Promotion of Energy Visualization Leading to Business Improvement

OZAKI Takayo, TAMURA Tetsuya

Abstract

Under the increasing severity in the availability of power supplies and the associated legal restrictions, the visualization of energy is evolving from simple viewing to visualization for the improvement of business. This paper introduces methods of visualization and analysis for the latter purpose together with actual case studies.

Keywords

energy saving, visualization, energy management system (EMS)
business improvement, energy analysis

1. Introduction

The amendment of the Energy Saving Act and the enforcement of the Tokyo Metropolitan Environment Securing Code in April 2010 caused enterprises' energy-saving personnel to struggle hard to deal with the new restrictions. After they finally completed and submitted the reports compliant to the new law and code, they had to experience new trials, such as the power failure due to the Tohoku Earthquake and the subsequent power shortages in 2011. Heavy consumers (with contracted power of 500 kW or more) were obliged to reduce power by 15% (Electricity Business Act, Article 27), making it a supreme imperative to cut 15% of the peak power consumption of the previous year. As a result of endeavors by every enterprise and every individual, the demand level under high-temperature hours in the summer of 2011 within the service area of the Tokyo Electric Power Company was about 9 to 10 million kilowatts lower than the level of the previous year.

This energy saving would not have been possible without the efforts of working people, who worked in factories even on weekends, changed the set temperature of air conditioners and reduced the number of lights being used. Similar efforts were also requested under the title of energy-saving "cooperation," rather than obligation, from lighter consumers (contracted power below 500 W), households and individuals.

The NEC Group also founded an energy saving project. Setting 15% reduction of maximum power consumption from the previous year as our goal, we enforced specific energy-saving measures in three steps: (1) regular saving, (2) summer enhanced saving and (3) emergency shutdown. As a result, a 21% power cut was achieved with regular saving (1) alone, and the power reduction rate finally reached 27% in the service area of the Tokyo Electric Power Company and 29% in that of the Tohoku Electric Power Company.

However, considering the issues with restarting Japan's nuclear power plants, electricity demand is expected to still be severe in the summer of 2012. This makes visualization desirable as a tool for identifying the real causes of problems in order to improve business by getting rid of "patience-based" energy saving. This paper introduces a process for developing visualization from simple viewing to visualization for the improvement of business by following the steps below.

Step 1:
Feedback of results
Step 2:
Discovery of waste in equipment usage
Step 3:
Discovery of waste in business processes
Step 4:
Independent actions of field staff for business improvement

2. From "Patience–based" Energy Saving to Business Improvement

2.1 Visualization Efforts

In the summer of 2011, many enterprises tried to improve the consciousness of their employees toward energy saving by means of visualization. The NEC Group also posted a power consumption indicator (**Fig. 1**) on the portal website visited by every employee every day. The indicator showed the percentage between the current power usage and the permissible

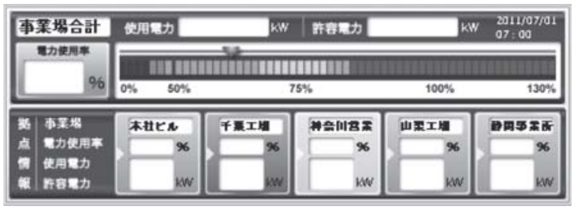


Fig. 1 Power consumption indicator.

peak power of each office in easy-to-read signal-like coloring to improve employees' consciousness toward energy saving.

2.2 Step 1: Feedback of results

"Viewing the results of one's efforts in a visible form": this is a requirement for energy-saving practices to be continued without becoming temporary. To our regret, however, we must admit that it is very difficult to discover the causal relationship between actual actions and results and waste if it is the total volume that is being fed back. The feedback of total volume that can relatively easily show the effects of one's efforts is the monthly account statement delivered from the power company. As its current form includes the consumption of the same month in the previous year, it can be useful as feedback on one's efforts. Nevertheless, since the information is given on a monthly basis, it is not possible to identify which action taken on which date was really effective. In Step 2, we will introduce visualization for the discovery of waste in equipment usage.

2.3 Step 2: Discovery of waste in equipment usage

If the information visualized is the total or monthly accumulated value, it is hard to use it to achieve further energy saving. It is necessary to measure more detailed consumption data over time. An example of a mechanism for measuring and visualizing household power consumption is HEMS (Home Energy Management System). This system installs wattmeters on a household's distributor panel and measures the power consumption of each circuit breaker. HEMS enables timely feedback of energy-saving results. It makes it possible to obtain effect-measuring information, for example identifying the energy-saving effect obtained by changing the air conditioner temperature setting, and to discover waste in a timely manner, for example finding a home appliance consuming power in a room occupied by nobody. The reduction effect is not only represented in terms of wattage and percentage, but also as the saved electrical charge converted into the monetary unit of yen, which is expected to serve to enhance the will of consumers to save energy.

The discovery of waste is possible in offices and shops as well as in households by installing a sensor on each circuit breaker of the distributor panel of an office or shop and measuring the power data every minute. As the number of measuring points may be very large in offices and shops, it is necessary to classify the sensors according to equipment categories in advance so that trends can be seen at a glance and analysis can be performed easily.

Fig. 2 shows the daily power consumption data measured in an office of the NEC Group.

ICT equipment occupies 45 to 50% of the total power consumption on weekdays. The key is to check the share of each equipment category and mark out the areas in which reductions may be particularly effective or possible. Fig. 2 also shows that power at about 40% of the weekday level is consumed even on holidays when there is no one in the office. This suggests that there is a possibility to reduce power consumption for energy saving in this area. Similarly, we analyzed the data for each day by dividing it into time periods and were able to observe that weekday power consumption can be reduced by nearly 10% by eliminating waste in the unattended time periods of the early morning and late night.

Now let us consider a case that would be applicable to both shops and offices. There are many facilities employing individual air conditioners and forgetting to turn off air conditioning is one of the easiest-to-discover examples of waste. Apart from forgetting, there may also be cases in which wasteful power is consumed for air conditioning without workers' knowledge, as shown in **Fig. 3** . In districts where weather is

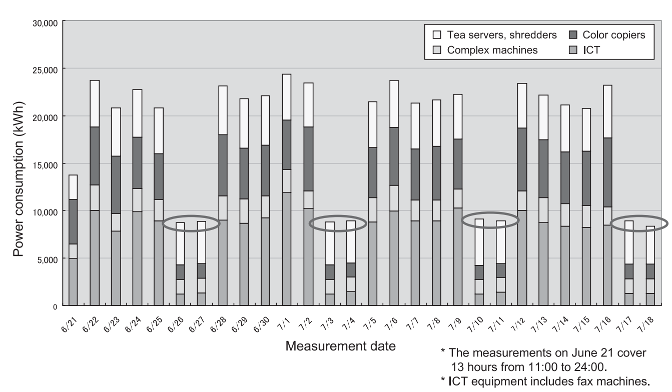
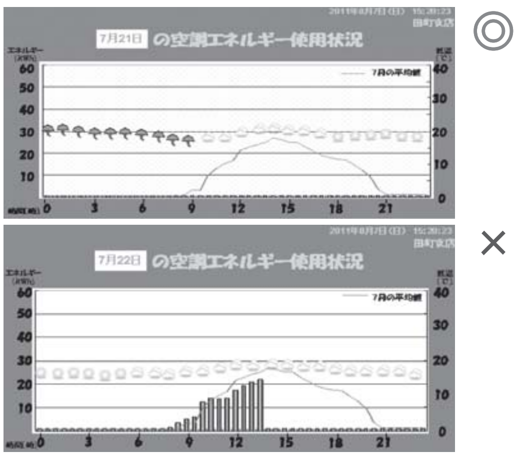


Fig. 2 Power usage situation in an office.



*The values shown here are merely images

Fig. 3 Air conditioning power usage situations.

fickle, sudden changes in temperature often occur, for example a warm day coming after several cold days or, in the summer, the temperature dropping suddenly after several hot days. Fig. 3 shows images of power usage situations for air conditioning in the summer. Since air conditioning is intrinsically correlated with temperature, cooling is unnecessary if the temperature is below a certain level. The ideal in this case is that the only power consumed is standby power, as seen in the upper graph in Fig. 3. However, after consecutive hot days, people tend to fall into the habit of switching the air conditioner on every morning, and it may be left on until someone realizes that the day's temperature is not so high. This situation is shown in the lower graph in Fig. 3. Unnecessary air conditioning is running in the morning, until someone noticing that it is not necessary switches it off. This kind of waste can be eliminated if it is understood in advance that air conditioning will be unnecessary on that day from the temperature forecast on the previous day.

There is also a margin for energy saving with refrigerators and freezers in the case of a food retailer. The percentage of power consumption by refrigerators and freezers out of the total consumption by food retailers is generally very high. Bulk purchase of energy-saving units might deserve study in the case of a new or renovated shop, but this usually necessitates a large investment. In the meantime, reduction of power consumption is possible by switching off the lights inside the units 30 minutes earlier than before (or switching them off as early as possible after closing). Needless to say, this can save the power consumed by lighting, but it also has the by-product of reducing the power used by the refrigerators and freezers. A small change in power consumption at such a level can be identified by applying visualization. When we talk about lighting, we tend to look at the lighting inside the shop, but additional waste is hidden in places like this. The on/off timings of the lights inside the units are in general set with timers, which means that, once the setting is changed, this energy-saving measure can be applied continually.

In Step 2, we introduced "discovery of areas of waste," which pinpoints waste from equipment usage situations. In Step 3, we will focus on "discovery of waste in processes," which consists of reviewing daily business operations and processes from the viewpoint of energy saving.

2.4 Step 3: Discovery of waste in business processes

In an office that uses a large amount of ICT equipment, like that of the NEC Group, the percentage of power consumption by ICT equipment out of the total consumption of the office is relatively high. In addition to PC energy-saving settings, which are rather a matter of course, it is also possible to reduce peak power consumption and the level of power usage through reform of daily operations. **Fig. 4** is a graph of the power consumption of ICT equipment over a weekday in an office of the NEC Group. The graph shows that the peak hour is between 8:00 and 9:00 in the morning. This is because the work start time of the office is 8:30 and everyone turns on a PC at the same time. This action may be excusable with desktop PCs, but notebook PCs do not always need to be kept on. If their

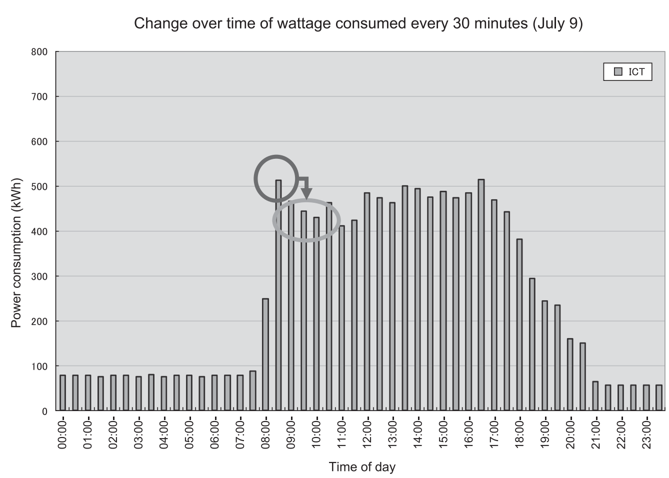


Fig. 4 ICT equipment power usage situation.

batteries were charged in the off-peak time that comes one or two hours later, it would be possible to level the power consumption without forming a peak.

An office or workshop often has certain business processes that have become its habits. If business processes are reviewed from the viewpoint of energy, there is the potential to find new areas of saving. Finally, Step 4 is the step for making general employees in the field find new points of saving by themselves and take leadership in business improvement activities, including energy-saving activities, instead of simply following the business improvement instructions received from the personnel in charge of energy saving.

2.5 Step 4: Independent actions of field staff for business improvement

Contrivances are necessary to make employees who are busily working in the field find areas for improvement and perform energy-saving activities by themselves. These contrivances naturally include visualization for identifying the current situation, but indicators showing whether the current status is good or bad are also necessary. For this purpose, it is important to set a baseline indicating the lowest target and the final goal, including margins/allowances. The variables affecting power consumption change depending on the type, form and content of each business. For instance, in the case of a retail shop, power consumption varies depending on floor area, sales and the temperature of each day. In the case of an office, the variables include floor area, the number of employees and the temperature of each day. Which of the variables are to be used changes depending on the type, form and content of the business, so it is necessary to set the baseline by selecting optimum variables. **Fig. 5** shows a baseline for maximum temperature and power consumption. If actual power consumption values are located below the baseline (black line), the office or shop is implementing energy-saving activities successfully. When a final goal line (white line) is added to the graph, energy saving at an even higher level will be possible.

When visualization leads to discovery of waste and margins for energy saving, employees in the field can take appropriate actions by themselves. For example, let us consider a case of peak cutting. In an enterprise with a high voltage contract (below 500 kW), the contracted power is set equal to the maximum value out of the maximum power demand over the past 12 months, including the current month. This means that, if the maximum power demand in summer is large, the current arrangement forces the enterprise to pay a high basic charge

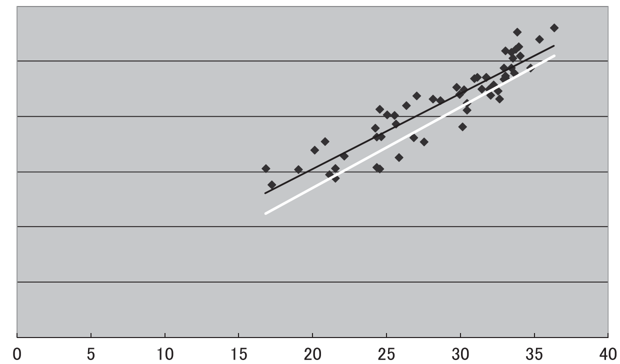


Fig. 5 Maximum temperature and power consumption.

throughout the subsequent year. If a function were provided to give an alarm upon detection of the approach to that specific peak, the enterprise would be able to avoid a sudden encounter with the power peak by enforcing proper countermeasures in advance against margins for energy saving. This would be very effective for decreasing the contracted power (basic charge) in the subsequent months. However, since the maximum power demand is determined based on measurements every 30 minutes, the peak cut is meaningless if it is not performed within a 30-minute period. This means that the previous method, in which field employees execute an action after receiving notification from headquarters, would be difficult to implement.

Therefore, the independent-minded execution of energy-saving measures by field staff, in which visualization is permanently maintained and field employees execute quick-acting energy-saving measures by themselves by using alert functions in cases of emergency, can greatly contribute to the reduction of contracted power in the long term. Improvement of energy-saving thinking among field employees may be easier in retail shops, where cost consciousness is thoroughly proliferated among the staff and any shop cost reduction leads immediately to the improvement of business profits.

3. Conclusion

To make visualization more than simple viewing, it is important to identify trends by means of analysis from multiple angles, including inter-facility analysis, inter-office analysis and analysis of correlation with variables such as sales amount, not to mention time series analysis. Finding the trends per equipment type or business type not only serves for energy saving but also applies to prior maintenance of equipment as well as to reform of business processes. We firmly believe that the advancement of business process reform by approaching it from the angle of energy saving will be one of the most important objectives of visualization activities in the future.

Authors' Profiles

OZAKI Takayo
Manager
Smart Energy and Green Business Development Department
New Business Promotion Division

TAMURA Tetsuya
Senior Expert
Smart Energy and Green Business Development Department
New Business Promotion Division

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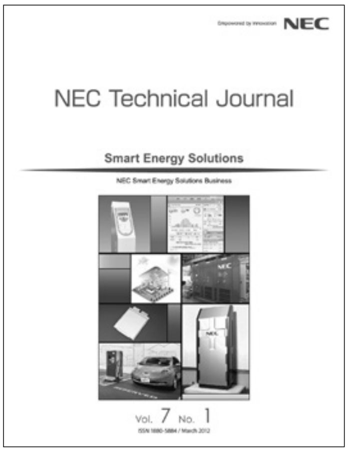

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Special Issue TOP