Chapter 2

Deployment of Energy Management System Technologies

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Chapter 2
Deployment of Energy Management System Technologies

1. General Overview of EMS

1.1. About EMS

(1) Importance of EMS technologies for energy efficiency

The promotion of energy efficiency is sometimes identified with the promotion of appliances with high energy efficiency. In fact, the diffusion of electrical appliances with high energy efficiency, such as air-conditioning inverter and light-emitting diode (LED), is supposed to have a great impact on reducing energy consumption. Policy measures related to energy efficiency, such as the labelling system to visualise the benefit of energy efficiency and the minimum energy performance standard (MEPS) to motivate the manufacturers to upgrade their product list with more energy-efficient products, are often referred to as the recommended policy tools for emerging countries that set out to promote energy efficiency. The phaseout of incandescent light bulbs from the market is a more direct approach to discourage the sale of inefficient appliances in the market.

Meanwhile, it is also pointed out frequently that waste of energy arises not only from the use of inefficient appliances but also from the inefficient use of appliances. In other words, there may still exist a potential of reducing energy consumption even for those who just started using the appliance with highest-end energy-efficiency performance. Leaving the lights and air-conditioning unit on and setting the unit's temperature too low for comfort are simple examples of inefficient use of appliances that leads to waste of energy. These simple cases may be dealt with by changing the mindset of users. This is the reason some governments are taking initiative on promoting awareness campaign for saving energy, such as Japan's 'Cool Biz' campaign recommending that office buildings set the temperature of air conditioning at 28°C during summer.

However, although appealing to the mindset of end-consumers is important at any time, relying only on human awareness may have limitations in the case of large consumers of energy, such as factories and office buildings where the structure of energy supply and demand system is too complicated for a single person to handle with human sense.

In the case of office buildings, as already discussed in the first-year report of this study, measures, such as adjusting the air flow of ventilation and controlling the flow of water pumps, are considered to have certain impact on reducing energy consumption. Since monitoring and analysis of various data are indispensable for identifying the optimised configuration of these operations, EMS technologies that serve as tools of data monitoring and analysis will greatly help.

In the case of industrial sector, which will be discussed further in this second-year report, the size of energy supply and demand system is larger. Its structure is more complicated, therefore, the number of parameters necessary for analysis becomes much greater. Also, EMS technologies play a more important role in monitoring and analysing operational data of energy supply and demand system.

In a more advanced stage, EMS technologies, instead of human efforts, are expected to assume the function of optimising the operation of appliances. This is called automated control. Technologies of automated control have almost reached the status of commercialisation, and some of these are already in practical use. The advancement of ICT is expected to support the diffusion of EMS technologies.

(2) Necessity of policy measures to promote EMS deployment

As regards the all-out diffusion of EMS, some challenges still exist in terms of not only technology, such as data transaction among various types of appliances, but also cost-benefit balance. The initial costs for implementation may be the largest factor to discourage EMS deployment, and further cost reduction may be a future challenge.

Another possible hurdle for the diffusion of EMS is the uncertainty about the financial return on investing in EMS – an owner of facilities may be reluctant to invest despite the probability that the expected benefit will assure cost recovery. The reason is that EMS itself does not contribute to energy efficiency but is used only as a tool for energy efficiency, thus the expected benefit arises indirectly. Compared with the expected benefit in investing in costly energy-efficient appliances that may show in a more direct manner, the benefit of investing in EMS that is derived from the performance of appliances connected to EMS may appear to be unclear.

To overcome this hurdle, measures for mitigating the uncertainty of benefit of EMS investment and those for mitigating the burden of initial investment should be considered. This study considers that there is a good space for policy intervention to support this campaign, such as the provision of financial incentives, the promotion of ESCO business, and the mandatory reporting and target setting on energy efficiency for large consumers of energy. A set of recommended policy measures for promoting the deployment of EMS technologies will be discussed at the conclusion of this study report.

1.2. Development stages of EMS technologies and types of applicability

(1) Development stages of EMS technologies

As discussed in the first-year report, the basic and common functions of EMS technologies are described in four development stages.

Stage 1. To visualise the energy demand by using metres or monitors. Based on previous research, a reduction of 8–10 percent can be expected when the attitude of consumers regarding energy use, especially towards lighting and power outlets,[1] changes.

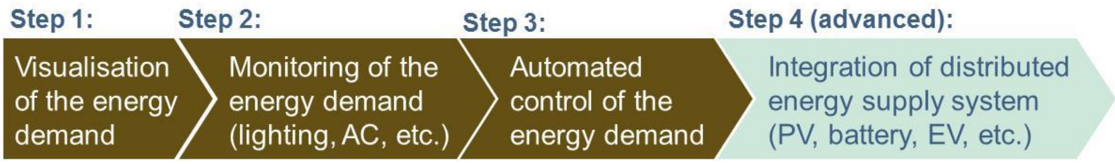
Stage 2. To monitor the energy demand by using ICTs. To make the process effective, the analysis should be able to identify the energy loss factors that need to be improved and the proposed countermeasures.

Stage 3. To control the energy demand automatically through data transaction. Conceptually, both consumer facilities and distribution grid system can be connected and controlled by identifying the total energy demand vis-à-vis the capability of existing grid systems, which is called demand response.

Stage 4. To integrate the distributed energy supply systems (e.g. photovoltaics, energy storage, and electric vehicles).

[1] Ministry of Environment, Japan (2011), Evaluation and Relation Program 'Visualization of Emission Gas – Effect of Electricity Consumption Reduction by Visualization in the Office – Case of Okamura Corporation'. http://www.env.go.jp/council/37ghg-mieruka/r372-01/mat01.pdf

Figure 2.1: Development Stages of Energy Management System



AC = air conditioner, EV = electric vehicle, PV = photovoltaics.

Source: Author.

(2) Applicability of EMS

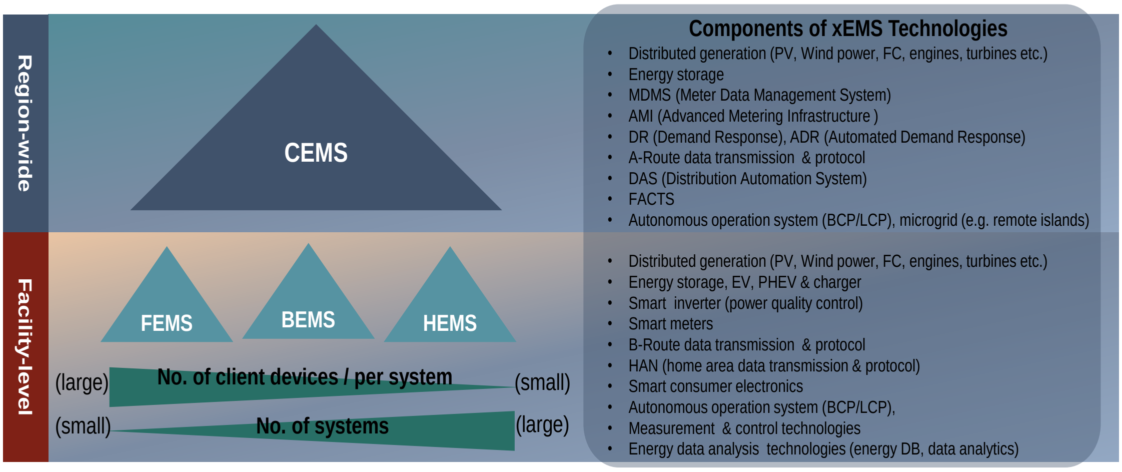
There are various types of EMS with different names according to the target users.

The application of EMS technologies started with large energy consumers, such as those in the industrial and the commercial sectors. EMS for the industry sector or factories is called FEMS; for buildings, BEMS; for residential houses, HEMS that has become available and is driven by the development of smart consumer electronics; and community energy management system (CEMS) that integrates the facility-level EMS into the community-level energy management and has just been developed. These various types of EMS are called xEMS, the collective term.

Regardless of the difference in names, the expected functions are not fundamentally different among them. The main difference is the extent of complexity or simplicity of their functions depending on the types of the target users, which differ in the volume of energy demand and in the main appliances used by them.

Considering that HEMS and CEMS are still at the beginning of commercialisation and, thus, will take some time for them to gain wide diffusion, this study focuses on the possibility of deploying EMS technologies for industrial sector and for office buildings that are ahead in actual implementation.

Figure 2.2: Applicability of Energy Management System and Technology Components



BEMS = building energy management system, CEMS = community energy management system, FC = fuel cell, FEMS = factory energy management system, HEMS = home energy management system, PHEV = plug-in hybrid electric vehicle, PV = photovoltaics, xEMS = various types of energy management system.

Source: Author.

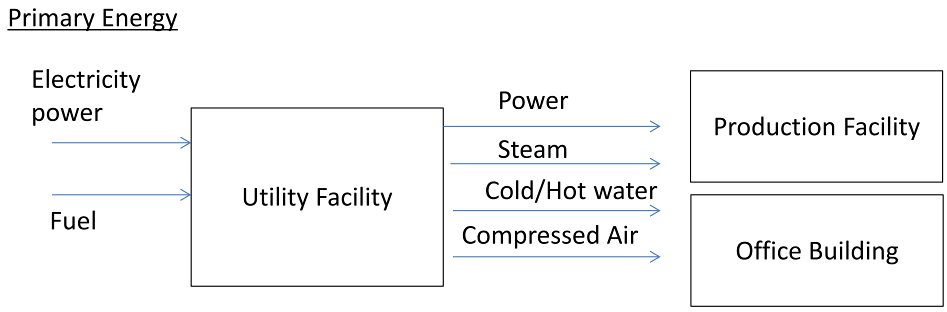
1.3. Roles of EMS

EMS serves for the management of energy use by providing the data for monitoring and analysing the flow of utility services, such as electricity, steam, hot and cold water, and compressed air. Not only electricity but also other types of utility services are generated by consuming energy sources, such as the combustion of fossil fuel (directly as primary energy) or the use of electricity supply or both. Hence, reducing the use of these services decreases the consumption of energy, thereby cutting the costs of energy in the end.

In general, when the energy consumption of a single consumer is large, the consumer is apt to own the facilities of utility supply, such as cogeneration system, boiler, chiller, and air compressor. This is typical for large factories. In this case, the EMS covers both the operation of demand-side and supply-side facilities of utility services.

On the other hand, when the energy consumption of a single consumer is small, the consumer usually does not own the utility facilities but relies on the services of external suppliers (i.e. utility service companies). This is typical for residential sector. In this case, the EMS focuses on the operation of demand-side facilities, although an advanced type of HEMS may have a function to receive data from utility service companies so that the consumers can adjust their operation depending on the costs of utility services.

Figure 2.3: Flow of Utility Services



Source: The Energy Conservation Center, Japan (2014).

2. Energy Management Practices Using EMS

2.1. General overview of energy management practices

(1) Data monitoring and analysis

Grasping the status of energy use is important as the first step of energy management practice. It serves for identifying the point of wasting energy consumption, for studying the measures of energy saving, and for estimating the effect of energy saving by implementing the measures. After implementing the energy-efficiency measures, the energy use data are referred to for verifying their effect.

Only by monitoring the data on the display may give some hint for detecting the point of reducing energy consumption. However, because the changes in energy use data are the result of various factors, such as changes in season, in operational pattern (a day, week, month, year, etc.), and in production process (in the case of industrial sector), these data should be analysed to determine more accurately the possibility of energy saving. In the case where the obtained data are sometimes related to one another, a sophisticated approach of data analysis should be devised to identify their correlation.

In the process of plan−do−check−act (PDCA) cycle, data monitoring and analysis especially serve for the phases of plan and check. The methodologies of data analysis may also be updated regularly to follow the accumulation of obtained data in the course of PDCA cycle.

(2) Basic Functions of EMS

To serve for this purpose, EMS provides data of energy use visually and the tools for data analysis. The following are examples of data analysis tools provided by EMS.

(1) Trend analysis. Showing the changes of energy use in a day, comparison with past months, comparison with past years, and so on.

(2) Peer analysis. Comparison of energy consumption with other plants to identify the difference in energy use performance between them.

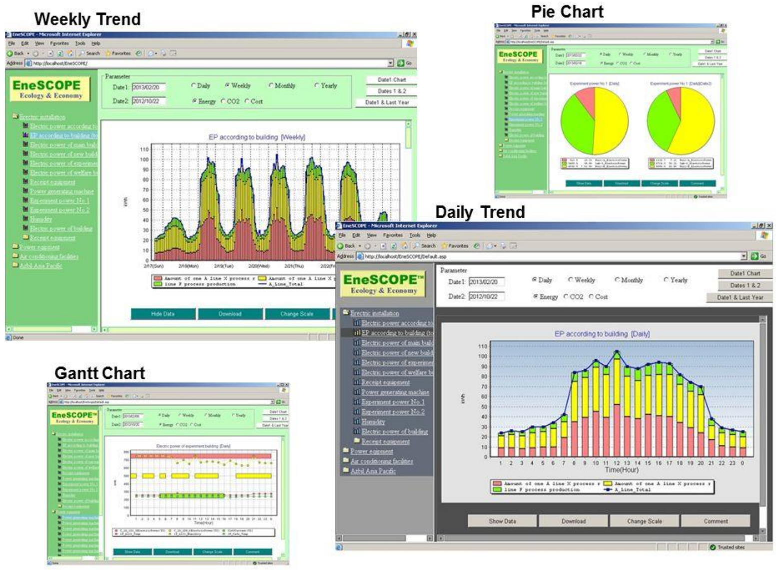
(3) Analysis of fixed and variable portions of energy consumption. It is generally observed that a certain volume of energy consumption may occur even when the operation is dull, and the other portion of energy consumption increases or decreases in accordance with the operational activities (e.g. production). Minimising the fixed portion is ideal so that the energy consumption becomes as proportional to the operational activities as possible, and the analysis to segregate between fixed and variable portions serves for this.

(4) Correlation with explanatory parameters. Analysis of the correlation with factors, such as operational activities (e.g. volume and composition of products) and analysis of the effect of external factors (e.g. operation days and weather conditions) to determine the correlation.

(5) Analysis of the effect of energy-saving measures. The effect of energy-saving measures is studied by comparing the energy use before and after implementing the measures. Theoretical estimation of energy use is provided for comparing with the actual performance.

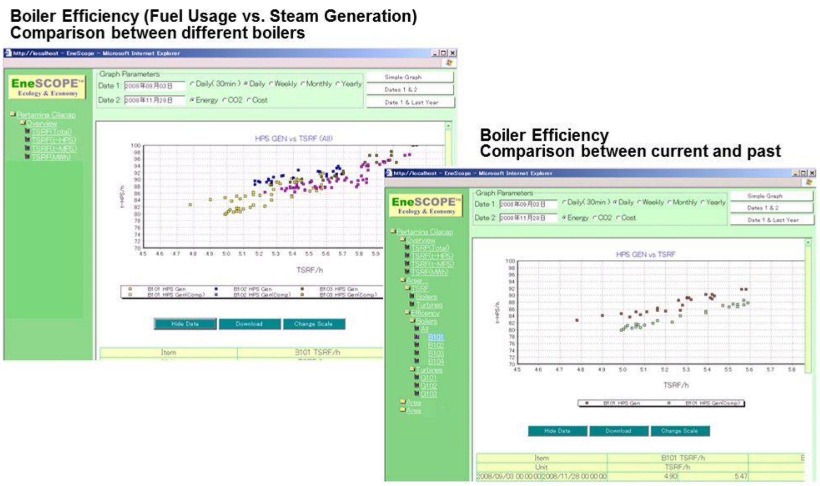
The following figures are sample screen shots of EMS.

Figure 2.4: Screenshots of Trend Analysis (sample)



Source: Azbil Corporation, 'EneSCOPE Catalogue'.

Figure 2.5: Screenshots of Analysing Energy-Efficiency Measures (sample)



Source: Azbil Corporation, 'EneSCOPE Catalogue'.

(3) Measuring instruments

Although EMS is a useful tool to monitor and analyse the flow of energy supply and demand, it is not a device to measure data. Therefore, it is necessary to install measuring instruments for each of the data to be monitored.

Grasping the status of energy consumption in detail is desired – i.e. measuring each floor or room of a building rather than only the entire building or measuring each appliance. However, the more measuring instruments are installed, the more costs are required for capital investment not only for the measuring instruments but also for EMS that can handle larger number of data. Therefore, it is a trade-off between the budget and the measuring instruments installed, and priority should be given in accordance with the relevance of the measured data considering the cost-benefit balance.

Although it is not easy to generalise what the optimised arrangement of measuring instruments would be in terms of cost–benefit balance, because the system configuration may vary depending on the buildings and plants, the following priority order should be taken into account in installing the measuring instruments.

(1) Grasping the energy use of the entire building or plant;

(2) Grasping the overview of energy flow within a building or plant; and

(3) Grasping the status of main appliances that consume huge volume of energy and their characteristics.

It is recommended that these measuring instruments be linked online with EMS so that the measured data are transmitted electronically. This will save manual documentation and help avoid committing errors in data recording. Keeping a database of electric data is useful for generating charts for data analysis using spreadsheet software. The following are the summary of benefits of collecting operational data online.

(1) Real-time data acquisition;

(2) Ease of data recording (database of operational data);

(3) Ease of data analysis (using spreadsheet software for generating charts and so on); and

(4) Remote sharing of database (via Web browser and so on).

Furthermore, gathering the operational data in real time using ICT will be the basis for the advanced stage of EMS, i.e. automatic control.

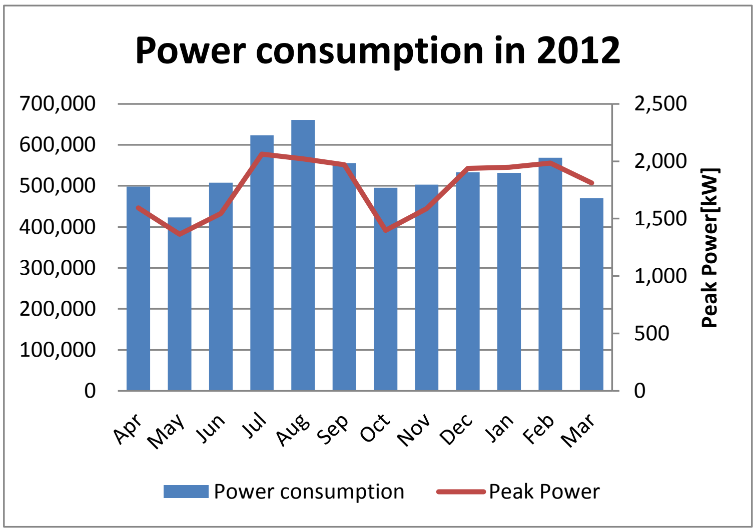
2.2. Basic approaches of data analysis

Some examples of data analysis using the operational data obtained from EMS are presented below. These are basic approaches commonly applicable for any kind of consumers. More customised approaches of data analysis may need to be devised depending on each user's specific concerns about energy management.

(1) Visualisation of yearly energy use

The annual trend of energy use is displayed graphically and analysed for grasping the seasonal characteristics of energy demand, such as the difference in load profiles between warm and cold seasons and between rainy and dry seasons.

Figure 2.6: Annual Trend of Energy Demand (sample)

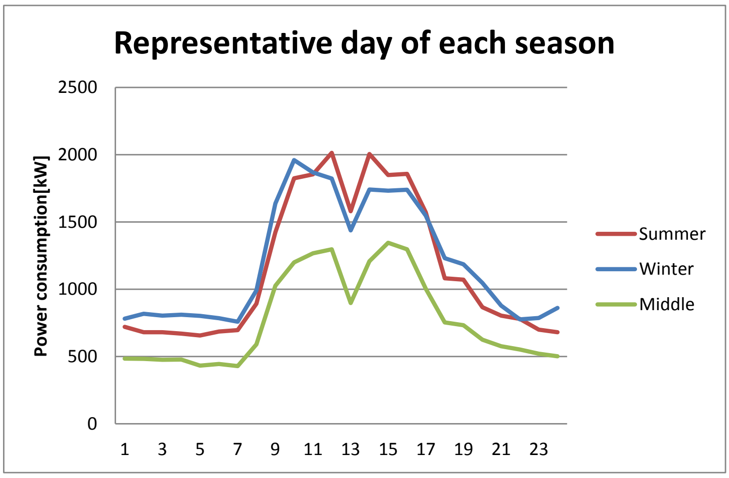


Source: The Energy Conservation Center, Japan (2014).

(2) Trend analysis of daily energy use in each season

A typical daily load curve is selected from each season, displayed graphically, and analysed for grasping the time-of-day characteristics of energy demand, such as the difference in load profiles between daytime and night-time and between operational time and non-operational time.

Figure 2.7: Daily Trend of Energy Demand in Each Season (sample)

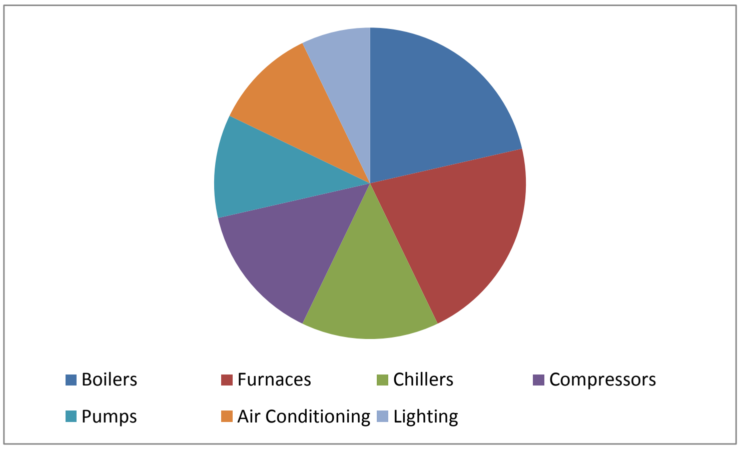


Source: The Energy Conservation Center, Japan (2014).

(3) Analysis of energy consumption categorised by appliance

Annual energy use is segmented into the groups of appliances for grasping the status of energy consumption of each type of appliances in total energy demand, as typically illustrated in a pie chart (Figure 2.8). Measuring the actual energy consumption of each appliance is desired, but if specific measurement is not possible for technical or budgetary reasons, this can be substituted by estimation using the assumed availability factor of each appliance.

Figure 2.8: Pie Chart to Indicate the Share of Energy Use among Appliances (sample)

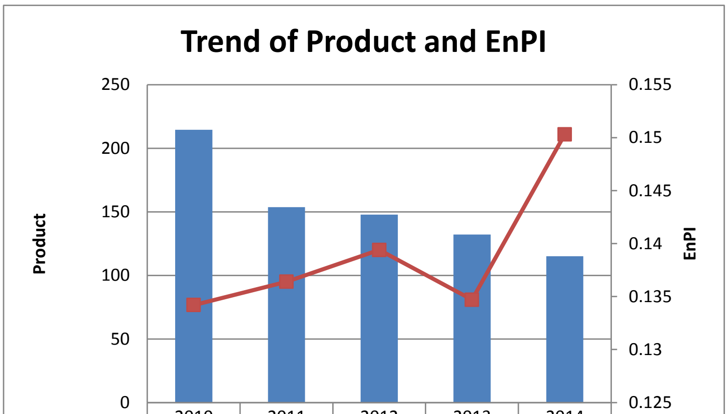


Source: The Energy Conservation Center, Japan (2014).

2.3. Energy management using energy performance indicator

To evaluate the status of energy efficiency of a certain plant (e.g. factories and buildings), energy performance indicators (EnPIs) is prepared. An example of EnPI is the annual (monthly, daily, or hourly) consumption of energy of a certain place (appliance) in comparison with the production of a factory.

Figure 2.9: Specific Energy Consumption as an Example of Energy Performance Indicator (sample)



	2010	2011	2012	2013	2014
Product	214.6	153.6	147.8	132.1	115.1
EnPI	0.1342	0.1364	0.1394	0.1347	0.1503

Source: The Energy Conservation Center, Japan (2014).

(1) Baseline setting

First, the user should identify the performance of energy demand in the business-as-usual (BAU) case as the baseline data. An appropriate period is determined as the BAU for the user. The energy performance indicators (EnPIs) in the BAU period is regarded as the baseline data before implementing energy-saving measures.

EnPI is formulated again after implementing the energy-saving measures for comparing with the baseline energy demand and confirming the effect of these measures. For evaluating the effect as accurately as possible, it is recommended to set other factors that also affect the energy demand as identical as possible, such as season, time, and atmosphere temperature.

Besides the aforementioned factors, the following issues may also affect the performance of energy consumption.

(1) Increase or decrease in the volume of production and sales;

(2) Change of production components, especially the increase or decrease of products consuming much energy;

(3) Outsource of production, transfer of functions of production;

(4) Value added of products;

(5) Combination of multiple types of products; and

(6) Implementation of measures for mitigating the environment burden.

(2) Specific energy consumption

EnPI should be an indicator that can be used for evaluating the performance comparably regardless of the changes in miscellaneous factors. Since it is not easy to find the conditions where all the relevant factors affecting the energy demand are almost the same, specific energy consumption (SEC) is used as the tool for evaluating the performance with ease.

SEC, which is also known as energy density, is defined as the energy consumption divided by the production volume and is a practical tool for evaluating energy efficiency. As regards volume, which is the denominator, various types of parameters are used depending on the characteristics of energy consumption, such as tons of production, quantities of products, monetary value of shipment, processing areas (in square metre), operation hours, total working hours, number of workers involved, and business hours. In any case, selecting a parameter that is related to energy demand as directly as possible is recommended.

SEC is used for comparing the performance among such different occasions.

(1) Comparison with the same period in previous years;

(2) Comparison with the performance of other factories or other appliances that have the same functions;

(3) Comparison with the planned target; and

(4) Comparison with the general benchmarks (average performance of the industry).

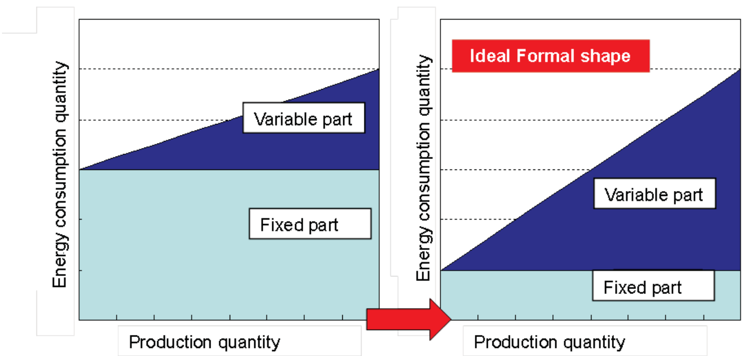
(3) Identifying the fixed part of energy use and turning the fixed into variable

In considering energy-saving measures for improving SEC, an important factor is to identify the fixed part of energy use and to control this to minimise energy consumption. When a factory, for example, is in operation although its activity is dull, a certain volume of energy consumption, such as lighting, exists regardless of the production quantity.

The larger the share of fixed part of energy consumption is the more energy is used when the production volume is small and the worse the SEC becomes. Furthermore, appliances that are operating constantly regardless of production may account for a relatively large share in the annual energy consumption, although their share in the peak demand is small.

Therefore, in formulating the energy-saving measures, it is important to identify the appliances that contribute to the fixed part of energy consumption and to consider the measures for turning them into variable operation, i.e. enabling them to be turned on and off depending on the status of production.

Figure 2.10 Fixed and Variable Parts of Energy Consumption (sample)



Source: The Energy Conservation Center, Japan (2014).