Optimized Energy Management at Fujitsu Group Companies

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Fujitsu has established environmental reference models by using information and communications technology (ICT) products and solutions with the purpose of reducing the environmental load on consumers and society and improving environmental efficiency. Under the banner "Green Reference for Tomorrow," Fujitsu has designated four types of facilities within the Fujitsu Group—R&D sites, plants, offices, and data centers—as the types of sites to be modeled. Various types of know-how are accumulated by putting the solutions into practice at these sites. "Energy management" is a core solution, and Fujitsu has striven to continuously improve it by optimally using the knowledge it has obtained through operations at these sites. This paper presents a new type of environmental management based on the Fujitsu Group environmental policy. It is implemented in an "Environment Management Dashboard" solution. The paper also discusses the expansion of this solution to all of the Fujitsu Group sites and introduces our research and development initiatives at representative R&D, factory, and office sites.

1. Introduction

In the Fujitsu Group, we are expanding our business activities by incorporating management policies in accordance with our commitment to environmental sustainability, which is positioned as one of the most important items in the management of environmental conservation. The Fujitsu Group environmental policy, which defines the concept of our environmental practices, helps reduce the environmental load on consumers and on society in general and helps improve environmental efficiency through the provision of an integrated service based on superior technology and ICT products and solutions.

Here we present the "Environment Management Dashboard" solution, which implements a new type of environmental management based on this policy, discuss the expansion of this solution to all of the sites in the Fujitsu Group, and introduce our initiatives for representative R&D, factory, and office sites.

2. Initiatives common to all sites

When a company implements environmental practices, it generally evaluates and verifies those activities, gathers a variety of environmental information for implementing sustained improvements, creates indicators for that information, and applies them.

In the Fujitsu Group as well, we have gathered environmental information using an environmental performance summarization system and a basic environmental practices system in order to strengthen environmental management by implementing environmental practices performed by various activity agents that work autonomously in-house. We have created an "Environment Management Dashboard" as an information system that enables us to reference and apply this environmental information in a one-stop manner through an intraweb, which started operation in July 2011.[1] During the initial creation period, we set CO_2 output as the key performance indicator (KPI) for environmental practices. Then, after the Great East Japan Earthquake and Tsunami, we added electrical power usage and cost as input information because we determined that it is also important to manage the cost of electrical power as a KPI (**Figure 1**). We use the number of employees in the workplace, the total floor area, and the number of units produced as the denominator of the consumption indicator used to evaluate energy efficiency, which is another KPI. As an example

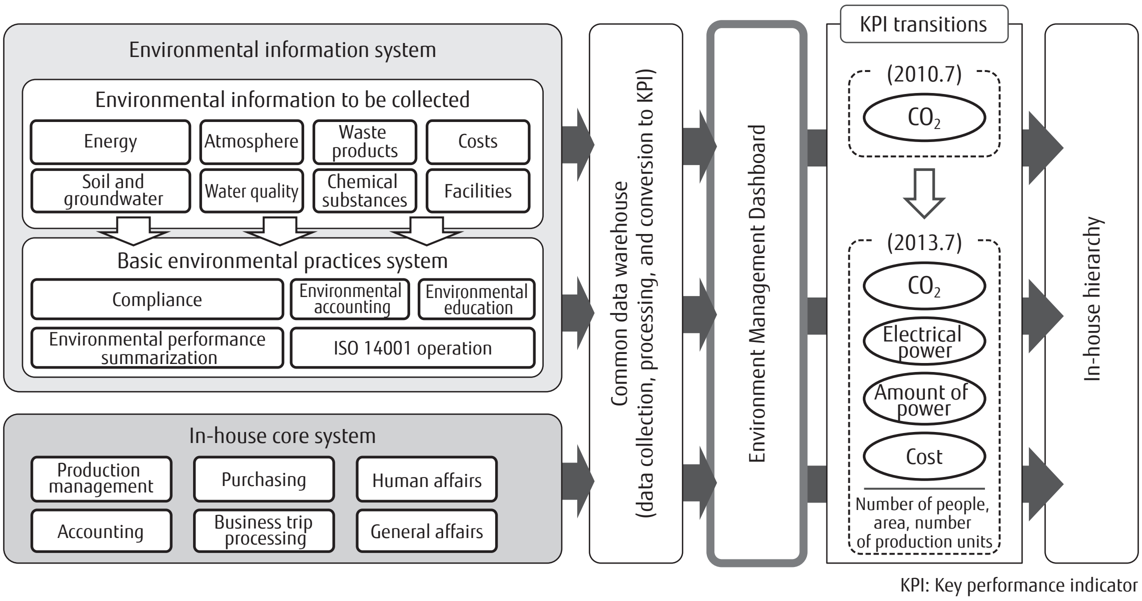

Figure 1
Environment Management Dashboard and KPI transitions.

of these efforts, here we introduce the main functions of the Environment Management Dashboard.

2.1 Dashboard function with electrical power as KPI

Usage limits were set on electrical power usage in the summer of 2011, after the Great East Japan Earthquake and Tsunami struck. As a result, many business offices, including those of companies in the Fujitsu Group, implemented energy-saving measures to control peak electrical power usage. We implemented these measures through the introduction of our Environment Management Dashboard into our 72 (at that time) offices throughout Japan that had contracted for electrical power of 500 kW or more. This dashboard enabled us to monitor electrical power usage in 30-minute units.

Data on electrical power usage is collected in the following two ways. For offices with Fujitsu's building management system, data on incoming electrical power and usage is collected by the building management system. It is output as a file in CSV format and transmitted by file transfer protocol (FTP) to a database in which it is collected and then used to visualize power usage. For offices with a non-Fujitsu building management system or with no such system, measuring equipment was newly installed for acquiring data from the output signals of the meters installed by electrical power companies in substations. The measurement data is transmitted in CSV file format to a data-collection server using a LAN or mobile communications network. This data collection process has enabled real-time management of the efforts to not exceed the targeted peak electrical power usage in each office.

Within the Fujitsu Group, we have also applied the "Joint Utilization Control Scheme" as defined by the Electric Business Act. This has enabled us to monitor electrical power usage at all the participating workplaces and has contributed greatly to our energy-saving activities.

The information system created by the Environment Management Dashboard is continuously being improved on the basis of operating results. One example of this is the function we developed for predicting peak electrical usage. We found that we could implement more effective energy-saving measures for an office if we could predict the day's peak electrical usage and the time at which it would occur. We thus developed such a prediction function and incorporated it, along with the predicted electrical power demand curve, into the Environment Management Dashboard.

The prediction function comprises a model for predicting the peak power and one for predicting the demand curve. The peak power prediction is done by multi-regression analysis using the ambient temperature at 6:00 a.m., the power consumption at 9:00 a.m., previous power consumption data, and previous ambient temperature data. The demand curve prediction is done by normalizing and combining previous demand patterns that are similar to that day's demand pattern (**Figure 2**).

2.2 Dashboard functions with amount of power and cost as KPIs

After the Great East Japan Earthquake and Tsunami, nuclear power stations mostly halted operations, and energy costs rose due to the resulting increase in the proportion of power generated from fossil fuels and to the increases in fuel regulatory costs. These increases in energy costs affected the operations of most companies, including those in the Fujitsu Group. We thus developed a function that enables users to monitor power usage and related cost information in order to quickly and effectively aggregate information on energy cost and to use the results. More specifically, management can continuously monitor electrical power unit price information (yen/kWh) for all the offices within the Fujitsu Group.

2.3 Dashboard function with CO_2 output as KPI

The Fujitsu Group has set a target of reducing greenhouse gas emissions (mainly CO_2 output) attributable to our offices by at least 20% compared with 1990 levels by March 2016. To help management achieve this target, we have made it possible for managers to access CO_2 emission data on the Web. These data include the annual target, the current month target, and the current month results.

In addition to the already implemented comparison/analysis functions, management support functions for each business department and workplace, and message functions, we have newly developed and/or improved three dashboard functions.

1) Drill-down function

We have developed a drill-down function that enables users to view information for the entire Group, for individual offices, and for other organization levels, either in summary or detailed form. For example, a user can view CO_2 emission levels for the whole company, for a building, and even for a workplace. This function is linked to the energy management function described in Section 3.1. It is particularly useful for determining the causes of increases and decreases in CO_2 emissions.

2) Specific consumption indicator management function

Under the Act on the Rational Use of Energy (Energy Conservation Act), business operators are being asked to reduce their specific energy consumption by an annual average of at least 1%. The specific consumption indicator management function

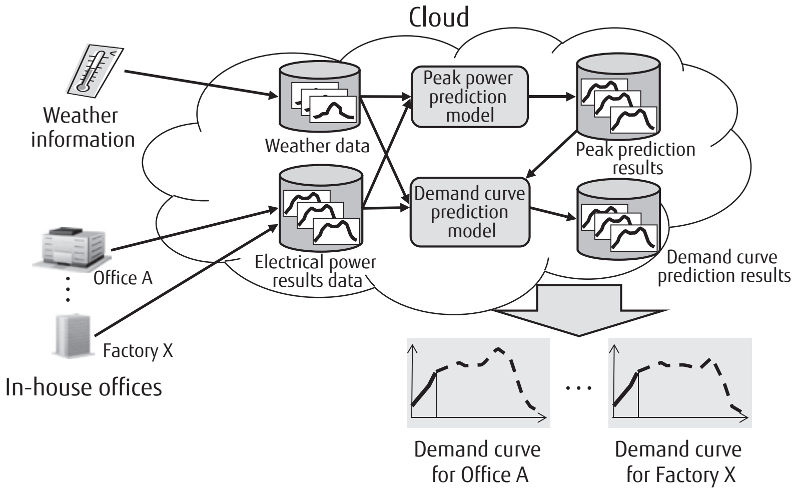

Figure 2
Models for predicting peak electrical power and electrical power demand curve.

we developed enables users to calculate the specific energy consumption for the number of people in or the area of a workplace. The energy usages of our approximately 1000 offices and tenant offices in Japan are collected using a system designed for the Energy Conservation Act. Each usage is then divided by the number of people in or the area of the corresponding workplace. This enables the specific energy consumptions to be compared and to be sorted in ascending or descending order.

3) Improved message function

A limit on CO_2 emissions is set each month for each workplace. If the limit is reached or exceeded, "alert" is displayed on the dashboard. If the emissions are between 95% and 100% of the limit, "attention" is displayed. And if the emissions are less than 95% of the limit, "achieved" is displayed. Previously, the result for a workplace was visible only on the page for that workplace. An improvement to the function has made it possible to view the result for any workplace from the top page by selecting from a pulldown list categorized in accordance with the business structure. Another improvement enables multiple workplaces for each division to be selected on a map. The results for those workplaces are then displayed together, enabling the user to quickly compare workplace performance.

2.4 Future development

This dashboard function will enable the use of various advanced technologies to support Smart Cities. For example, demand response technologies can be used to support the introduction of smart meters, the introduction and expansion of renewable energy usage, and the introduction and reduction in cost of storage technology. We are continuing to develop dashboard functions based on their operation and improvements in the workplace (in each division). Currently, the dashboard is aimed at energy usage, so the KPIs are energy related. We plan to expand their application so that they also serve as resource efficiency indicators (water, raw materials, waste, etc.).

3. Initiatives at Kawasaki factory

Research and development initiatives are underway at a number of Fujitsu Group sites. A typical research and development site is at our Kawasaki factory, which we focus on here as a case study.

3.1 Application of energy management function

The Kawasaki factory has a high level of energy consumption, and approximately 90% of the energy consumed is electrical power. It was previously possible to determine energy usage only by building or by substation. Energy measuring devices have now been implemented in those buildings where energy consumption is the highest. Moreover, an energy management function has been developed that enables Kawasaki management to view the energy consumption status in real time in hourly units for each type of use (office automation devices, air conditioning, lighting, etc.), by floor, and by site area. This enables them to determine the causes of increases and decreases in CO_2 emission levels by using the drill-down function described above. They have used this information to implement functions that autonomously reduce the environmental load created by the Kawasaki factory. In other words, environmental practices can be implemented from both the supply side and the demand side of energy.

3.2 Energy analysis

From their analysis of the data collected, management at the Kawasaki factory determined that electrical power usage was roughly split among three areas in substantially the same proportions: a "DC area" used as a data center, "work areas" used by ordinary employees, and "shared areas" used for the maintenance facilities. They also determined that the proportions were basically fixed throughout the year.

They were able to reduce energy expenses by approximately 11% by making improvements in facility operations in the DC area (such as by improving air conditioning efficiency through the application of thermal simulation technology) and in the shared areas (such as by improving substation operation, switching contractual demand, and using heat storage tanks to cut peaks in demand). In addition to other energy-saving activities (such as collectively switching off workplace lights during lunchtime and when work is not allowed), Kawasaki factory researchers are conducting proof of concept experiments on microgrids.

A microgrid is a small-scale electrical power network. At the Kawasaki factory, solar power generation and storage batteries were experimentally combined to provide the electricity needed to light the work areas of approximately 400 people on one floor and to power the office automation devices used by approximately 200 people. To enable efficient use of the solar power, which is difficult to predict, a supercomputer was used to prepare over 10 000 optimal operating scenarios for storage batteries that are based on predictions of the amount of solar radiation hitting the solar panels. The data used was weather data for the previous three years. The operation of the storage batteries (charge or discharge) was controlled using "operating plan optimization technology" (**Figure 3**). With this technology, the optimal operating scenario based on the level of solar power available and the power usage level that best match the current situation is used as the operating plan. Storage battery operation is further optimized by re-evaluating each hour the plan to use on the basis of the continuously updated level of solar power available and the power usage level. As a result, the peak electrical power usage from the early afternoon until evening, which is the period of greatest electrical demand, was reduced by an average of 23%. This led to a reduction in the cost of purchased electrical power by 8%. The application of this approach to the aggregator business and to smart city businesses will be investigated.

4. Initiatives at other factories

Since manufacturing activities account for 30 to 40% of the energy usage of the entire Group, reducing the energy consumed by our production equipment is a major challenge. We recently developed a "specific productive energy consumption management tool" that reduces the amount of energy used for production by visualizing the energy usage by unit of production, verifying the effects of the measures taken, and detecting energy disturbances in real time.

4.1 Definition of specific productive energy consumption

The specific productive energy consumption management tool uses ICT to break down the total energy usage of a factory into three components and provides visualization of the actual energy consumed in making things as the "production proportional share of energy" (**Figure 4**). In the past, it was difficult to see energy-saving effects in production departments due to the effects of non-production factors such as fluctuations in ambient temperature, because we managed the total energy usage of the entire factory without a detailed

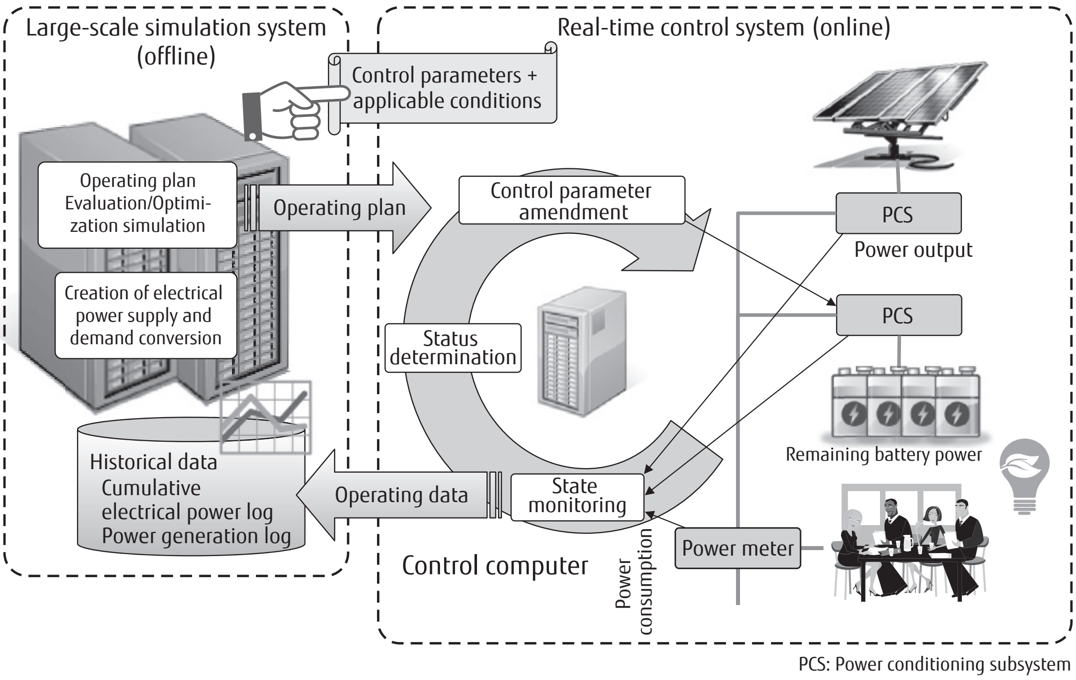

Figure 3
Overall configuration of storage battery operating plan optimization technology.

breakdown. We can now calculate the basic energy required for producing a single product unit by using the equation below. The calculated value is defined as the specific productive energy consumption; a low value indicates that production is using energy efficiently.

$$\text{Specific productive energy consumption (kWh/unit)} = \frac{\text{Amount of power}}{\text{Number of units produced}}$$

For real-time monitoring, we are implementing a database and visualization method based on an electrical power measurement energy management tool and information on the number of units produced. A visualization case study is shown in **Figure 5.** This visualization tool detects energy abnormalities and identifies the effects of countermeasures. It can be applied to uses such as determining new targets. For example, we set standard labor hours on the basis of the number of assembled components and number of screw mountings. If the upper limit is exceeded, a countermeasure alert is transmitted in real time, advising that the number of assembled components or screw mountings should be reduced and initiating identification of the effects of those measures. This tool can also be used to set new targets in situations such as when improvements to the efficiency of the entire line or to its management have been made.

4.2 Production line case study

We have introduced this tool into the server production line at Fujitsu Isotec Limited (Date City, Fukushima Prefecture) and are currently putting it into trial operation. We installed 37 electrical power sensors in the main server production line to enable us to measure at ten-minute intervals the power usage at each stage of the line (comprising assembly, testing, and packing). Wireless sensors were used so that the layout of the line did not have to be switched. The corresponding production information (order number, number of units produced, and line operation time) are automatically input from the production management system. The data collected are being used to visualize the specific productive energy consumption. As well as being used in the management departments of the factories and production floors where the system is installed, the data collected is readily available to the management departments at the head office in a one-stop manner.

The results of analyzing the correlation between the number of units produced and the power usage during the trial process are shown in **Figure 6**. They show that electrical power was still be used after production ended for the day and on holidays. However, this was because the equipment for automatic product testing was always on (i.e., standby power had been measured).

We have installed communication sensors that monitor the RUN state and have automated the on/off functions for test electrical power and standby power on the product side in an attempt to synchronize operation of the products' test program with the test equipment. These measures have resulted in an approximately 26% reduction in standby power usage (**Figure 7**). We will continue to use ICT to analyze the correlation between production volume and power usage so as to reduce

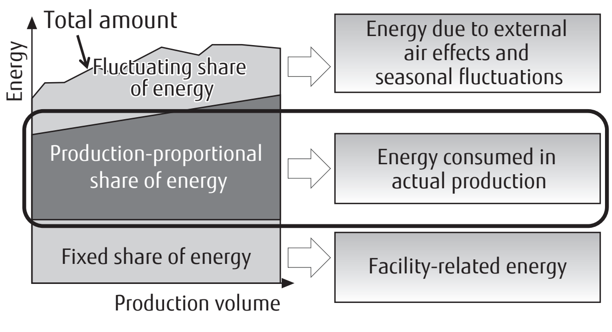

Figure 4
Segmented visualization of production-proportional energy.

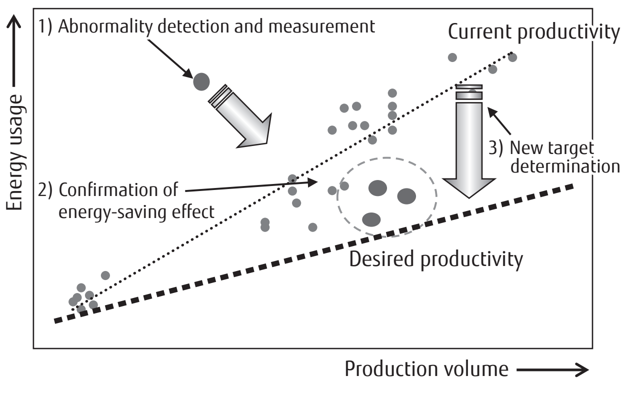

Figure 5
Visualization of production-proportional energy and application example.

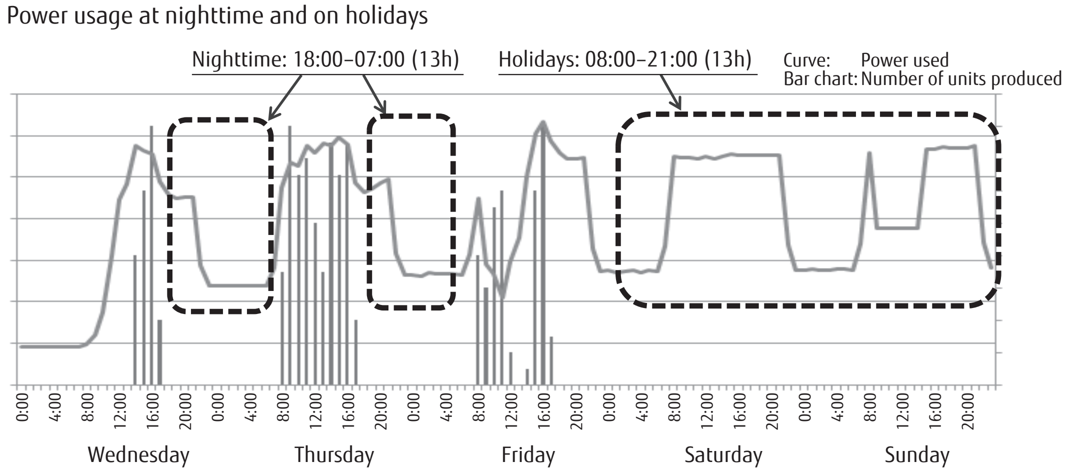

Figure 6
Standby power visualization results.

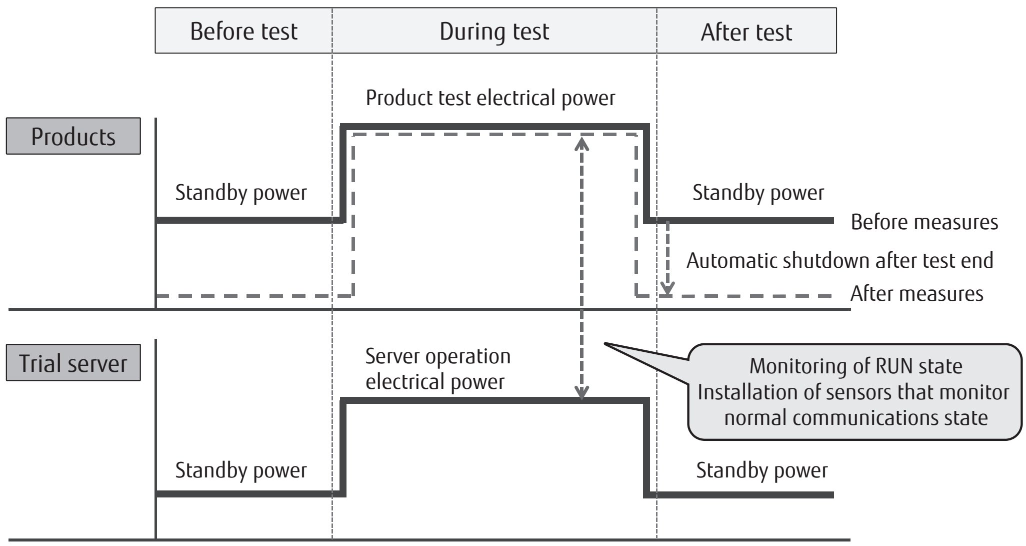

Figure 7
Reduction in standby power usage.

wasted energy, clarify the variation in the basic unit of energy by the same type of equipment, and achieve even lower energy consumption.

5. Initiatives in offices

Research and development initiatives are also undertaken in various Fujitsu offices. Here we introduce an example of such an initiative undertaken at Fujitsu Solution Square in Tokyo.

5.1 Application of energy management function

We modeled the office buildings at Fujitsu Solution Square in a manner similar to that for the research and development site at the Kawasaki factory described above. We measured the amount of energy used by the gas air conditioning units that are characteristic of these buildings, determined in detail the amount of electricity and gas they consumed on the basis of data collected by several hundred sensors, and sought to identify the best energy mix. Our data analysis revealed that close to 60% of the energy used was for the building maintenance facilities that air conditioning accounted for a large proportion of that usage.

5.2 Facility operation improvements

While energy-saving measures for air conditioning usually focus on complying with a specified temperature setting, we have taken a different approach. We have applied the data we have acquired to the air conditioning installations themselves, in other words, to the operation of the facilities. Air-conditioning units of office buildings can be classified as internal air conditioning units, which are installed individually on each floor, and as outdoor-air processing units, which provide the air for general ventilation. First of all, a check of the operation status of the outdoor-air processing units revealed that internal humidity was controlled by only the outdoor-air processing units. We then implemented cascade control: the temperature of the air supplied to the outdoor-air processing units is changed in real time on the basis of the dew point temperature of the returning air. This cascade control enables the outdoor-air processing to be optimized in accordance with the humidity of the outdoor air and enables the internal air conditioning units, which are more efficient in terms of ventilation than the outdoor-air processing units (**Figure 8**), to be more effectively utilized.

In comparison with the levels for 2010, the electrical power consumption of the air conditioners was reduced by 21%, and the gas consumption was reduced by 26%.

5.3 Initiatives towards visualization of efficiency indicators

In addition to evaluating energy usage in offices and at various sites from the viewpoints of efficiency, productivity, and comfort, we have also evaluated it in terms of people. We did this by using the number of IP addresses (number of network connections) in use on each floor as an approximation of the demographic

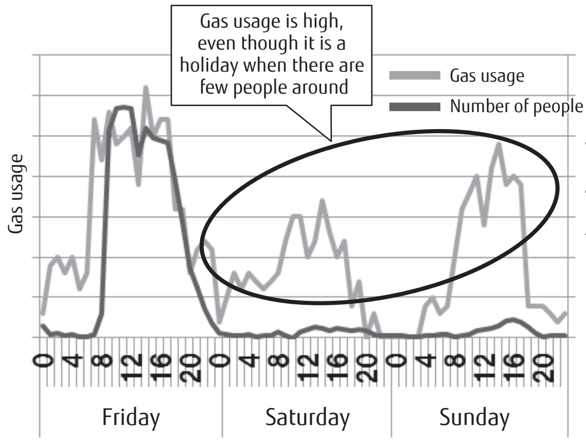

Figure 9
Analysis using number of network connections.

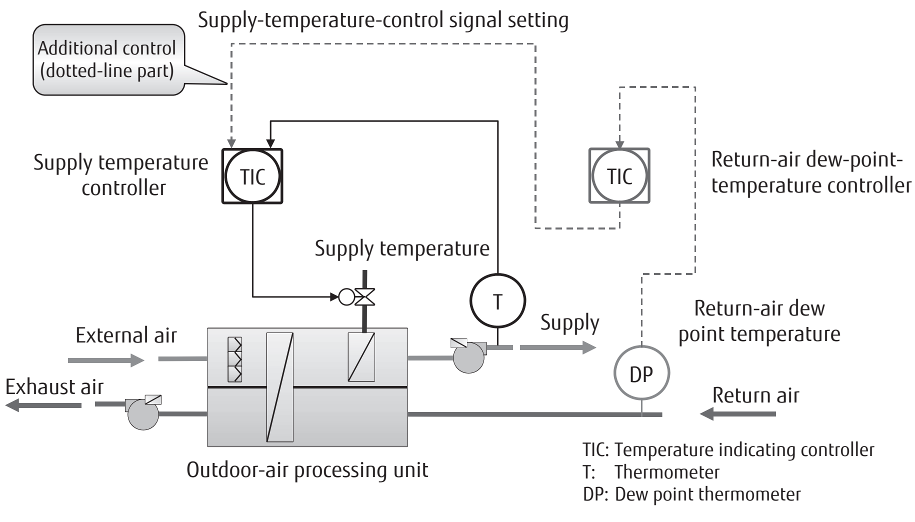

Figure 8
Cascade control of outdoor-air processing units.

situation. Using this number, we estimated the amount of energy use per person.

A comparison of gas usage between weekdays and holidays showed that, although the total usage on a holiday was less than that on a weekday (**Figure 9**), the amount per person was actually much greater. This is because, even though there are fewer people working on holidays, the air conditioning is still cooling the entire area. One way to solve this problem is to adopt innovations in work style, such as limiting the work areas on holidays.

6. Conclusion

We have started providing our customers with some of the solutions we have developed as reference models, including the solutions we have introduced here. Our approach is to first test our solutions in-house, make improvements, repeat the plan-do-check-act (PDCA) cycle, and make more improvements.

We will continue to help our customers reduce their environmental loads and to improve environmental efficiency by using the concepts described here and thereby contribute to the realization of a smart society.

References

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