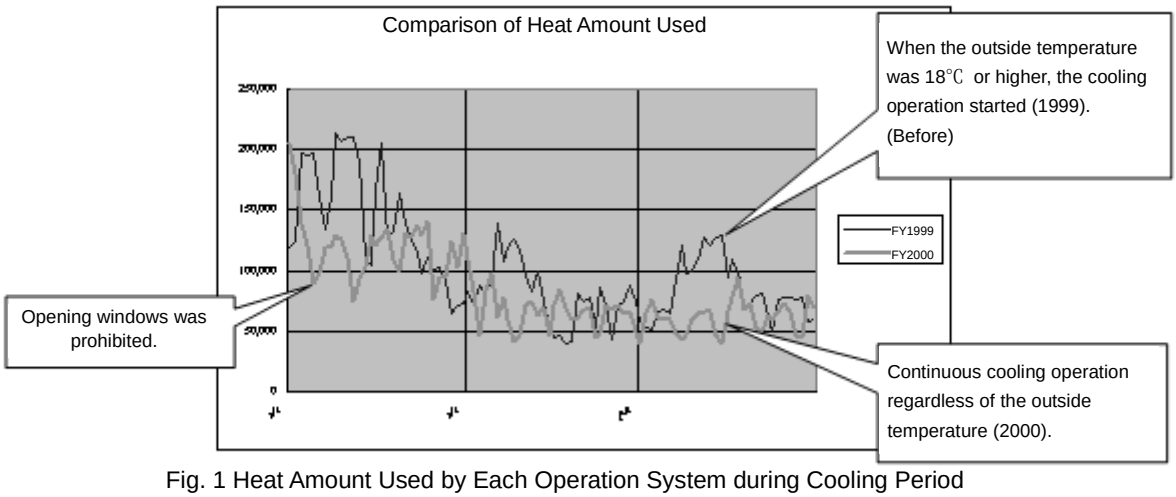


Fig. 1 Heat Amount Used by Each Operation System during Cooling Period

B. Improvement of operation efficiency of the waste heat boiler by heating the combustion air for the cogeneration system (Implemented in fiscal year 2001).

While monitoring the amounts of the power and steam generated by the cogeneration system, it was noticed that the efficiency of the waste heat boiler tended to decline from the beginning of December.

In the middle season when the demand for steam decreases, the operation efficiency of the waste heat boiler naturally decreases. But the above tendency was noticed in the season when the demand for the heating steam was going to be highest and the waste heat boiler must have been working most efficiently, so we checked the boiler focusing on its pressure settling value, but we did not find any problem.

The decrease of the waste heat boiler's efficiency became noticeable when the outside temperature became zero or below, but we kept sending the outside air as the combustion air, because it was generally said that to make the power generation efficiency of the cogeneration system better, the combustion air temperature of the gas turbine should be kept slightly low.

For this reason, we modified a part of the combustion air duct of the cogeneration system and operated the cogeneration system by heating the combustion air with the waste heat staying around the ceiling of the boiler room. As a result, we could improve the operation efficiency of the waste heat boiler approximately 6% compared with that of the waste heat boiler operating in the most freezing season before implementing the measures.

Figure 2 shows the transition of the operating efficiency of the cogeneration system for which measures were implemented in fiscal year 2001.

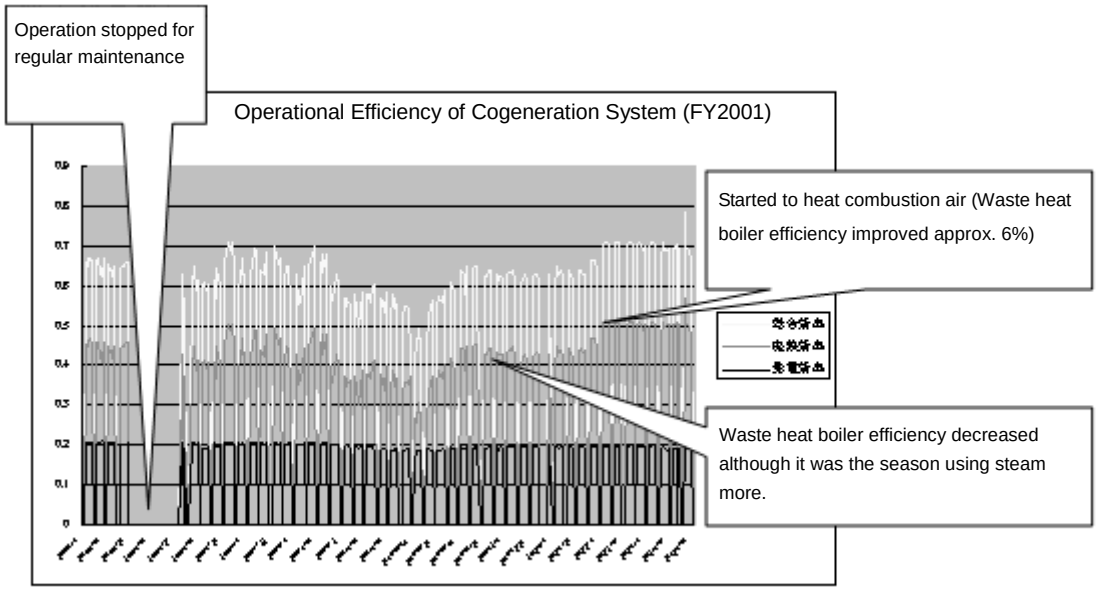


Fig. 2 Transition of Operational Efficiency of Cogeneration System

C. Expansion of operational period by using bypass damper control of total heat exchanger for system air handling unit (Implemented in fiscal year 2003).

If the system air handling unit for the hospital buildings is operated in the winter using the total heat exchanger, the charge air temperature increases about 20℃ and it becomes too hot in the hospital and the total heat exchanger cannot be used until the outside temperature becomes below 0℃. So we used to increase the charge air temperature up to 18℃ to 19℃ with the hot water coil and supply it.

Then, we made it possible to manually open and close the total heat exchanger's bypass damper so that we could discharge all of the air in the winter without passing it through the total heat exchanger. As a result, it became possible to use the total heat exchanger when the outside temperature was around 5℃. Because of this, the operational days of the air handling unit were increased for another 30 days or so in a year, and we could reduce the wasteful use of the hot water since fiscal year 2003 (Fig. 3).

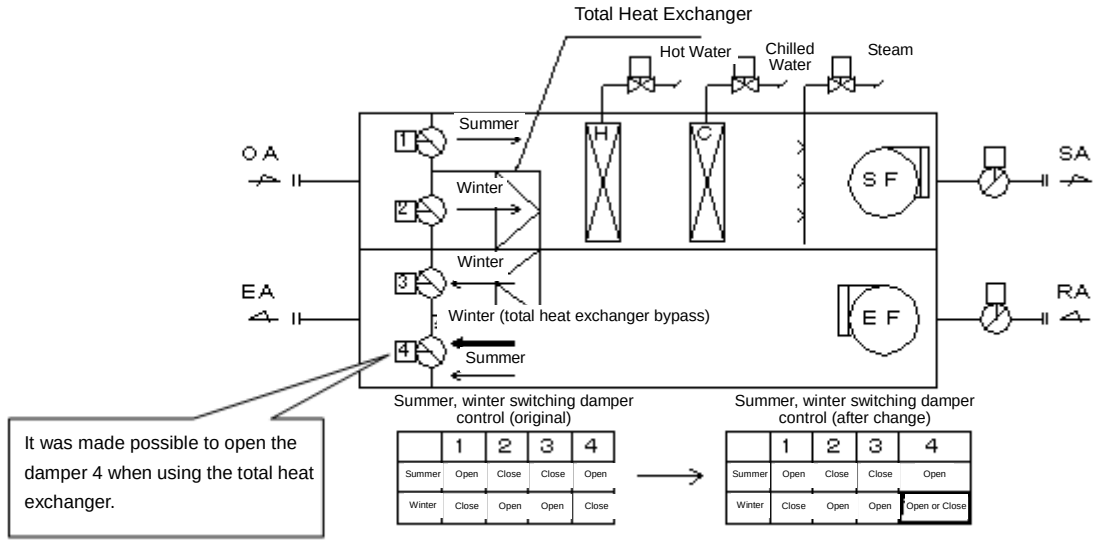


Fig. 3 Schematic of Built-in System Air Handling Unit Total Heat Exchanger

D. Reduction of electricity by using natural cooling heat energy for the closed cooling tower for heat source water (Implemented in fiscal year 2003).

The closed cooling tower is used as a heat source for the heat pump units and there are about 460 heat pump units installed at divisions which work day and night including the inspection division, the medicine division, the X-ray division and the dialysis room.

The temperature of the heat source water for these heat pump units is set at 28℃ to 30℃ throughout a year, and the temperature must be controlled using the cooling tower because there is demand for cooling even in the winter. It snows and the temperature becomes very low in the winter here Sapporo. Still, the water is used for sprinkling water in the winter of snowy cold region Sapporo, so their sprinkling and water supply pipes must be wrapped with the tape heater and electricity must be supplied to it to prevent the pipes from freezing (Fig. 4).

From December, 2003, in order to reduce the pumping power of the cooling tower and the electricity for the tape heater and to prevent the rupture of the sprinkling pipes or water supply pipes due to freezing in case the tape heater was broken, we stopped the sprinkling pump and water supplying and started to operate the cooling tower using the outside air as natural cooling.

As a result, it became possible to smoothly control the temperature of the heat source water, and there is no problem to operate. So we successfully reduced the electricity used for the heater and the sprinkling pump and the well water used for cooling.

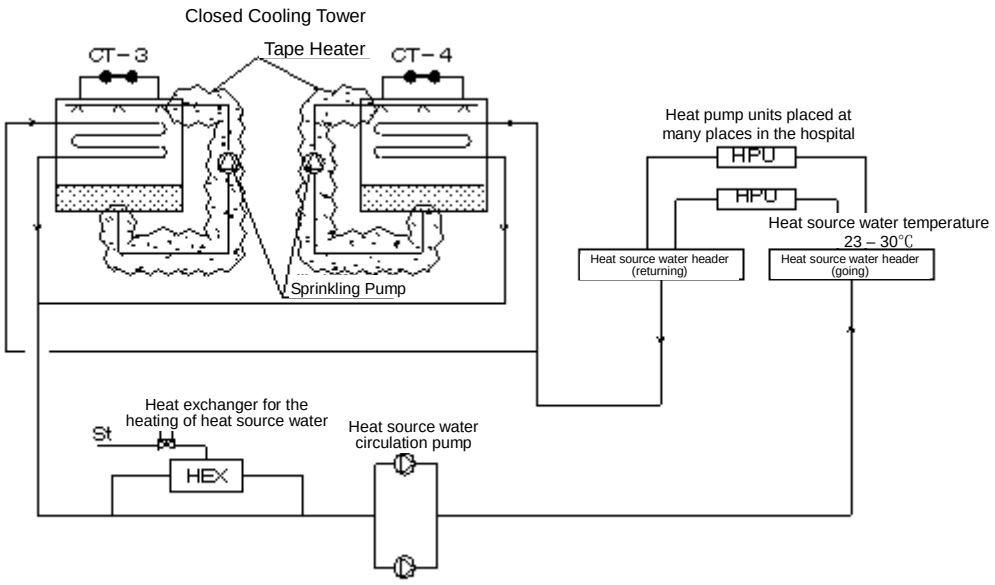


Fig. 4 Heat Source Water System Schematic

(2) Introduction of ESCO Business

In order to reduce the costs of utility which had amounted to as much as 500 million yen a year in Sapporo City General Hospital where vast amount of energy had been consumed, we tried by our own to reduce the amount of energy consumption in the software aspect including operation method of the equipment, and we obtained some results.

To further achieve the target for the reduction of energy consumption based on the Law concerning Rational Use of Energy, we worked with the Environment Bureau of Sapporo City to introduce the ESCO business which concerned the implementation of energy conservation measures such as introduction of inverter air conditioners.

By introducing the ESCO business in Sapporo City before other organizations did, we could expect not only the energy conservation effect as well as environmental and financial effects for the city's facilities but also ripple effects to other municipal bodies and private business organizations in Hokkaido district, thus contributing to the reduction of CO_2 emission which was an environmental issue of the world.

When introducing the ESCO, the ESCO organization investigated the operational state of our equipment and studied the energy reduction plan. As a result, the ESCO organization proposed to reduce the energy approx. 19% and the CO2 emission approx. 19%, so we implemented the reduction measures.

(3) Examination and Result of Measurement and Verification of Energy Conservation by ESCO Business

As a result of the energy conservation activities by the ESCO business in fiscal year 2006, the reduction of the city water and sewer were short to expected amount, but the usage of electricity and gas was reduced greatly by the introduction of ESCO equipment and the more efficient way to operate the equipment. As a result, we could reduce the use of primary energy, CO_2 emission and costs of utility as compared with the expected reduction in Table 1.

Table 1 Achievement of FY2006 (Sapporo City General Hospital ESCO project energy conservation achievement report)

Items	Primary Energy equivalent Value	CO_2 Emission	Reduction of utility cost (Light, Heat and water)
Expected reduction amount	44,062 GJ/year (Approx. 20%)	2,346 t･CO_2/year (Approx. 21%)	43 million yen/year (Approx. 12%)
Achievement of 2006	57,358 GJ/year	3,042 t･CO_2/year	53 million yen/year
Ratio of reduction achievement	130%	129%	123%

5. Effects Achieved After Implementing Measures (Compared with fiscal year 1999)

With all of the above mentioned measures implemented during the period from FY2000 to FY2006, we could reduce the use of the primary energy by 34%, utility cost by 42%, CO_2 emission by 35% and the primary energy consumption specific unit by 35%.

As regards the energy consumption specific unit, we achieved 2.84 GJ/m^2 a year in fiscal year 2006 which was the improvement better than 3.53 GJ/m^2 a year, the average value of the hospitals in the whole country (Fig. 5 to Fig. 8).

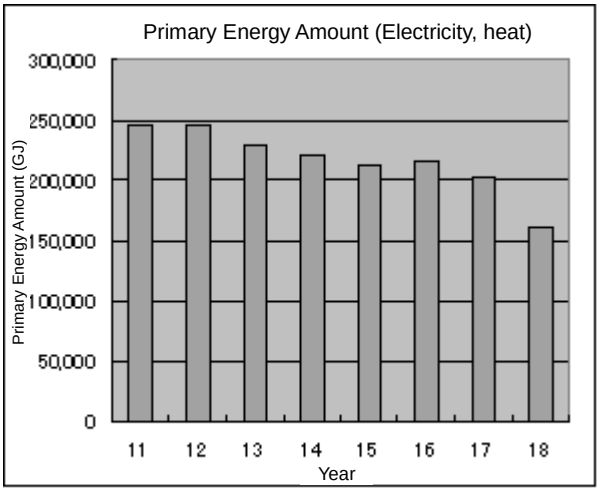


Fig. 5 Primary Energy Amount by Year (Electricity, heat)

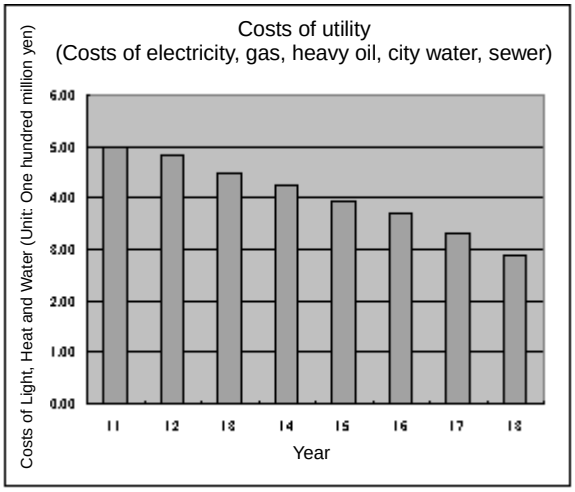


Fig. 6 Costs of Lighting, Heating and Water by Year

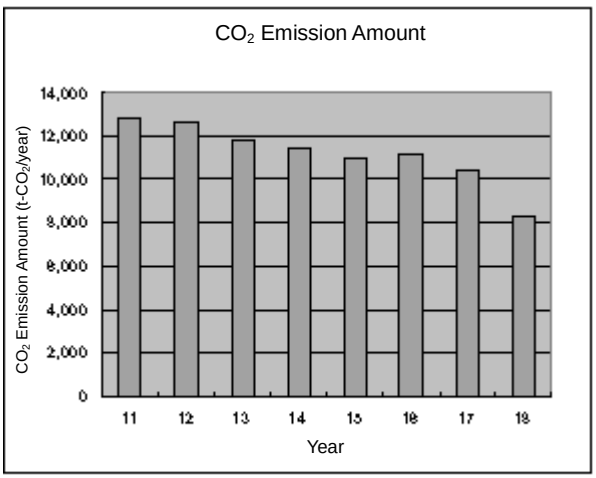


Fig. 7 CO_2 Emission Amount by Year

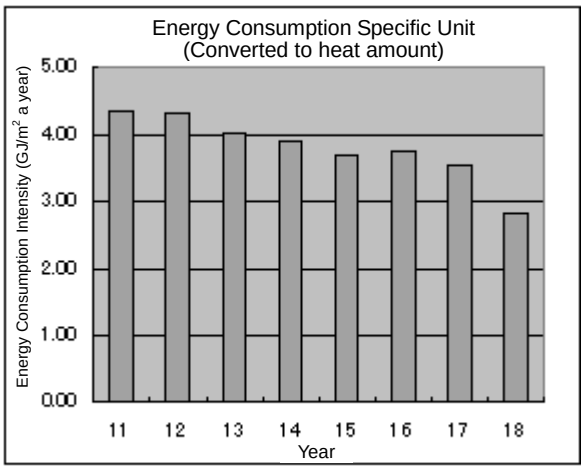


Fig. 8 Primary Energy Consumption Specific Unit

6. Summary

We have continued the energy conservation activities for 7 years since fiscal year 2000. At first, we made the improvement of equipment and the review of operation method for the equipment without great expense and we could reduce the energy by implementing various measures.

In fiscal year 2005, in order to realize greater energy conservation effect, we introduced the ESCO business which conducted 7 years from FY2006 to FY2015 as the service period.

With these activities, we could continuously, almost every year, reduce the energy more than the previous year.

We think we should give the credit for this to the QC activities including the ESCO business which covered the entire energy conservation of the hospital.

7. Future Plans

The ESCO service entered the 2nd year in fiscal year 2007, so we want to establish an operation method which consumes less energy based on the operation result of the previous year. Meanwhile, we will continue the energy conservation activities from now too, because there is no end to the energy conservation.

Lastly, we would like to thank people who helped us make this report.