Energy Conservation and Environmental Improvement in Hospitals

- ESCO Project at Okinawa Hokubu Hospital -

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Environmental preservation is an important corporate social responsibility (CSR) activity as well as financial indicator, not only in industry but also in local governments. This paper reports an example at Okinawa Hokubu Hospital. This hospital introduced the energy service company (ESCO) project and succeeded in reducing expenditure and environmental burden by implementing energy-saving measures while also considering the safety and hygiene of the facilities. In the business model of the ESCO project, service providing companies supply customers with energy-saving equipment, cover the installation cost by reducing utility costs, and create a surplus for customers. This project won the Chairman's Prize, the Energy Conservation Center, Japan (in the support service section in organization category) in the 2009 Energy Conservation Awards sponsored by the Ministry of Economy, Trade and Industry.

INTRODUCTION

Since large general hospitals consume a lot of energy (electric power, heat, etc.) 24 hours, 365 days, advanced control is necessary and effective to increase the efficiency of the use of energy in the facility in the same way as in a plant, etc.

Okinawa Hokubu Hospital, confronting the need to upgrade the aging heat source and air-conditioning systems, etc., was required to take energy conservation measures and upgrade the equipment in order to cut costs and reduce environmental burden according to the environmental policy defined by Okinawa Prefecture. To meet these requirements, an ESCO (Energy Service Company) project was undertaken in 2007 to save energy and improve the environment led by Yokogawa Electric Corporation and joined by 6 companies, including local ones, based on an shared savings agreement in which the ESCO bears the initial cost. The measures to save energy and improve the environment included improving the heat source system with a change of the generator operation.

The project resulted in the improvement of the safety and hygiene for the hospital staff and facility users, as well as achieved an energy reduction rate of 37.4% and a carbon dioxide reduction rate of 51.8%. In January 2010, this project won the Chairman's Prize, the Energy Conservation Center, Japan (in the support service section in the organization category) in the 2009 Energy Conservation Awards sponsored by the Ministry of Economy, Trade and Industry.

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BASIC POLICY FOR TECHNICAL PROPOSAL AND ENVIRONMENTAL PROBLEMS

In undertaking the project, the following basic policy for technical proposal was established, in particular, paying attention to the safety and hygiene for users of the hospital facility, including the staff of the hospital.

- Implement energy saving upgrade to create an environment appropriate to a hospital facility.
- Contribute to global warming prevention by achieving a substantial energy reduction and CO_2 emission reduction.
- Significantly reduce the facility maintenance and management cost while at the same time contributing to management quality improvement.
- Improve the environment inside the hospital facility.

In addition, we took environmental measures, including those to solve environmental problems in this facility as shown below.

- There are annoying vibrations in the rooms of the Emergency Center.
- Equipment in the vicinity of the rooftop smoke vent is prone to corrosion due to soot and smoke.
- Some wall sections in the corridor are hot and air-conditioning does not work well.
- Long-lasting radiation heat inside the hospital due to the afternoon sun causes a burning sensation on the skin.

ENERGY-SAVING AND ENVIRONMENTAL IMPROVEMENT MEASURES

We adopted the measures for the energy-saving and environmental improvement that changed the operation scheme of the generator and fundamentally renovated the heat source system that enables the change. Also, we aggressively introduced products that have features to meet the needs of the hospital and advanced energy-saving systems such as a phosphorescent evacuation indicator and water pump energy saving control system. The following provides an overview of these measures.

Fundamental Renovation of Heat Source System

Table 1 shows environmental problems and factors related to the heat source system before the improvement.

Table 1 Environmental Problems and Factors related to Heat Source System

Problem	Factor
There are annoying vibrations in the rooms at the Emergency Center.	Vibrations are generated depending on the operation condition of the generator.
Equipment in the vicinity of the rooftop smoke vent is prone to corrosion due to the soot and smoke.	Soot and smoke due to fuel oil combustion for the generator via the rooftop smoke vent causes corrosion of the equipment installed on the rooftop.
Some wall sections in the corridor are hot and air-conditioning does not work well. (The effective temperature of the wall is approximately 50 °C)	Fuel oil combustion gas from the generator passes through the flue and the heat transfers to the wall in the corridor in the vicinity of the flue.

We reviewed these problems and concluded that the use of A-type heavy oil (equivalent to bunker A oil) and combustion exhaust gas should be reduced and the operation scheme of the generator should be changed to solve the problems.

With respect to a substantial change of the operation scheme of the generator and the heat source system, we decided to change the operation of the generator from regular use to emergency use, suspending the operation during regular times. This change can not only reduce the operation and equipment upgrade costs but also significantly improve the environment.

The following shows energy-saving measures as well as measures to solve the above problems. Figure 1 provides an overview of the heat source systems before and after the improvement. Numbers in the figure correspond to those for the measures to be explained below.

- Measure 1: By changing the operation of the generator from regular use to emergency use, the A-type heavy oil consumed by the generator, the combustion exhaust gas, and the generation of vibrations were minimized. The generator is only operated for emergencies and periodic maintenance.
- Measure 2: By upgrading the steam absorption refrigerator to a highly efficient inverter (INV) turbo chiller and eliminating the use of steam for the refrigerator, the use of A-type heavy oil and combustion gas exhaust were reduced. The existing cooling tower for the steam absorption refrigerator was used for the new highly efficient INV turbo chiller to minimize the cost. The existing water-cooled chiller was not removed but is put out of operation during regular times so that it can be used as backup equipment for emergency maintenance of the highly efficient INV turbo chiller, or in case of an unexpectedly high load.
- Measure 3: Steam is essential for the sterilization in the kitchen and the medical central supply room. Production of steam was limited only to the demand that essentially needs steam. Accordingly, the flue and smoke tube boiler was upgraded to a once-through boiler with an appropriate capacity, resulting in a significant reduction in the use of A-type heavy oil and combustion gas exhaust.

With the fundamental change of the operation scheme of the generator and the heat source system, the vibrations in the rooms in the Emergency Center were removed, the corrosion of equipment in the vicinity of the rooftop smoke vent was stopped, and the wall temperature in the vicinity of the flue became low so that heat is not felt anymore. The generator suspended due to the change of the operation scheme is periodically run on a trial operation basis to prepare for an emergency in the event of a blackout, etc.

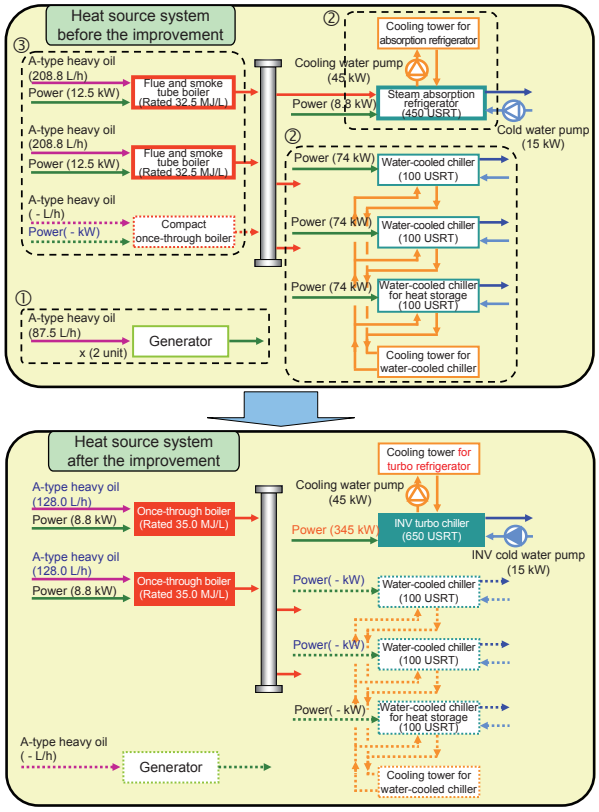


Figure 1 Improvement of Heat Source System

Adopting Three-Mode Switch Lighting

Three-mode switch lighting was adopted in response to the improvement request received from the nurses' station that more brightness of the light than usual is needed occasionally. The three-mode switch light employs a double-click method

in which turning the switch off and on within two seconds switches between three brightness modes: Energy-saving, Medium, and High, and so the existing switch can be used as is. Each of the modes has an energy-saving effect compared with the existing light, and since the light turns on normally in energy-saving mode, a significant energy-saving effect can be expected. Since the upgrade work just require to replace the stabilizer and fluorescent tubes and then clean the lighting equipment, and does not require to replace the selector switch in the facility, it was completed almost without interrupting the operation of the hospital.

Implementing Stable Operation and Energy Management by Upgrading Central Monitoring and Control System

We upgraded the aging central monitoring and control system emphasizing the fact that the hospital is operated all day long. Duplex architecture was employed for upper-level controller and upper-level network to provide redundancy and ensure stable operation. When upgrading this system, energy management points were added to form an energy management platform for future improvement of the energy management quality. Yokogawa's CENTUM CS 3000 Integrated Production Control System and FA-M3 Range-free Controller were employed as the core of this system.

Adopting Phosphorescent Evacuation Indicator

Phosphorescent evacuation indicators, which won Chairman Prize of Energy Conservation Center, Japan (ECCJ), Energy Conservation Grand Prize for excellent energy conservation equipment, in 2006, was adopted. Since this product had never been used in any hospital facility in Okinawa, presentation was to be given at the fire station in the region to explain the product and the objective and benefits of introducing the product before approval was obtained. This evacuation indicator does not use any power to produce luminescence, so no power needs to be supplied, and no consumable parts are contained in the structure, so no consumable parts and maintenance costs are required.

Adopting Econo-Pilot water pump energy saving control system

Yokogawa's Econo-Pilot water pump energy saving control system, which won Director General Prize of Agency of Natural Resources and Energy, Energy Conservation Grand Prize for excellent energy conservation equipment, in 2002, was adopted. This product applies pipe friction predictive control to achieve maximum energy saving effect, which method constantly measures the load-side flow rates and controls the revolutions of the pump to enable the optimal water supply pressure to be applied according to the measured load flow rates. For details on the pipe friction predictive control, refer to "Econo-Pilot HSP Energy-saving System for Heat Source Water Pumps" in this issue.

Automating Basin Water Tap and Installing Water Saving Device

Since the annual water resource abundance per capita in Okinawa is less than 60% of the nationwide average, water resources are important. Accordingly, water saving is also an important issue, so the basin water taps were automated and water saving devices were installed to the water taps and toilets in order to save water. The automatic water tap eliminates the need for users to touch the tap and thereby improves hygiene for facility users.

ENERGY-SAVING EFFECTS AND INTANGIBLE ENVIRONMENTAL IMPROVEMENT EFFECTS

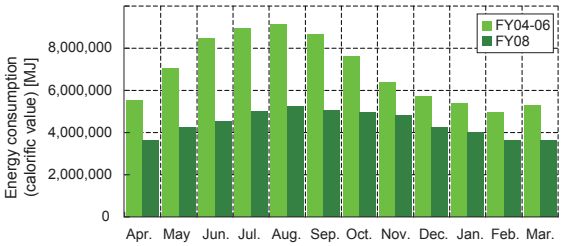
Energy-saving Effects

As shown in Table 2, this project saved a significant amount of energy in FY08 compared with the 3-year average from FY04 to FY06. Figure 2 and 3 show reduction of energy consumption and use of water per month.

Table 2 Energy-saving Effect List

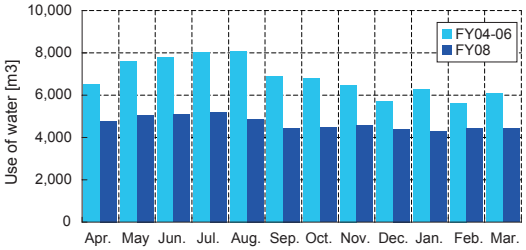
Item	Effect	Unit	Remarks
Energy reduction	31,115,760	MJ	Sum of the electric power and fuel oil reduction after conversion to calorific value
Carbon dioxide reduction*1	2,430,448	kg-CO_2	Carbon dioxide reduction (compared with the 3-year average from FY04 to FY06)
Energy -saving rate	37.4	%	Energy reduction rate (compared with the 3-year average from FY04 to FY06)
Carbon dioxide reduction rate	51.8	%	Carbon dioxide reduction rate (compared with the 3-year average from FY04 to FY06)
Cost reduction*2	59,298,444	¥	Sum total of electricity charge, A-type heavy oil charge, and water charge reduction value

*1 : Carbon dioxide conversion factors used to calculate the carbon dioxide reduction volume were provided by Okinawa Prefecture at the ESCO project bid.
*2 : Lighting, heating and water utility cost reduction (including tax).



FY04-06: Past 3-year average (base line) from FY04 to FY06
FY08: Energy consumption in FY08

Figure 2 Energy Consumption



FY04-06: Past 3-year average (base line) from FY04 to FY06
FY08: Use of water in FY08

Figure 3 Use of Water

Table 3 List of Improvement Details and Intangible Environmental Improvement Effects

Improvement Item \ Intangible Environmental Improvement Effects		Cost Reduction						Environmental Improvement inside Hospital										Social Responsibility		Environmental Burden Reduction ••• Effective use of water resource	Fossil Fuel Conservation ••• Effective use of fossil fuel
		Corrosion prevention of rooftop equipment	Equipment maintenance cost reduction	Deterioration prevention of medical equipment, etc.	Reducing the air-conditioning load by suppressing the heat transfer from the flue	Reducing air-conditioning load by suppressing the solar radiation heat	Reducing the purchase work of A-type heavy oil, etc.	Reducing the radiation heat from the wall by suppressing the heat transfer from the flue	Vibration and noise reduction	Increasing convenience for tap water users	Improving hygiene for tap water users	Reducing UV load on the eyes	Increasing convenience for lighting users	Increasing safety by preventing the scattering of broken glass pieces	Increasing safety for facility users	Optimizing air-conditioning in the hospital	Increasing efficiency of the energy management work	Reducing the times of tank trucks driving into the hospital	Ensuring smooth traffic in the vicinity of the hospital		
Improving the heat source system	Changing the operation scheme of the generator (from regular use to emergency use)	✓	✓		✓		✓	✓	✓									✓	✓		✓
	Upgrading the steam absorption chiller to a highly efficient INV* turbo chiller (650 USRT**)		✓		✓		✓	✓										✓	✓		✓
	Controlling the rotation of the primary cold water pump according to secondary-side load changes																				✓
	Upgrading the flue and smoke tube boiler to a once-through boiler		✓		✓		✓	✓										✓	✓		✓
	Changing the connected boiler of the existing water-cooled chiller		✓																		
	Installing a detachable thermal jacket on the steam pipe						✓								✓						✓
Improving the air-conditioning system	Using the Econo-Pilot water pump energy saving control system for controlling the secondary cold water pump																				✓
	Introducing air volume control by the INV* revolution control of the air-conditioner fan motor and combining an energy-saving fan belt																				✓
	Using air volume control by the INV* revolution control of the supply and exhaust air fan motor according to the kitchen's exhaust temperature																				✓
	Upgrading the aging air-conditioner and sirocco fan															✓					
Upgrading the central monitoring and control system	Upgrading the central monitoring and control system																✓				
	Making the energy management items appropriate																✓				✓
	Introducing the energy management system																✓				✓
Other improvements	Increasing the lighting efficiency												✓								✓
	Upgrading the evacuation light to the phosphorescent evacuation indicator		✓												✓						
	Automating the basin water tap									✓	✓									✓	
	Installing a water-saving device to the water tap and the toilet																			✓	
	Introducing light-blocking film to the windows			✓		✓						✓		✓							

* INV : Inverter ** USRT : U.S. refrigeration ton

Improvement Details and Intangible Environmental Improvement Effects

This ESCO project put emphasis on the design to create an environment appropriate to the facility, including environmental improvements inside the hospital. Table 3 shows a list of intangible effects other than the numerical effects explained in Table 2. The effects are classified into categories: Cost reduction, Environmental improvement inside the hospital, Social responsibility, Environmental burden reduction, and Fossil fuel conservation.

The effects to note include a reduction in the heat transfer from the flue to the wall surface as a result of changing the operation scheme of the generator, environmental improvement inside the hospital as a result of the reduction of vibrations and noise, and corrosion prevention of the rooftop equipment as a result of the reduction of soot and smoke.

CONCLUSION

It is important for the energy-saving efforts in a hospital facility to consider environmental improvements inside and outside the hospital, in addition to the reduction of lighting, heating and water utility costs. Another key to the success of an ESCO project is collaboration with local companies.

By combining the know-how of energy-saving and environmental improvement applied to this project and Yokogawa's know-how of production efficiency improvement accumulated in the areas of measurement, control, and information, we will continue to propose energy-saving solutions to create maximum effect for customers who are committed to environmental improvement and operation improvement in hospital facilities, manufacturing plants, etc. and we will contribute to the environmental management and business activities of customers.

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