

Using IT to Eliminate Energy Waste in Production Lines

- A Case of Yokogawa's Kofu Factory -

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The Kofu factory of Yokogawa Electric Corporation has been working on conserving energy since the 1990s. In October 2009, it won the Minister of Economy, Trade and Industry Award in the Green IT Award 2009, which was held by the Green IT Promotion Council. It was commended for introducing an energy conservation management system which, combined with the production management system, visualizes the amount of energy consumed per product while securing quality, delivery time and safety; as well as for ongoing improvement activities, monitoring energy consumption by each line, and everyday electricity control. This paper describes these award-winning energy conservation activities, focusing on changes of CO₂ emission, Yokogawa's energy-saving IT products, and introduction of the benefit principle which makes employees more energy-aware.

INTRODUCTION

The Kofu factory of Yokogawa Electric Corporation has been working on energy-saving activities since the 1990s. In October 2000, the Kofu factory won the Minister of Economy, Trade and Industry Award in the Green IT Award 2009 for introduction of an energy-saving management system that identify the energy consumed per unit of products while ensuring quality, delivery and safety in conjunction with a production management system, and for accumulated measures such as sober improvement activities, monitoring of the amount of energy consumed in each production line and managing of electric power on a daily basis. The Kofu factory is also highly evaluated for such activities as setting medium- to long-term environmental targets and disclosing results.

This paper discusses energy-saving activities until the winning of the award, focusing on changes in CO₂ emissions and production output, visual management of energy consumption and energy-saving case studies using Yokogawa's energy-saving IT products, and the benefit principle for encouraging employees to save energy.

OVERVIEW OF ENERGY-SAVING ACTIVITIES

Figure 1 shows the appearance of award-winning Kofu factory. Figure 2 shows changes in CO₂ emissions, production output, and CO₂ emissions per production output in the Kofu factory. CO₂ emissions are calculated by converting the amount of electricity and city gas consumed to CO₂ emissions

equivalent, while production value is calculated by summing up the list prices of products made in the factory. The management index is a basic unit of CO₂ emissions (tons) per 100 million yen of production, which is standard in the electric and electronics industry in Japan.



Figure 1 Kofu Factory

The energy-saving activities in the Kofu factory are divided into three phases, which are discussed in detail in the following sections.

- 1) The phase of awareness (FY90 to FY98)
CO₂ emissions were curbed while production increased slightly, so CO₂ emissions per production output was reduced by 23% compared with that in FY90.
- 2) The phase of energy reduction using Yokogawa's IT products (FY99 to FY06)
Although production rose significantly, CO₂ emissions per production output was reduced by 56% using Yokogawa's energy-saving IT products compared with that in FY90.
- 3) The phase of model factory (since FY07)
A new building (No. 7 building) was completed, while production output was hardly boosting, so CO₂ emissions

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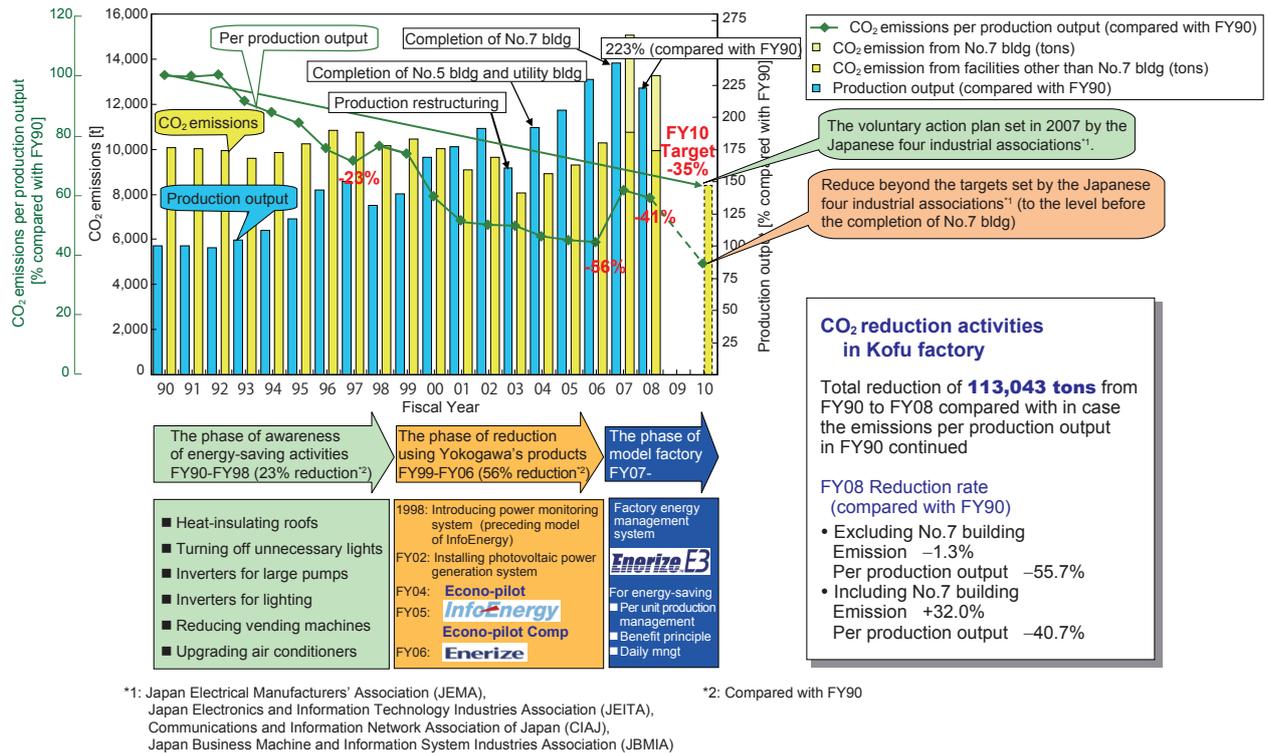


Figure 2 Changes in CO₂ Emissions, Production Output, and CO₂ Emissions per Production Output in the Kofu Factory

increased significantly, and the reduction ratio of CO₂ emissions per production output compared with that in FY90 was 41%, which was lower than that in the previous phase. Therefore, measures to conserve energy were reviewed and ways of reducing factory costs relating to energy consumption were studied for the first time in Yokogawa's factories. The Kofu factory re-started its activities as a model factory of Yokogawa.

THE PHASE OF AWARENESS

At that time, the importance of saving energy came to be recognized publicly as well as in the factory. Zero emission activities were carried out jointly with other factories in the Kokubo Industrial Park where the Kofu factory is located. Employees became more aware of environmental preservation and energy saving through activities such as recycling of waste paper and plastics.

Workers turned off unnecessary lights when and where possible, and the company invested in auxiliary facilities for buildings such as applying heat-insulating coatings on the roofs of factory buildings. However, since the amount of energy consumption was not measured, energy savings had to be calculated manually and the estimation greatly fluctuated depending on the rate of operation assigned for each equipment.

PHASE OF REDUCTION USING YOKOGAWA'S IT PRODUCTS

In this phase, energy consumption started to be measured and we tackled the reduction of energy consumption per production

output through measurement and control using Yokogawa's IT products. Meanwhile, an environment management system was set up in 1997, ISO 14001 certification was acquired, and environmental preservation activities were accelerated through PDCA cycles to achieve energy saving targets. The following examples show how Yokogawa's IT products are used.

Introducing Econo-Pilot

Econo-Pilot water pump energy saving control system was introduced and control for water flow for air-conditioning in No. 5 building was changed from return water valve control to motor revolution control. For example, when the water flow is halved, the electric power consumed by the motor of the water pump is theoretically reduced to one eighth. So the electric power required is significantly reduced. Figure 3 shows the effects of introducing Econo-Pilot. Energy consumption in FY03 reduced by 75% compared with that in FY00.

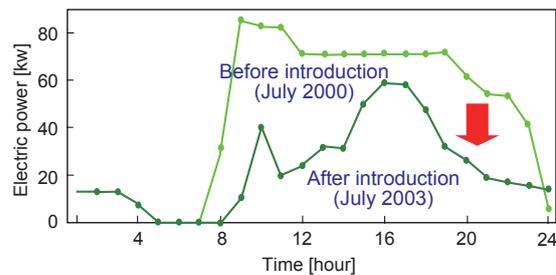


Figure 3 Effects of Introducing Econo-Pilot

Introducing InfoEnergy

InfoEnergy distributed energy management system was introduced to measure and collect data on energy usage and thus to visualize how energy is used.

InfoEnergy identifies the correlation between the inputs such as electric power and gas consumed by equipment and the outputs such as the temperature and flowrate of cold/hot water and the pressure and flowrate of compressed air created by equipment, and shows the efficiency of energy usage and wasted energy. InfoEnergy collects data on power consumption as well as digital and analog signals such as temperature, pressure and flowrate, and manual data input is available as well. In addition, its grouping function can display usage by area or type (air-conditioners and lighting) and its alarm output function ensures that abnormalities can be quickly dealt with. InfoEnergy does not require dedicated viewing software; the information can be displayed on any PCs connected to an in-house LAN, and everybody can confirm the situation. Figure 4 shows its functions and utilization.

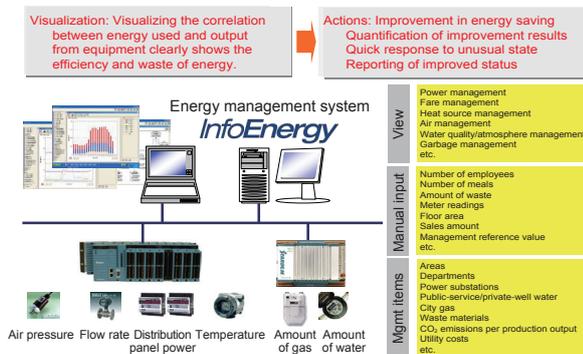


Figure 4 InfoEnergy Functions and Utilization

The introduction of InfoEnergy enabled to estimate energy-saving effects based on actual measurements before implementing the measures and verify the effects based on actual measurements rather than theoretical calculations. In the case of compressed air described below, the power consumed by the compressors and the amount of compressed air were measured to confirm the efficiency of each compressor and identify low efficient compressors. This information was taken into account when making energy-saving measures and investment plans; to be stopped during the light workload or prioritized for upgrading.

Introducing Econo-Pilot Comp

The Kofu factory is using compressors to compress air and uses it as energy for production. Introducing Econo-Pilot Comp compressor energy-saving control system for eleven screw-type compressors significantly reduced power consumption.

To keep the pressure constant, compressors are switched between load operation (compressing air) and unload operation (standby). Even during unload operation, compressors consume about one-third of power that is used during the

load operation so that they can be promptly switched to load operation at any time. Thus, the key to saving energy is to eliminate unnecessary unload operation and stop them. To do this and conserve energy, Econo-Pilot Comp controls multiple compressors systematically by restricting the number of compressors in operation and predicting a possible pressure drop. Figure 5 shows the effects of introducing Econo-Pilot Comp.

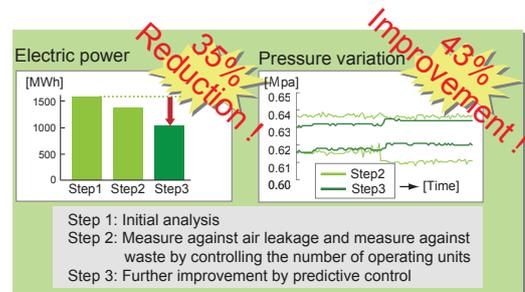


Figure 5 Effects of Introducing Econo-Pilot Comp

To prevent air leakage, flowmeters were installed in each area, with which InfoEnergy measured the amount of compressed air. Compressed air supply valves were also installed to stop the supply of compressed air on site when the production line is stopped.

THE PHASE OF MODEL FACTORY

While production output hardly increased, a new building was completed (floor area of approx. 12,000 m²). The air-conditioners in the building consumed large amounts of energy to keep temperature and humidity constant, which increased CO₂ emissions per production output. Accordingly, along with developing countermeasures for the new building, new measures were implemented as a model factory in Yokogawa, which include the measurement of CO₂ emissions per unit production and allocation of heating and lighting costs (hereafter call them utility costs) to each department.

Integration of Top-down and Bottom-up Energy-Saving Measures

To improve the CO₂ emissions per production output, top-down and bottom-up energy-saving measures have been integrated.

As a top-down measure, energy saving was designated as a critical management item of the factory, like product quality and product cost, and numerical targets were set for each department. Also, Enerize E3 factory energy management system was introduced to build a system for allocating utility costs according to electricity and gas consumed by each department and for managing power consumption on a daily basis.

Thanks to these, workers became much more aware of energy saving in production. In 2008, workers focused on energy saving activities relating to air-conditioning, such as shortening the operating time of air-conditioners and lighting by reducing over-time work owing to improvement of operating efficiency, turning off air-conditioners 30 minutes

before the end of working hours, and optimizing the humidity settings which greatly affect the energy consumed by air-conditioners. This integration of top-down and bottom-up measures significantly reduced energy and costs.

Introducing Enerize E3

Focusing on the production line for EJA pressure/differential pressure transmitter which is the main product of the Kofu factory, Enerize E3 was introduced to manage the energy required to produce one product rather than per production output and to build a system for allocating utility costs according to the electricity and gas consumed by each department. Figure 6 shows the flow of production line.

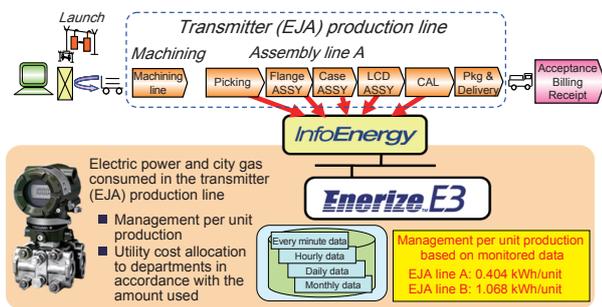


Figure 6 Introducing Enerize E3 to the EJA Production Line

To determine production quantity, product data in each process was acquired from the production management system. The electricity for lighting and air-conditioners across the floor and 100 V AC power and city gas consumed by respective processes were allocated to each process in proportion to the area occupied. The 200 V AC power was allocated to each process according to the rated electric capacity in the production equipment inventory information. Enerize E3 acquires and processes this information, and calculates and displays the energy consumption per unit production. Figure 7 shows typical screen shots.

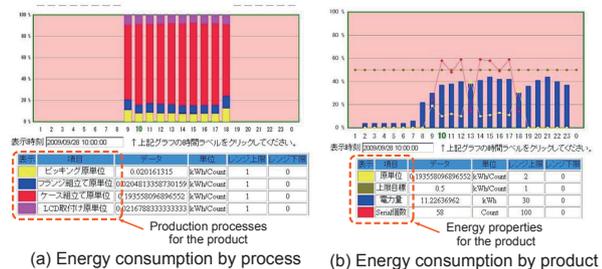


Figure 7 Screens of Energy Consumption per unit production

Enerize E3 was effectively used to build the system for allocating utility costs in accordance with electricity and gas consumed by each department. Since each process belongs

to a certain department, the electricity and gas consumed by each department can be calculated easily.

Before introducing Enerize E3, the utility cost budget was estimated based on the actual total cost of the previous year, and the utility cost per m² was calculated by dividing it by the effective total area of the factory. The actual utility costs were also calculated in the same way. In this approach, however, the utility costs per m² of a department using only PCs was identical to that of other departments having a clean room or machine tools which consume large amounts of electric power. This was not fair in terms of the benefit principle. In addition, this approach had a demotivating effect on energy saving efforts, because even if a certain department took energy-saving activities the effect was diluted across the factory.

After introducing Enerize E3, utility costs can be allocated based on actual consumption. So a department which successfully conserved energy can enjoy its effect in the form of lower utility costs. Enerize E3 powerfully encourages energy-saving activities by linking them to the production costs, which is one of real targets for each production department.

CONCLUSION

This paper described the transition of energy usage and energy-saving activities in the Kofu factory of Yokogawa Electric Corporation.

As for the management per unit production, some people had raised doubt about its necessity and importance. But all workers at the Kofu factory succeeded in achieving it for the first time in Yokogawa, considering it essential for further reducing production costs and preventing global warming.

Energy is required to make products but must be appropriate. Extra electric power not only boosts the production cost, but also wastes the fossil fuel, emits the extra CO₂, and accelerates global warming. The same is true for extra city gas. Extra energy does not disappear but has other adverse effects. For example, it accelerates the wear of drill edges and taps, causing further electric power consumption, which may result in a malfunction due to overload of motors or manufacturing defects. Furthermore, overheated machines may raise ambient temperature or generate oil smoke. These problems including product defects and environmental damage require additional energy. We will therefore continue working hard to minimize extra energy consumption and accelerate energy-saving activities.

The Kofu factory arranges tours to see our energy-saving efforts in action. Please join the tour. We hope that the energy-saving efforts and technologies of the Yokogawa group will help the environmental management and business of our customers.

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