ICT-based Optimal Plant Management Solution

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Reducing energy costs is one of the challenges facing the manufacturing industry today. Several internal factors such as a growing production volume contribute to this challenge, but rising energy tariffs and other external factors also play a significant role. Various measures have been taken by manufacturers to lower costs, including "visualization" of energy consumption, but ideas to achieve further reductions have apparently been exhausted. This article discusses a hitherto-neglected aspect of energy consumption, i.e., consumption relative to production volume, that may lead to further energy savings, and discusses a method to cut energy consumption by monitoring its correlation with production volume as well as with variable energy consumption, drawing on a real-case solution. It also discusses the implementation of the smart factory, which is aimed at comprehensively addressing plant-wide issues such as product quality, delivery, raw material cost, and workplace safety besides energy issues.

1. Introduction

Today, companies are being asked to change their mindset from corporate social responsibility (CSR) to creating shared value (CSV). While CSR refers to the "social responsibilities of a corporation," CSV means "creating shared value for both the corporation and society." This way of thinking can also be applied to the field of corporate environmental response. There is now a need to switch directions from an era of CSR intent on reducing environmental load even at the expense of profits to an era of CSV that engages in environmental load reduction and other socially responsible activities as a management strategy for generating profits.

We can consider two approaches to CSV. One is increasing sales while achieving reductions in environmental load by proposing environmentally conscious solutions. A classic example of this approach is the development and marketing of hybrid vehicles by automobile manufacturers. The other approach is increasing profits. In this case, the aim is to reduce costs and grow profits while reducing the environmental load of one's own company.

As an example of the latter approach to CSV by increasing profits, this paper discusses a specific way of thinking about "environmental management" using information and communications technology (ICT) to achieve both environmental load reductions and energy cost reductions and presents an application example.

First, we mention current issues surrounding the manufacturing industry and discuss the impact of energy costs. We then describe two conventional techniques for reducing energy costs and issues associated with them, introduce a new technique for resolving those issues and reducing energy costs, and present a solution to implement this new technique using ICT. Finally, with a look to the future, we discuss the smart factory concept and conclude the paper with thoughts about the future direction of optimal plant management.

2. Impact of energy costs

Key issues in the manufacturing industry can be summed up as quality, cost, delivery, and safety plus environment (QCDS+E). Of these, there are many companies that pursue quality, cost, delivery, and safety as part of an aggressive corporate strategy, but there are probably many companies as well that approach the environment as part of a defensive corporate strategy to comply with laws and regulations.

One issue affecting the manufacturing industry of late is the rise in energy costs. The reasons for this include internal factors (such as rising production volumes) and external factors (such as rising energy tariffs), with the latter becoming increasingly significant in recent years. For example, energy tariffs have sometimes risen by 15% year-on-year.

Let's take a look at the impact of such a 15% rise, taking Fujitsu as an example. On page 30 of the Fujitsu Group Sustainability Report 2013[1] published in July 2013, we can see the entry "Electricity purchased" under the category "Energy." Assuming a cost of 15 yen for 1 kWh, the amount of purchased electricity indicated here would come to about 29 billion yen, which means that a 15% increase would generate an additional cost of about 4.3 billion yen. Although Fujitsu does not release data on the actual cost of purchased electricity, it should be easy to see from this example how such a jump in the cost of energy could have a significant impact on company operations.

In short, a rise in energy tariffs is a serious issue for a corporation. To resolve this issue, adopting the CSV approach of reducing energy consumption and generating profits has recently become an important theme in the manufacturing industry.

The following section describes two conventional techniques for reducing energy costs and discusses issues associated with them.

3. Conventional techniques for reducing energy costs and associated issues

A number of measures have been taken over the years to reduce energy costs in the manufacturing industry.[2] The following describes two example techniques for reducing energy costs.

One technique is to manage energy consumption in monthly units. There are various methods for determining how much energy is being used on a monthly basis, such as examining the billing statement from the power company or checking the power meter once a month. This technique makes it possible to compare energy consumption with the previous month or with the same time in the previous year and determine increasing/decreasing trends. The issue of concern here is that the reason for any increase or decrease in energy consumption is somewhat subjective—there is nothing that supports the validity of any reason offered. To give an example, let's assume that much more power was used in the present month compared with the previous month and the reason given was that "much energy for air conditioning purposes was used because of high ambient temperatures." Now, it is very possible that a large amount of energy was actually used for air conditioning, but it is also possible that other factors were involved, such as an increase in production volume or needless use of standby power for production equipment. In addition, power consumption in monthly units has the disadvantage of concealing daily waste in energy consumption. Because of these drawbacks, this technique is often complemented with an additional technique.

The second technique is to manage energy consumption in units of days and hours, which can usually be accomplished by installing sensors to automatically determine actual amounts of consumed energy. This technique makes it possible to uncover increasing/decreasing trends on a daily and hourly basis, which means a finer degree of granularity than energy consumption in monthly units. In particular, it becomes possible to uncover wasteful energy consumption during non-production times, which cannot be revealed in monthly units, and to come up with measures to reduce such unnecessary use of energy. This technique should also help reduce peak power.

An issue with Step 2 is that once the need for dealing with a wasteful use of energy has been determined, the next action to take is not immediately obvious. Even if energy consumption can be determined in day/hour units and visualized, it only means that phenomena such as a large or small amount of energy consumption can be observed—it is still not possible to judge how much of that energy consumption is appropriate or not.

As can be seen from the above discussion, conventional techniques for reducing energy costs have their limits. They cannot provide a new "insight" on how to further reduce energy consumption.

The next section introduces a new technique for reducing energy costs.

4. New technique for reducing energy costs

To achieve further reductions in energy consumption, we divide energy consumption into three

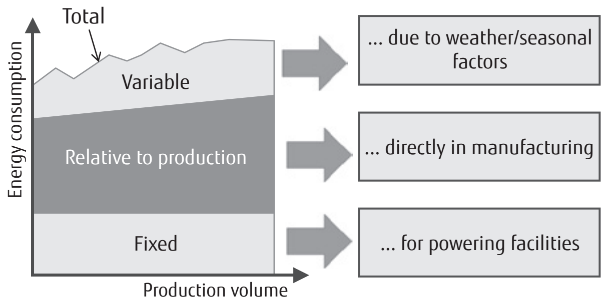


Figure 1
Energy consumption breakdown.

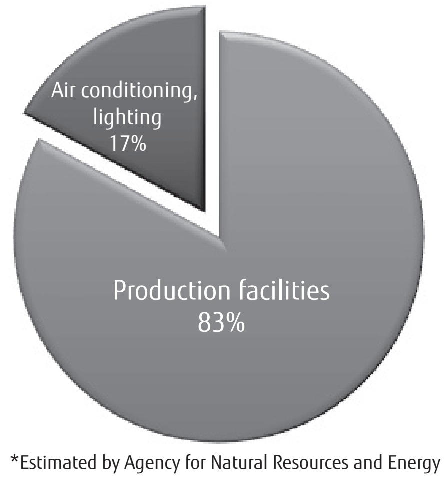


Figure 2
Typical power consumption ratios by application in manufacturing industry.

categories, as shown in **Figure 1**, and for each of them, we determine the amount of energy consumed and consider appropriate countermeasures as described below.

4.1 Reduce fixed energy consumption

Fixed energy consumption refers to energy that is needed even when production processes are at a standstill. It corresponds in general to energy used for air conditioning, lighting, and other facilities. Many measures have been taken in the manufacturing industry to reduce energy consumed for powering facilities.

Examples of such countermeasures include the thinning out of lighting equipment and the introduction of LED lighting and high-efficiency heat pumps.

4.2 Reduce energy consumption relative to production

Energy consumption relative to production refers to energy that is directly proportional to the volume of production performed. To achieve further reductions in overall energy consumption, it is important that energy consumption relative to production be reduced. This is because, while progress has been made in implementing measures to reduce energy consumed for powering facilities, little progress has so far been made in developing measures to reduce energy consumed directly in manufacturing.

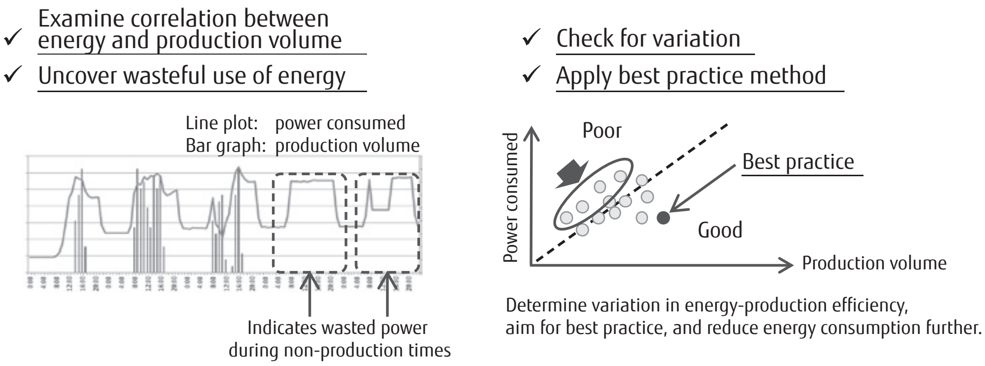
As shown in **Figure 2**, the power used by ordinary facilities (fixed energy consumption) makes up about 20% of all energy consumed while that by production facilities (energy consumption relative to production) makes up about 80%. These proportions differ in accordance with the type of manufacturing performed, but it can be seen from these figures that the impact of energy consumed by production facilities is significant and that measures for reducing this type of energy consumption must be implemented. Many manufacturers, however, have not implemented energy measures with respect to production facilities since a higher priority has been placed on ensuring product quality rather than on reducing energy consumption.

Recently, however, this order of priority has begun to change. One reason is the rise in energy tariffs, which has had a major impact on costs. As a result, the priority given to reducing energy consumption has become about par with that given to ensuring product quality.

To reduce energy consumption relative to production, it is first necessary to examine the correlation between production volume and energy consumption.

For example, analyzing this correlation can reveal that unnecessary power is being used during a time slot in which no production is being performed, as shown in **Figure 3 (a)**. In this way, the appropriateness of energy consumption at certain points in time can be understood, and further reductions in energy can be achieved. This is something that could not be done by simply visualizing increases or decreases in energy consumption, as discussed in Section 3.

Additionally, in a plant that mass produces products, examining the variation in energy-production efficiency can be a useful technique. It is generally thought that energy consumption in a production



(a) Analysis of correlation with production volume (b) Distribution of production volume and energy consumption

Figure 3
Technique for reducing energy consumption relative to production.

process should be proportional to production volume. However, as shown by the distribution of production volume and energy consumption in **Figure 3 (b)**, variation can exist. Among the data points in the figure, the one with the best energy-production efficiency can be defined as "best practice." Accordingly, if data points corresponding to poor energy-production efficiency can be brought closer to best practice, further reductions in energy consumption can be achieved. To do so, it is necessary to look for "differences" between the best practice point and the other data points by studying information on the way energy was consumed, the way that production facilities were maintained, and the skills of the operators involved.

4.3 Reduce variable energy consumption

Variable energy consumption refers to energy consumption that varies with the weather and season. To manage this type of energy consumption, the correlation between energy consumption and air-temperature/humidity and seasonal information spanning spring, summer, autumn, and winter must be analyzed. This is the same approach as that applied to the correlation between production volume and energy consumption discussed above.

As described above, a technique that looks for correlation or variation between production volume and energy consumption is needed to achieve further reductions in energy consumption. Implementing this technique by manual methods, however, would be difficult, as doing so would require much labor to collect and examine various types of data to analyze for correlation and search out underlying factors in variation.

An alternative approach is Fujitsu's Environmental Management Dashboard, which uses ICT as a means of reducing energy costs, as described in the next section.

5. Energy management using ICT

The use of ICT is effective for reducing energy costs. The concept of ICT in environmental management at Fujitsu is shown in **Figure 4**. The key feature is that the correlation and variation shown in the graphs of Figure 3 can be visualized in real time as power/environment-related information (primary data) and management information (secondary data). This, of course, enables new insights to be gained, but it also makes it easy to analyze the factors explaining such correlation and variation while significantly shortening the time devoted to analysis. Of importance here is the use of secondary data in the form of management information, which includes production information, weather/season-related fluctuations, equipment information, and personnel information. The greater the amount of this information, the easier it is to gain new insights and uncover underlying factors. At Fujitsu, secondary data is acquired by interacting with various core systems, and in the end, both primary data and secondary data are centrally managed as big data. This ICT is implemented as an Environmental Management Dashboard, which Fujitsu is in the process of commercializing as a reference tool. There are already plants that have achieved energy-consumption

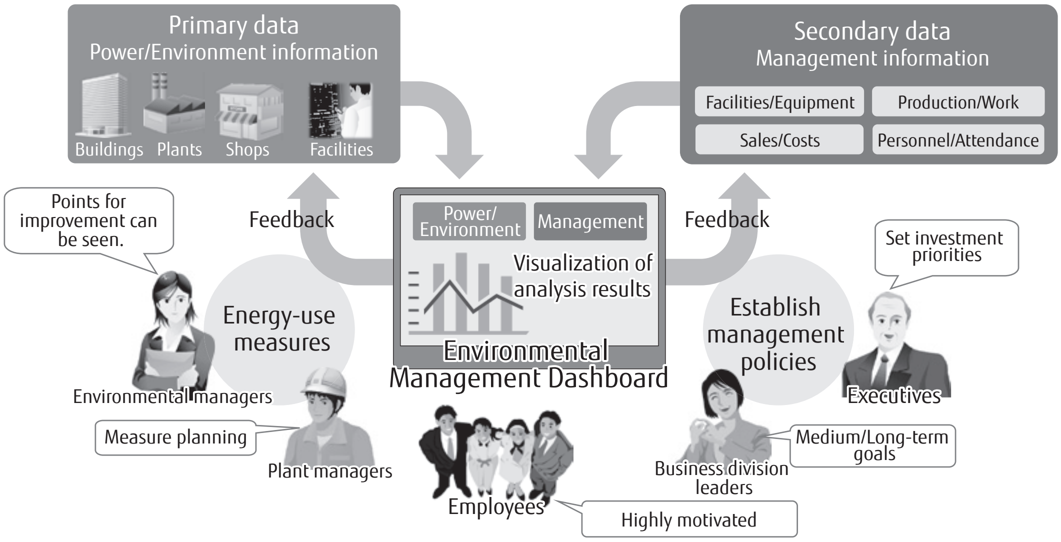


Figure 4
Concept of Environmental Management Dashboard.

reduction effects of 10% and more by introducing this Environmental Management Dashboard.

Application of the Environmental Management Dashboard can be broadly divided into three types. First, it can be used to analyze accumulated big data (past information) to gain insights and uncover underlying factors. Second, it can be used to reduce waste in energy consumption. Here, threshold values for various indices can be set to enable abnormal values to be detected in real time. Because of this capability, it is now possible to take on-site countermeasures once it is understood that an abnormal condition has arisen. Third, the Environmental Management Dashboard can be used to immediately determine the effect of a new measure. Analyzing big data and understanding relevant factors does not necessarily mean that there is only one measure to be implemented. A great advantage of using ICT is that the effect of any one measure can be quickly understood.

6. Extendibility to the smart factory

Many plants that have implemented the Environmental Management Dashboard are thinking about extending its use to optimal plant management. This is because issues in the manufacturing industry go beyond energy problems, as discussed above in Section 2. These issues reflect different aspects of the manufacturing process as summed up by QCDS+E. In short, achieving a reduction effect in energy consumption may be meaningless if quality drops. To give a specific example, a side effect of turning off the standby power supply for production machines to reduce energy consumption is that production efficiency and yields can drop until those machines come back on line and reach stable operation. To solve this problem, the Environmental Management Dashboard can be used to collect not only energy-related information as it should be but also multi-faceted information related to quality, cost, delivery, and work safety as secondary data. This will make it possible to extend the Environmental Management Dashboard and these diverse types of information to optimal plant management, i.e., the smart factory. There are already plants that have set out to achieve a smart factory in this way.

7. Discussion and future direction

Use of the Environmental Management Dashboard will, of course, help to achieve further reductions in energy consumption, and it will also bring into view the genuine arrival of the smart factory. Looking forward, we consider that forecasting using big data and automatic control techniques will be essential to realizing the smart factory in practice. In this regard, it should be possible to use big data (production volumes, facility conditions, weather conditions, etc.) to predict days that will have similarities to those in the past and therefore to predict the demand for power on those days. Similarly, we would like to make it possible to use audio-and-visual sensing data to predict problems and failures in production equipment.

8. Conclusion

Reduction of energy costs is a major issue facing the manufacturing industry. This paper introduced a new technique for reducing energy costs that addresses the reduction of fixed energy consumption, energy consumption relative to production, and variable energy consumption. It also presented the Environmental Management Dashboard as an effective means of implementing this technique using ICT. The manufacturing industry, however, is also concerned with QCDS+E, so extending the Environmental Management Dashboard to the smart factory concept as a form of optimal plant management was discussed. Realizing a genuine smart factory will require prediction tools using big data and automatic control techniques, so an Environmental Management Dashboard leveraging the capabilities of ICT will be needed.

Fujitsu is committed to proposing and deploying its Environmental Management Dashboard throughout the manufacturing industry with the aim of contributing to society by reducing energy consumption and environmental load.

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