ERIA Research Project Report 2015, No. 17

Study on the Advancement of the Energy Management System in the East Asia Summit Region

Edited by

Yasushi Iida
Inoue Shota
Yanfei Li

Economic Research Institute for ASEAN and East Asia

ERIA Research Project FY2015 No.17

Published in February 2017

Preface

The necessity of energy efficiency is agreed on by any person in any country as far as that person is aware of the concern about depleting natural resources and the effect of energy consumption on the environment. However, because energy efficiency covers very broad issues and various measures to deal with it, discussion on the promotion of energy efficiency may only result in the list of something-for-everyone that is too general for practical application.

Since every part of the energy supply and demand system comprises technologies, energy efficiency cannot be achieved without any kind of technologies, neither can any energy efficiency measure be successful without considering the effect of energy efficiency on human activities. Among various types of technologies related to energy efficiency, those that serve as the interface with human activities play the most important role. Thus, we assume that energy management system (EMS) technologies, which help visualise, monitor, and control the energy supply and demand, can be a cornerstone in this context.

Needless to say, the installation of EMS itself is not simply the solution because it is a rather-costly investment and it cannot be justified without an analysis of the expected benefit, i.e. energy-efficiency potential by deploying EMS. Close analysis of the energy efficiency potential, from both macro and micro perspectives, should be made in confirming its effectiveness.

The last but not the least thing to consider is the institutional framework. In general, costly investment, even when its economic benefit is expected in the end, is apt to be avoided if it takes time to recover cost. This is more conspicuous in a market that is not mature enough for the price mechanism to work perfectly. To mitigate this incompleteness, appropriate policy intervention may be needed to help promote EMS technologies.

The study aims to provide suggestions for policy planners in the East Asia Summit region on possible ways to promote EMS technologies. We hope this study can bring new insights for those involved in this issue.

Yasushi Iida

On behalf of the Study Team

August 2016

Contents

List of Figures

List of Tables

List of Project Members

Dr Yanfei Li (Organiser): Energy Economist, Economic Research Institute for ASEAN and East Asia (ERIA).

Mr Shigeki Kamiyama (Organiser): Managing Director for Research Affairs, Economic Research Institute for ASEAN and East Asia (ERIA).

Mr Shigeru Kimura (Organiser): Special Advisor to the President on Energy Affairs, Economic Research Institute for ASEAN and East Asia (ERIA).

Dr Han Phoumin (Organiser): Energy Economist, Economic Research Institute for ASEAN and East Asia (ERIA).

Mr Yasushi Iida (Study Team Leader): Chief Consultant, Mitsubishi Research Institute (MRI).

Mr Shota Inoue (Study Team Leader): Consultant, Mitsubishi Research Institute (MRI).

Ms Andriah Feby Misna: Deputy Director, Technical Guidance and Cooperation on Energy Conservation, Ministry of Energy and Mineral Resources (MEMR), Indonesia.

Mr Ignatius Rendroyoko: Senior Manager of Distribution Asset Management, Perusahaan Listrik Negara (PT PLN (Persero), Indonesia.

Ms Falisya Binti Boor Azam: Principal Assistant Secretary, the Energy Sector, Ministry of Energy, Green Technology and Water (MEGTW), Malaysia.

Mr Mohd Najib Hamsan: Senior Manager, Sustainability & Green Energy Unit, Corporate Planning & Sustainability Department, Tenaga Nasional Berhad (TNB), Malaysia.

Mr Shaun Yap: Engineer, Energy Efficiency & Conservation Department, National Environmental Agency (NEA), Singapore.

Ms Amaraporn Achavangkool: Energy Conservation Expert, Department of Alternative Energy Development and Efficiency (DEDE), Thailand.

Mr Wilas Chaloeysat: Assistant Director, Electrical System Services Department, Metropolitan Electricity Authority (MEA), Thailand.

Mr Nguyen Tan Binh: Director, Science Technology and Environment Department, Vietnam Electricity (EVN), Viet Nam

List of Abbreviations

AHU	air handling unit
APC	advanced process control
ASEAN	Association of Southeast Asian Nations
barG	bar gauge
BAU	business as usual
BEMS	building energy management system
CASO	compressed air system optimisation
CEMS	community energy management system
CO_2	carbon dioxide
EAS	East Asia Summit
EE	energy efficiency
EMS	energy management system
EnPI	energy performance indicator
ERIA	Economic Research Institute for ASEAN and East Asia
ESCO	energy service company
FEMS	factory energy management system
GPA	Green Power Asia Pte Ltd
HEMS	home energy management system
HRSG	heat recovery steam generator
Hz	Hertz
ICT	information and communications technology
kPa	kilopascal
ktoe	kilotonne of oil equivalent
kW	kilowatt
kWh	kilowatt-hour
LED	light emitting diode
lx	lux
MEPS	minimum energy performance standard
MW	megawatt
PDCA	plan−do−check−act
PID	proportional−integral−derivative
ppm	parts per million
Proton	Perusahaan Otomobil Nasional
RE	renewable energy
SEC	specific energy consumption
toe	tonne of oil equivalent
VND	Vietnamese dong
WG	working group
xEMS	various types of energy management system

Executive Summary

This study aims to analyse the potential for the deployment of energy management system (EMS) in the East Asia Summit region, especially focusing on Association of Southeast Asian Nations (ASEAN) countries, and to propose, upon identifying the policy challenges that are common in the region, policy recommendations for the promotion of EMS. The duration of the study is two years, and this report deals with the results of the study in the second and final year, to complement the first-year study report (ERIA Research Project FY2014 No. 39, published in September 2015).

The first-year study chose five ASEAN countries, namely, Indonesia, Malaysia, Singapore, Thailand, and Viet Nam, as the target countries. Referring to the international statistical data and the discussion at the Working Group meeting that consisted of two members each from these countries, the study identified the characteristics in energy consumption that are common in the ASEAN region, aand noted also the differences among countries. To confirm the applicability of EMS for office buildings – building energy management system (BEMS) – the study conducted case studies to confirm the applicability of EMS on two sites, one in Indonesia and another in Thailand. Based on the walk-through of these buildings, the study identified some key points for improving the energy efficiency of office buildings by adjusting the operation of their air-conditioning system, which can be a potential for deploying BEMS. The results are summarized in the aforementioned first-year report.

Subsequent to the first-year study is this second-year study, which focused on the applicability of EMS for factories – factory energy management system (FEMS) – to supplement the first-year study that mainly targeted office buildings, and proposed a set of policy recommendations for promoting the deployment of EMS in the ASEAN region as a whole.

The second-year study report first discussed the importance of deploying EMS in a practical point of view. It is important to note that waste of energy is caused not only by the use of inefficient appliances but also by the inefficient use of appliances. Therefore, even without replacing energy-consuming appliances with more efficient ones, by monitoring and analysing the operational data of these appliances and by optimising their operational setup, certain potential of energy efficiency may be derived. Installation of EMS, which provides visual information, serves as the solution. However, because of this indirect role of EMS to serve for energy efficiency, the benefit of installing EMS may appear to be unclear. Therefore, this study pointed out that a policy intervention is necessary to support the diffusion of EMS.

The study also conducted case studies that focused more on the industrial sector, FEMS. In fact, the industrial sector consists of various types of subsectors. The utility services the subsectors consume, such as electricity, steam, hot and cold water, and compressed air, also vary. Effective energy-saving measures, therefore, also differ depending on industries. This study listed typical energy-saving measures, indicated which measure is especially effective for which industries, and described specifically how these measures will be implemented.

(1) Optimisation of compressed air system;

(2) Optimisation of combustion and steam supply;

(3) Optimisation of heat-source equipment;

(4) Optimisation of boiler, turbine, and generator; and

(5) Optimisation of distillation tower.

Two sites were selected for the industrial sector case study: (i) the air compressor system at Proton City in Malaysia and (ii) the cogeneration plant operated by Green Power Asia Pte Ltd (GPA) in Singapore. Although conducting the survey at only two sites may be too rough to grasp the whole view of the industrial sector, optimisation of compressed air system and optimisation of boiler, turbine, and generator are commonly used by various types of industry. In terms of the types of industry, automobile, food, and beverage are among the industries that widely exist in Southeast Asia.

For the GPA case, which is eager to reduce the cost of supplying electricity and steam to its client, this study initially proposed the operation optimisation system to minimise the excessive power generation over the demand of the site. Although the system is not well fit for the case because of too little flexibility in operation, this study considers this idea feasible widely in the Southeast Asian region when the target facility is large and complicated enough.

For the Proton case, the site operator is already aware of the importance of reducing the consumption of compressed air, which accounts for about 17 percent of energy use, and has already started an initiative for this since 2014. Although its initiatives have achieved good results in energy efficiency, this study observed that there are still several energy-saving measures for compressed air systems, especially by reducing the air pressure more meticulously at each point of demand side, and estimated that there is a potential of reducing the energy consumption of the air compressor system by 8.71 percent.

The second-year study also conducted one more case study on office building at EVN Head Office in Viet Nam to supplement the case studies in the first year. The office building was completed in 2014 and its installed facilities are still new, but the study observed that much can still be done to improve the energy efficiency by optimising the operational management, such as adjusting the discharge pressure of pumps, operating intermittently the parking lot fans, and controlling the lights by windows. Based on the survey results, this study estimated a potential of energy saving by 7.4 percent.

Despite the case study results that witnessed the possibility of energy efficiency by optimising the operation of appliances, this study observed that there are some challenges for the deployment of EMS, i.e. main factors that may hamper the investment in EMS.

(1) Identification of the benefit of EMS implementation. Since EMS itself is not an energy-saving appliance but is a tool to support the energy efficiency of an entire factory or building, a sophisticated methodology to evaluate its effect is needed.

(2) Financial support and incentive for EMS installation. Financial support and incentive to EMS installation is still inactive in many countries because EMS deployment is supposed to be a relatively advanced step of energy efficiency.

(3) Private sector's involvement in energy-efficiency businesses. Policy intervention should be advanced from direct subsidies to investment to the promotion of private sector's involvement in energy-efficiency-related businesses.

(4) Economically irrational energy prices. In countries with domestic production of energy sources, energy prices are generally set lower than the international prices, and this deprives of energy demand's price elasticity.

To deal with the aforementioned challenges, this study proposed four policy recommendations to facilitate the deployment of EMS and energy-efficiency technologies.

(1) To strengthen mandatory reporting and target setting on energy management. Mandating the reporting on energy consumption and target setting for energy consumption is expected to enhance the awareness of the consumers (e.g. large factories and buildings) to monitor specifically the status of energy consumption.

(2) To provide assistance for the capacity development of energy managers. Developing the capacity of energy managers to devise meticulous methodologies of evaluating the effect of energy efficiency helps in verifying the benefit of using EMS.

(3) To provide incentives for promoting energy service company (ESCO) business. Promotion of ESCO business stimulates the suppliers of EMS to develop their business from simply selling the EMS system alone to providing the customer with various kinds of solution services related to energy efficiency.

(4) To take decisive actions for energy policy reforms since designing energy tariff rates that appropriately reflect the actual costs of supply motivates the consumers to invest in energy-efficiency technologies. However, because energy price may be a politically sensitive issue in some countries, it may take time to adjust the domestic energy prices to a completely cost-reflective structure.

Chapter 1
Introduction

The rapid economic growth in the East Asia Summit (EAS) region countries has driven the formation of new industrial and commercial facilities, as well as the energy-supply infrastructure, and this trend is expected to continue. Therefore, concrete efforts to control energy consumption is required to maintain sustainable economic development in these countries, which otherwise will have to increase significantly their energy supply to meet the demand.

Experiences in developed countries have shown that an important perspective for improving energy efficiency on the consumption-side is not only to promote the diffusion of highly efficient energy equipment but also to formulate an institutional framework for efficient energy use, such as an energy conservation law, at the initial stage of capital accumulation and the development of industrial or commercial facilities.

In line with the oil crisis in the 1970s, the rise of climate change issues since the 1990s, etc., developed countries have devised various political and technical approaches for energy management. In particular, the advancement of information and communications technology (ICT) since the early 2000s has greatly helped the development of the energy management system (EMS), which is also widely called xEMS, the collective term of various types of EMS, such as factory energy management system (FEMS), building energy management system (BEMS), and home energy management system (HEMS). Furthermore, efforts have been accelerated to relate the load management functions of EMS with demand response.

With the expected economic growth and changes in industrial structure and in energy consumption pattern in the EAS countries, it is important to study the prospects of the advancement of the EMS that meet the specific needs of each country in the region. Conducting a study on this subject as an ERIA research project to identify the common policy challenges for the advancement of the EMS in the EAS region is expected to contribute to the sustainable economic growth of the region.

1. Objective

This study aims to analyse the potential for the deployment of EMS technologies in the EAS region and to propose, upon identifying the policy challenges that are common in the EAS region, policy recommendations for the promotion of EMS.

2. Achievement of the First-Year Study

During the first year (FY 2014), this study chose five countries in the ASEAN region, namely Indonesia, Thailand, Malaysia, Singapore, and Viet Nam. A working group (WG) was organized consisting of two members each from these countries, one from government agency and another from power utility who are responsible for implementing energy-efficiency policy.

At the first meeting in Jakarta in March 2015, the WG members shared their experiences on energy efficiency policies and programmes. Each of the five countries had already formulated legislation for energy efficiency and started programmes, such as mandating large consumers of energy to nominate qualified energy managers to administer energy management, energy-efficiency labelling for appliance, financial incentives for energy-efficiency measures, and so on. The deployment of xEMS, however, is still at an early stage in these countries, and although there are some cases of actual installation, most of them are still pilot projects.

The WG also conducted a case study for confirming the potential of deploying BEMS. The case studies were conducted in two sites, one in Indonesia and another in Thailand. First, the desk-based research on energy-saving actions or behaviours was conducted. Second, the effectiveness of energy-saving measures was examined through the field survey on the actual status of energy consumption, and the energy-saving effect was verified in detail.

Findings show that office buildings in high-temperature and high-humidity areas have more room for energy savings from air-conditioning systems. Two main points to improve in air conditioners of office buildings are to adjust the intake volume of fresh air from outdoors and the frequency of motor power using inverters.

The results of the study were presented at the second WG meeting in Tokyo in July 2015 and discussed more specifically in the first-year report.

3. Scope of Work of the Second-Year Study

Following the achievement of the first-year study, the study team dealt with the following tasks during the second year (FY 2015) to complete the study.

(1) Energy efficiency through deployment of EMS technologies

Following the discussion at the WG meetings that the dissemination of EMS was still at an early stage in ASEAN countries and that the benefit of EMS deployment had not yet been accepted widely, this study reviewed the roles of EMS as a tool to promote energy efficiency from practical point of view as discussed in Chapter 2. Energy-management practices using EMS were also introduced in this chapter.

(2) Case studies of deploying EMS technologies for the industrial sector

In addition to office buildings, the second-year study covered case studies for industrial sector (FEMS). Two sites, one in Malaysia and in Singapore, were selected for the study. With the support of energy auditing experts, factory or plant walk-through was carried out at the selected sites.

Based on the results of the case study, a set of energy efficiency measures was proposed and the cost-benefit balance of these measures was estimated. Following these results, the possibility of energy-saving through optimising the operation of energy-consuming appliances (e.g. air compressor, boiler, and turbine) that underlies the potential of EMS deployment was identified. The results were presented at the WG meeting and discussed more specifically in Chapter 3.

With the completion of items (1) and (2), the case studies cover all the five countries participating in the WG in the 2-year study period.

(3) Additional case study of deploying EMS technologies for office buildings

During the first-year study, case studies for deploying BEMS were conducted at two sites, one in Indonesia and in Thailand. To confirm the effectiveness of the analysis, another case study was carried out at one more site in Viet Nam where the climate conditions that strongly affect the air-conditioning demand and the status of economic development are different from those of the previous two sites. With the support of energy auditing experts, building walk-through was carried out at the selected site.

Based on the results of the case study, a set of energy-efficiency measures was proposed and the cost-benefit balance of these measures was estimated. Following the results of the case study on three sites, including the first-year study, the possibility of energy saving through optimising the operation of energy-consuming appliances (e.g. air conditioning, lighting), which underlies the potential of EMS deployment, was identified. These results were presented at the WG meeting and discussed more specifically in Chapter4.

(4) Identification of policy measures for EMS deployment

For accelerating EMS deployment in the ASEAN region, especially at the early stage, appropriate policy intervention to support it may need to be implemented, such as mandatory reporting and nomination of qualified energy managers for large consumers, promotion of energy service company (ESCO) business, energy price reforms, and so on.

Based on the current status of energy-efficiency policy in the five countries that was also discussed in the first-year study report, this study discussed the general characteristics of energy- efficiency institutional framework in the ASEAN region. With the results of the case studies for office buildings and factories, the impact of EMS dissemination on the national economy in the ASEAN region was then analysed.

In conclusion, the study presented a set of proposed policy options that the EAS countries should deal with to promote EMS dissemination. These options are explained in Chapter 5.

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.

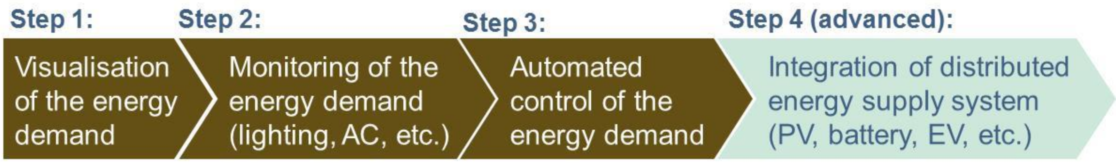
Stage 3. To control the energy demand automatically through data transaction. Conceptually, both consumer facilities and distribution grid system can be connected and controlled by identifying the total energy demand vis-à-vis the capability of existing grid systems, which is called demand response.

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

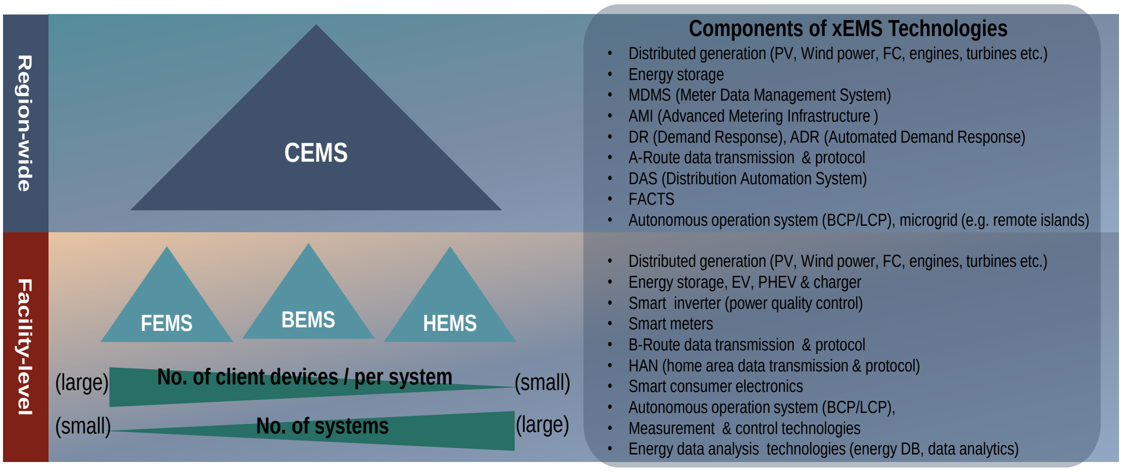
There are various types of EMS with different names according to the target users.

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.

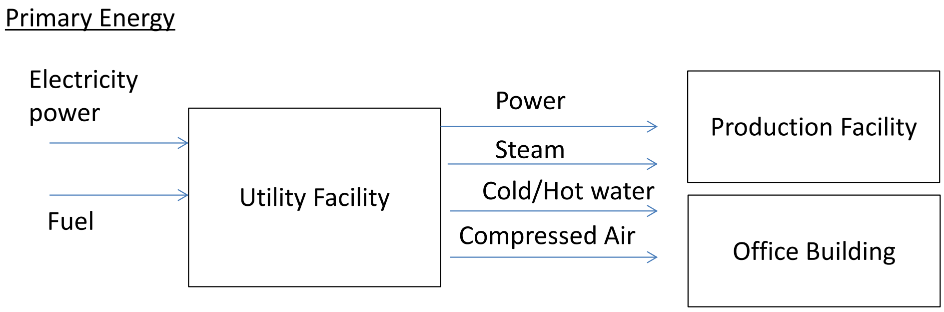
1.3. Roles of EMS

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.

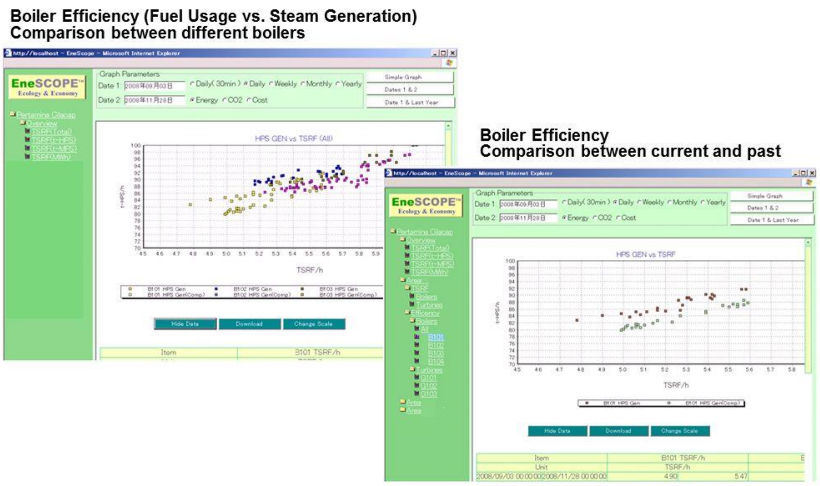
(5) Analysis of the effect of energy-saving measures. The effect of energy-saving measures is studied by comparing the energy use before and after implementing the measures. Theoretical estimation of energy use is provided for comparing with the actual performance.

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.

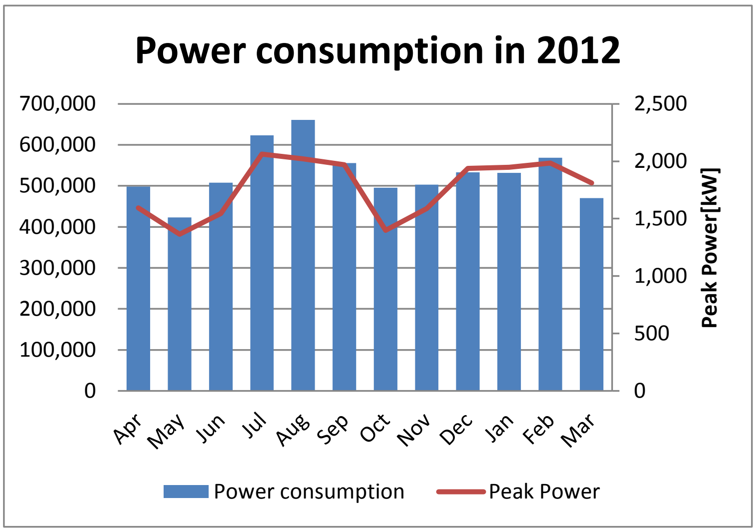
2.2. Basic approaches of data analysis

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)

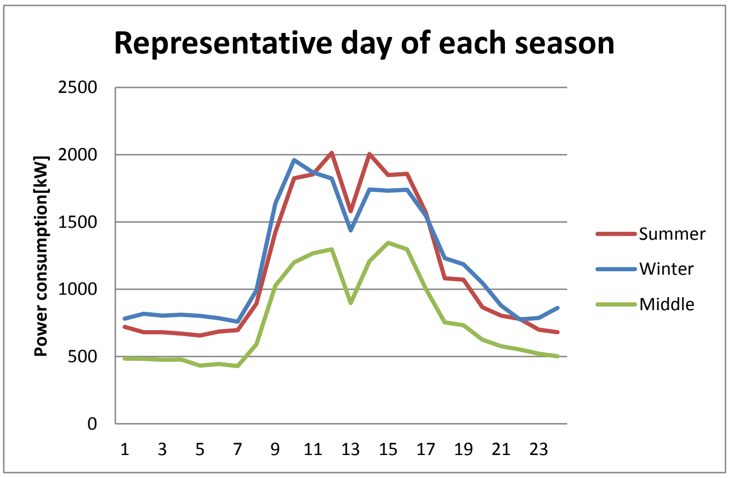


Source: The Energy Conservation Center, Japan (2014).

(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)

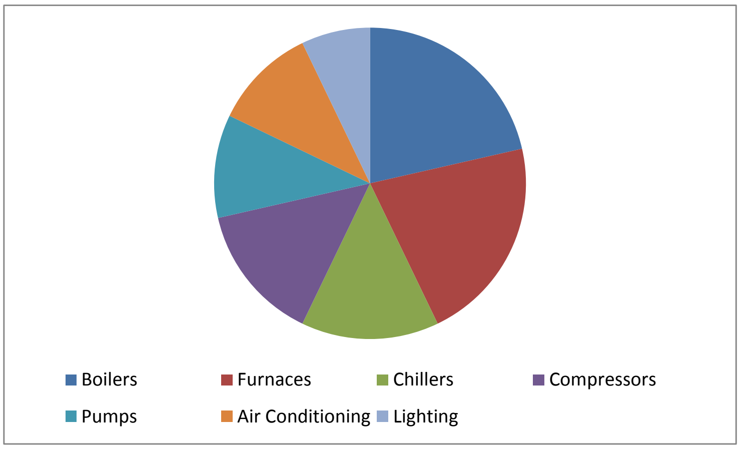


Source: The Energy Conservation Center, Japan (2014).

(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)

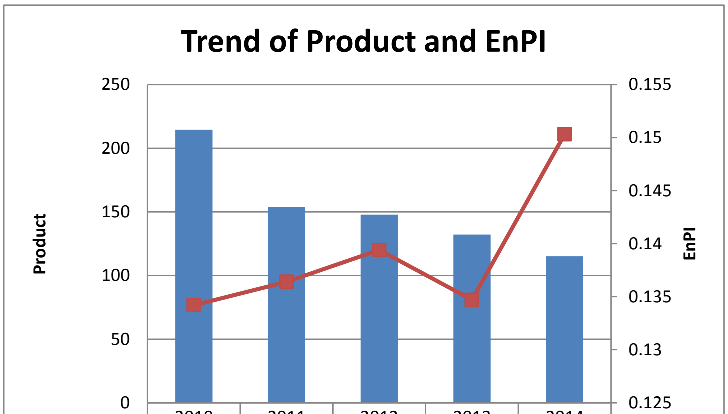


Source: The Energy Conservation Center, Japan (2014).

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).

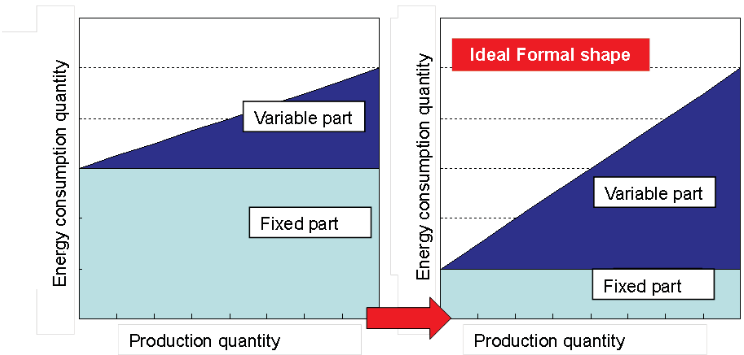
(3) Identifying the fixed part of energy use and turning the fixed into variable

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).

Chapter 3

Exploring Energy-Saving Potential for Industrial Sector Using Factory Energy Management System

In this chapter, the applicability of EMS is discussed, focusing more on the energy-saving potential for the industrial sector using factory energy management system (FEMS).

Since the structure of energy consumption in the industrial sector is generally more complicated than that in office buildings and varies a lot among the users, trying to grasp the comprehensive picture of FEMS applicability with only a few samples may be too rough.

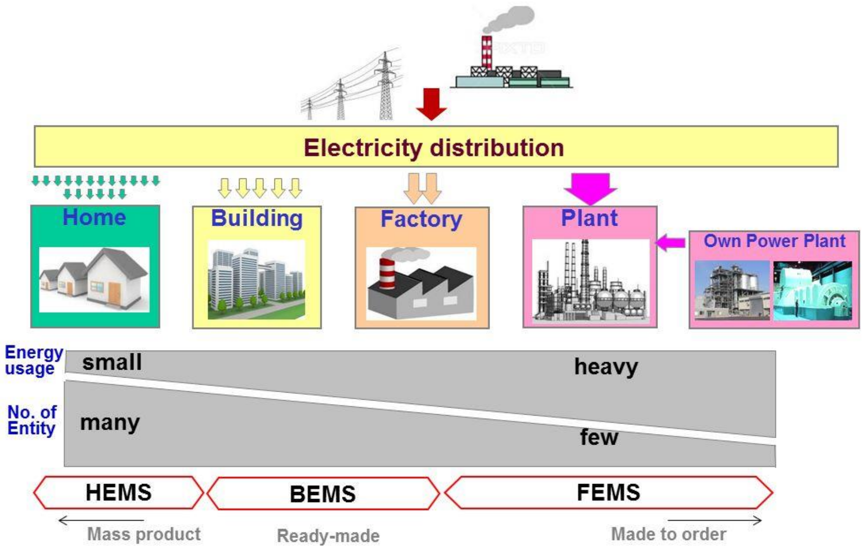
This chapter first discusses the general overview of energy consumption in the industrial sector and identifies the potential of energy efficiency considering the applicability of energy-saving technologies. The assumption of energy-saving potential is then tested through the case studies at the actual sites, and the implications and observations are drawn at the end of this chapter.

1. Applicability of FEMS

As discussed in Chapter 2, there is no difference in the basic functions among FEMS, BEMS, and HEMS but in the size of data and the number of target users. Compared with BEMS and HEMS, which target numerous users, the number of target users of FEMS is much smaller. However, since the size of each target user of FEMS is much larger than that of BEMS and HEMS, the effect of a single user's energy efficiency is huge. Also, since the profile of energy demand varies among users, FEMS is usually provided as a made-to-order product.

On the other hand, BEMS has a larger number of target users and is readily available as a ready-made product. HEMS, which deals with a larger number of smaller users, is a readily available mass product and involves lower price.

Figure 3.1: Applicability of FEMS, BEMS, and HEMS

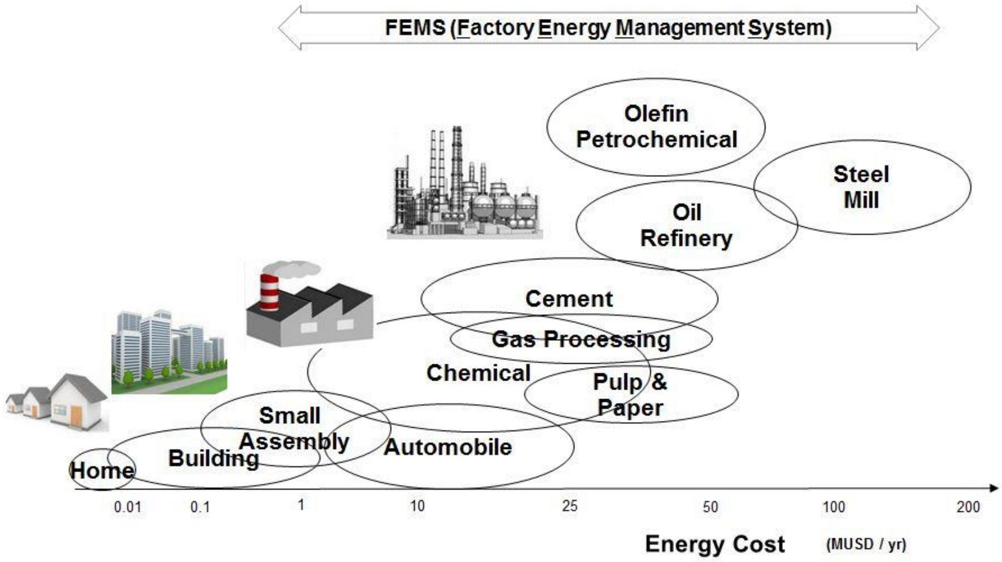


BEMS = building energy management system, FEMS = factory energy management system, HEMS = home energy management system.
Source: Azbil Corporation, 'Introduction of RENKEI Control System, Jointly Promoted by METI –Case Studies for True Energy-Saving Through Utilizing EMS & FEMS'.

The implementation of FEMS helps its users to grasp their energy consumption at ease and to run the cycle of PDCA for energy saving. Moreover, it should be noted that FEMS is a tool for energy saving by optimising the operation of appliances instead of investing huge capital for replacing the existing appliances with more energy-efficient ones.

The following figure plots various types of consumers in the industrial sector according to the volume of energy consumption as the horizontal axis. The target users of FEMS are medium- and large-sized consumers of energy.

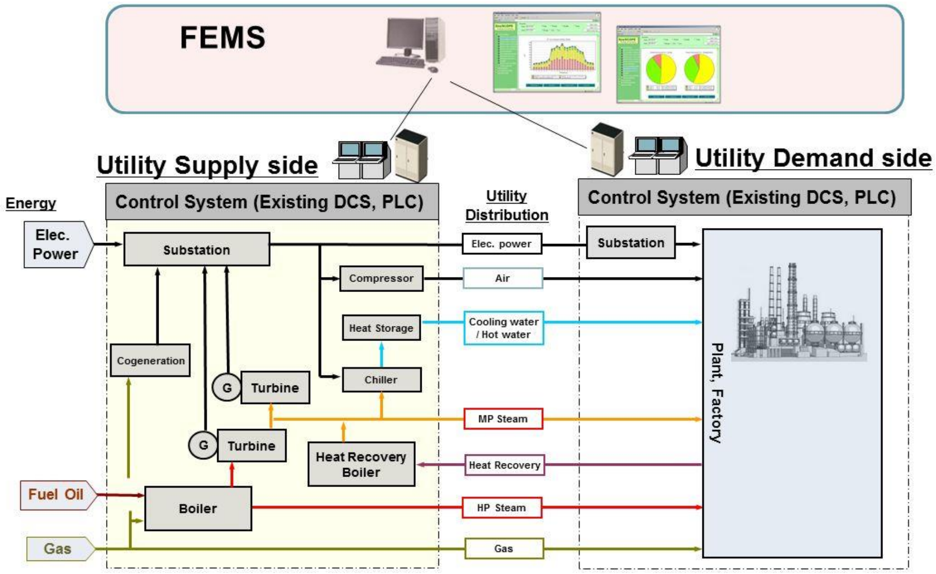
Figure 3.2: Image of Factory Energy Management System Applicability



Source: Azbil Corporation, 'Introduction of RENKEI Control System, Jointly Promoted by METI – Case Studies for True Energy-Saving Through Utilizing BEMS & FEMS'.

Since the facility setup also differs among the industrial consumers depending on the type of industries, FEMS's coverage is customised for each user to deal individually with a combination of various appliances. The following figure illustrates the general overview of FEMS's coverage. Because large industrial consumers are apt to own facilities of utility supply (electricity, heat, steam, hot or cooling water, and so on), FEMS often covers not only the demand-side but also the supply-side facilities of these utilities.

Figure 3.3: FEMS's Coverage of Supply-Side and Demand-Side Facilities



DCS = disturbance control standard, FEMS = factory energy management system,

PLC = power line communication.

Source: Azbil Corporation, 'Utility Facility Optimization Package Catalogue'.

2. Energy-saving technologies and industries

By establishing the connection between FEMS and the control system of facilities, their operational data can be obtained in real time, which facilitates the implementation of energy-saving measures.

Of the various energy-saving measures that differ among industrial consumers, the following are the typical energy-saving measures that can be handled from FEMS via the control system.

(1) Optimisation of compressed air system;

(2) Optimisation of combustion and steam supply;

(3) Optimisation of heat-source equipment;

(4) Optimisation of boiler, turbine, and generator; and

(5) Optimisation of distillation tower.

These are energy-saving measures that will be achieved by fine-tuning the control of appliances using FEMS. Energy-saving measures by installing or replacing or both the appliances themselves, such as installing inverters to motors and using LED for lighting and heat pumps, are not taken into account.

The following table is the matrix indicating the relation between these energy-saving technologies and the types of industry where these technologies are applicable. The horizontal axis shows a list of major industries that may require these functions. There may be still other types of industries not shown here but also require similar functions like those in the list.

Figure 3.4: Matrix of Applicable Energy-Saving Technologies and Types of Industry

			Industry																
			Pulp & Paper	Textile	Steel mill	Non-ferrous metals	Oil Refinery	Petrochemical, Olefins	Chemical	Ammonia, Fertilizer	Automobile	Mechanical assembly	Electric, Home appliance	Cement, Ceramic	District cooling system	Water treatment	Medium size co-generation	Food & Beverage	Pharmaceutical
FEMS Function	1	Energy Monitoring, Visualization	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	2	Energy Management, Performance Analysis	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
	3	Demand Prediction		o					o		o	o	o		o	o	o	o	o
	4	Operation Schedule		o					o		o	o	o		o	o	o	o	o
Energy-saving buit into FEMS	1)	Compressed Air System Optimization	o	o	o	o	o	o	o	o	o	o	o	o				o	o
	2)	Combustion & Steam Supply Optimization	o		o	o	o	o	o	o				o	o			o	o
	3)	Heat-source Equipment Optimization							o		o	o	o		o			o	o
	4)	Boiler Turbine Generator Optimization	o		o	o	o	o		o					o		o	o	
	5)	Distillation Tower Optimization					o	o	o	o									

FEMS = factory energy management system.

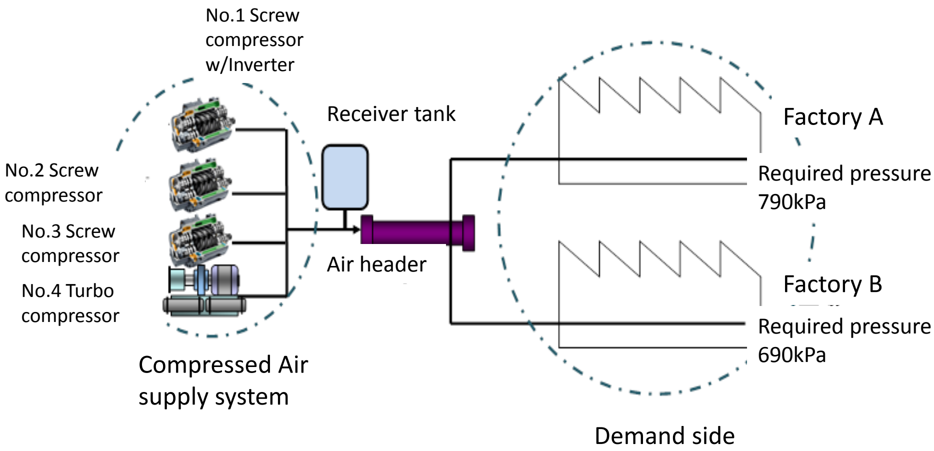
Source: Azbil Corporation (2016), Exhibition material for 'Sustainable Energy & Technology Asia'.

Each of these five energy-saving technologies is discussed further in the following section.

2.1. Optimisation of compressed air system

Compressed air is used in many factories for general purpose of air use or for instrumentation air use or both. It is apt to be an area of wasting energy where often there is lack of awareness in energy saving, because the outcome of energy use is converted into air that appears to exist by nature. In other words, there often exists a large room for improvement.

Figure 3.5: Example of Compressed Air System



kPa = kilopascal.

Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

When referring to the system configuration of Figure 3.5 as an example of compressed air system, the following three items are considered as the effective approaches for optimising the energy efficiency of the air compressor system (Figure 3.6).

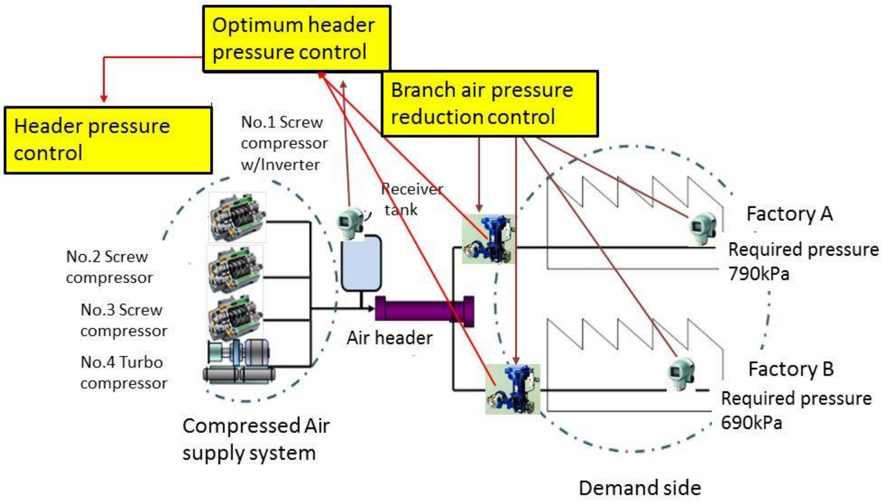
(1) Control of header pressure and the number of compressors;

(2) Adjustment of air pressure at each branch header; and

(3) Optimised control of header pressure.

It is generally observed that 10–30 percent energy saving of the compressed air system can be achieved by applying these measures of energy-saving control.

Figure 3.6: Energy-Saving Control for Compressed Air System



kPa = kilopascal.

Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

(1) Control of header pressure and the number of compressors

In general, air compressors consume less energy for the same volume of compressed air output if the discharge pressure is lower. It is generally observed that the energy consumption is reduced by 8 percent when the discharge pressure of a screw compressor is decreased by 0.1 MPa. Hence, lowering the discharge pressure of the compressors as much as possible contributes to energy efficiency.

If the user simply relies on the on–off control of compressors, the air header pressure may fluctuate greatly within the range of air pressure settings, and to avoid the sudden decline of air pressure, the user is apt to set the average discharge pressure of compressors at a relatively high level, which results in the waste of energy consumption.

For achieving an intelligent energy-saving control, it is recommended to install proportional–integral–derivative (PID) controller, which controls the air pressure of receiver tank, to reduce the fluctuation of header pressure. By doing so, the user can lower the setting of discharge pressure of compressors that results in saving energy.

It is important to note that partial-load, rather than full-load, operation of compressors impairs energy efficiency. Controlling the number of units in operation is performed by PID controller for optimised energy consumption. Partial load to deal with the changes of compressed air demand is managed by inverter-type compressors, while the other compressors operate at full load.

Figure 3.7: Concept of Proportional–Integral–Derivative Control

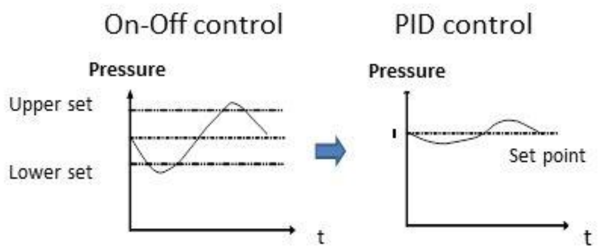
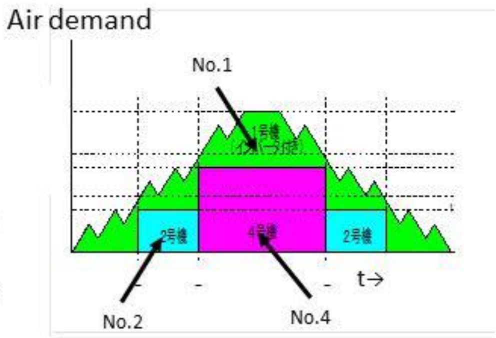


Figure 3.8: Controlling the Number of Units



PID = proportional–integral–derivative.
Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

(2) Adjustment of air pressure at each branch header

In general, air blow (including pneumatic cylinder actuation) and air leakage account for about 80 percent of the total consumption of compressed air, although the situation may vary depending on the sites. These kinds of air consumption and leakage can be reduced by lowering the air pressure at branch headers as much as possible. In addition, there is a potential of energy saving by reducing the air pressure during the time of non-operation, such as holidays and lunch breaks.

The necessary air pressure varies depending on the type of demand. In the conventional system, the compressed air is usually supplied to end consumption at the pressure as high as that discharged by air compressors. By applying the latest energy-saving control system, which installs pressure regulating valves at every branch, air pressure is adjusted at each branch to meet the demand of each site. In this manner, the air pressure of the total system can be reduced in accordance with the actual situation, and this helps in reducing the volume of air blow and air leakage and the energy consumption.

(3) Optimum control of header pressure

In the conventional system, the discharge pressure of compressors is set at a constant level to meet the largest demand of air consumption induced by pat experience. Optimising the control of header pressure contributes to energy savings.

FEMS provides the function of energy-saving control by monitoring the regulatory valve opening of each branch as mentioned in item (2) above. Energy-saving control adjusts the setting of air pressure of receiver tanks so that the PID controller can set the maximum opening of regulatory valves at each branch to the position of nearly full-open.

The optimised control of header pressure adjusts the setting of air pressure as low as possible, in accordance with the volume of current air consumption. By lowering the setting of average header pressure, energy consumption of the compressors can be reduced.

In our experience, energy-saving of about 10–18 percent can be achieved by applying these three energy-saving controls to a compressed air system.

2.2. Optimisation of combustion and steam supply

The following three items are considered to be the effective approaches for optimising the energy efficiency of the combustion and steam supply system: (1) air ratio control, (2) control of exhaust gas temperature, and (3) steam pressure control. It is generally observed that energy saving by 2–5 percent of the combustion and steam supply system can be achieved by applying these three measures of energy-saving control.

(1) Air ratio control

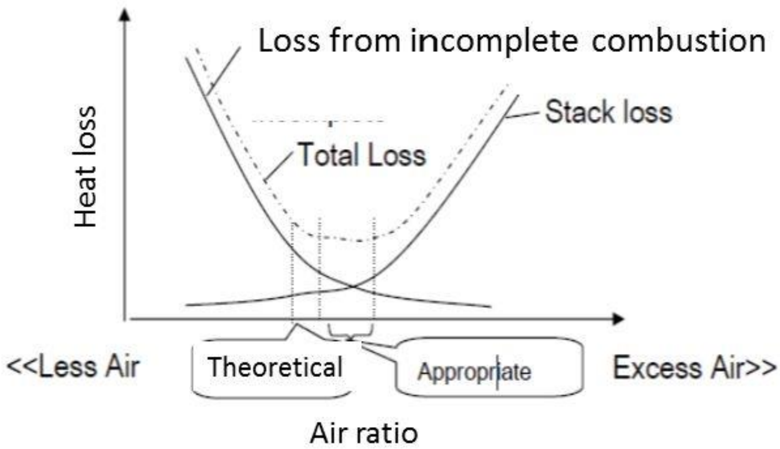
Air ratio refers to the ratio of actual volume of air supply for combustion against the theoretically calculated air supply necessary for combustion. If the air is supplied in combustion exceeding the theoretical requirement, the amount of heat transferred to this excessive air becomes the energy loss. Therefore, the smaller the air ratio is the more efficiently the energy management is achieved.

While the reduction of air supply to lower the air ratio as much as possible is favoured for lessening the energy loss, it should be noted that too much reduction of air supply may cause incomplete combustion. This leads to the discharge of combustible ingredients into the exhaust gas without being burned, and the unburned combustible content results in another form of energy loss.

To minimise the energy loss, the air ratio should be configured so that the sum of the heat loss in excessive air and the loss from unburned fuel would be minimised.

The following figure illustrates the relation between them. The heat in excessive air increases with the increase of air ratio, while the heat loss from unburned fuel increases drastically when the air ratio is lowered to 1.0 or less. The total heat loss from exhaust gas is minimised at a certain air ratio (the point of 'appropriate' in the figure). The optimal air ratio is identified in this approach, but this may vary depending on the combustion facilities, such as the form of combustion chamber and the type of burners.

Figure 3.9: Relation between Air Ratio and Heat Loss



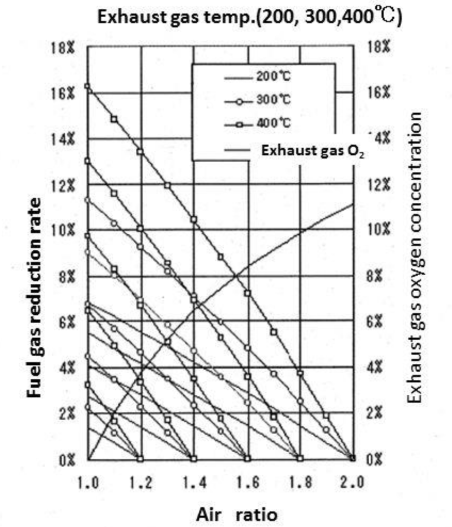
Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

(2) Control of exhaust gas temperature

If the air ratio is high, air that is not used for combustion is simply heated and wasted as exhaust gas. Furthermore, if the exhaust gas temperature is high, more thermal energy is wasted and discharged in the exhaust gas. In Japan, the government provides a guideline of normative reference value and target value of exhaust gas temperature.

Recovering heat from exhaust gas is needed to lower the exhaust gas temperature, and an economiser is usually used for this purpose. An economiser serves for exchanging heat between exhaust gas and feed water.

Figure 3.10: Air Ratio and Exhaust Gas Temperature



Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

(3) Steam pressure control

The requirement of steam pressure is different among the types of production, but in a conventional system steam is supplied at pressure as discharged by the boiler.

Reduction of steam header pressure can be effectively achieved by utilising the latent heat of the steam on demand side and, thus, reducing heat leakage and steam drain. The total thermal loss can be reduced in this manner.

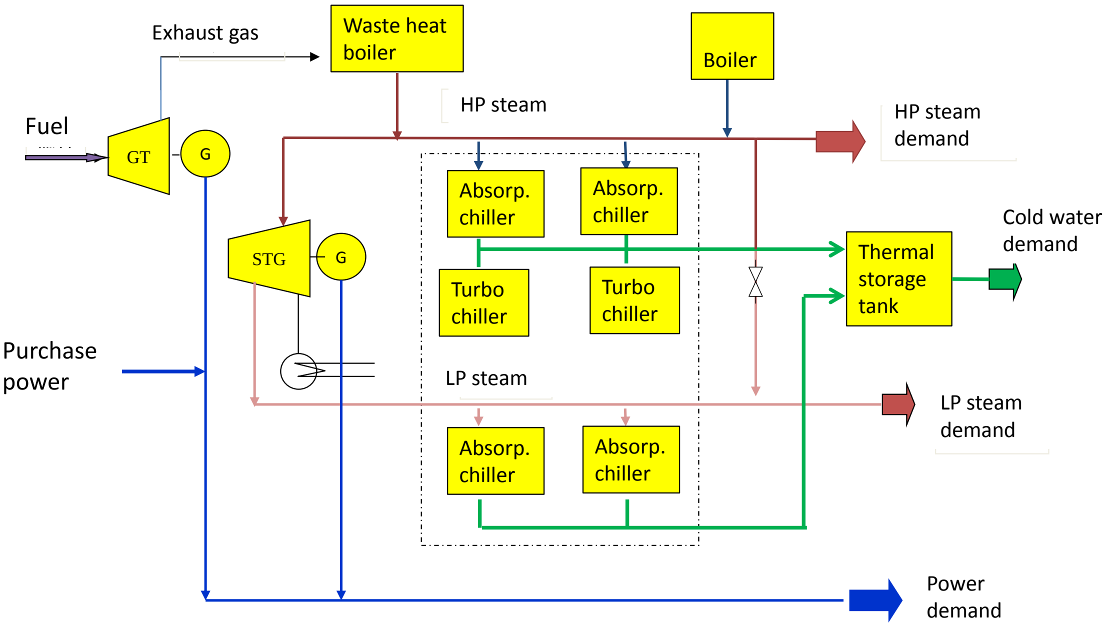
Using energy-saving control, pressure regulation valves installed at every branch can adjust the pressure at the branch to meet the pressure requirements. Reducing the steam pressure in accordance with the actual requirement of each branch helps reduce the total thermal loss.

2.3. Optimisation of heat-source equipment

Figure 3.11 shows a sample diagram of heat-source system, which supplies cold and hot water to the production process.

In this example, there are two turbo chillers using electric power and four absorption chillers using steam as the energy source. Electricity supply is partially generated by captive gas turbine, partially by captive steam turbine, and the remainder is supplied from the external grid. Steam supply from the steam turbine can be used for the demand of low pressure steam.

Figure 3.11: Overview of Heat-Source System



GT = gas turbine, HP = high pressure, LP = low pressure, STG = steam turbine generator.

Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

The following two items are considered as the effective approaches for optimising the energy efficiency of the heat-source equipment.

(1) Optimised operation and

(2) Trade-off solution.

It is generally observed that 3–7 percent energy saving of the heat-source equipment can be achieved by applying these measures of energy-saving control.

(1) Optimised operation

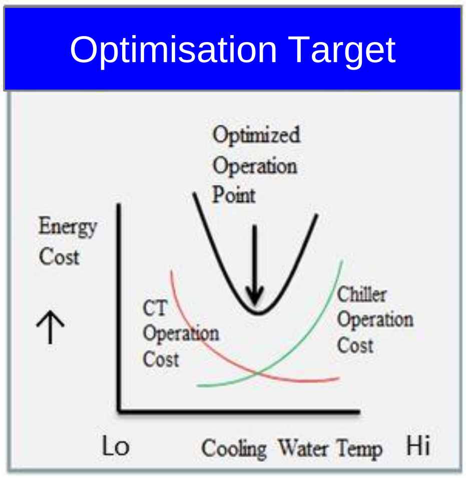
During the peak hours when the price of power purchase from the grid is high, use of absorption-type chillers using steam is of high priority; during the off-peak hours when the power price is low, use of highly efficient turbo chillers is of high priority. This leads to reduction of energy costs.

Cold water is stored in a storage tank during off-peak hours, and the stored cold water is used during peak hours. It is not easy for the user to determine which appliance to use under which conditions, and to determine the load allocation for optimising the operation.

(2) Trade-off solution

There are various trade-off issues in actual use, such as the relation between the temperature setting of cooling water and that of cooled water. If the temperature of cooling water is low, energy consumption of the cooling tower increases, but chillers work more efficient. If the temperature of cooled water supply is low, the efficiency of the chillers is worsened, but energy consumption of the conveyance pumps decreases.

Figure 3.12: Cooling Water Temperature



CT = cooling tower.
Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

The aforementioned issues, i.e. optimum operation to deal with how many units of appliance to operate and how to allocate the load among them, and the solution to trade-off, can be solved in real time by using the operation optimisation provided by FEMS.

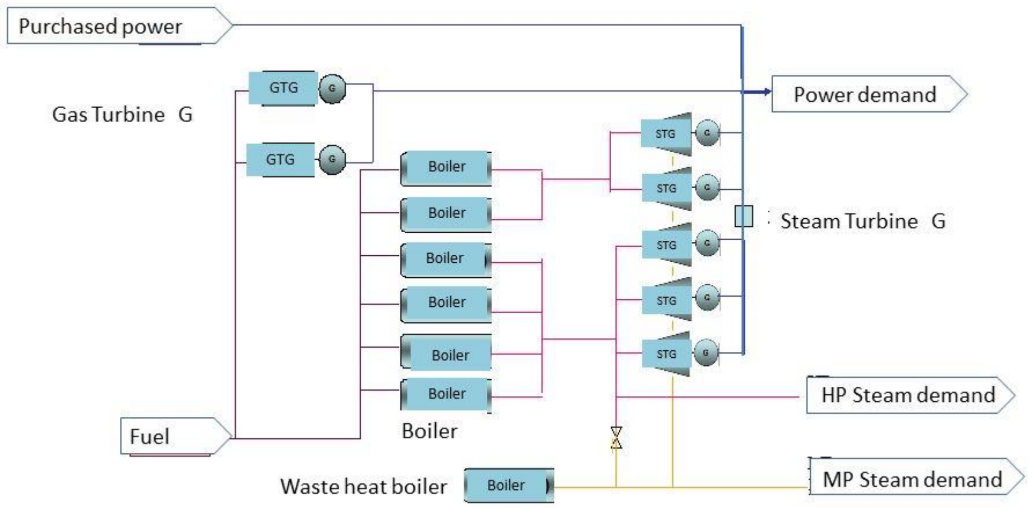
The operation optimisation system solves the optimisation and trade-off issues under various conditions. It minimises the total expense of electricity purchase from the grid and the cost of fuel and contributes to energy efficiency.

2.4. Optimisation of boiler, turbine, and generator

Figure 3.13 shows a sample diagram of utility facilities for oil refinery. Electricity is supplied by captive gas turbine generators, captive steam turbine generators, and also from the external grid. Steam supply from the steam turbine can be used for the demand of low pressure steam.

Steam for operating steam turbine generators is supplied from the steam boilers. Steam demand on the process side is supplied by heat recovery boilers or obtained from steam turbine generators.

Figure 3.13: Boiler and Turbine Generator Cogeneration System



HP = high pressure, MP = middle power.

Source: Japan Electronics and Information Technology Industries Association (JEITA) (2016).

It is not easy for the user to determine how to operate the utility equipment at the minimum cost of electricity and steam, which changes conditions at every moment. By using the online operation optimisation system, these complicated issues can be solved in real time.

The number of operating boilers and their load allocation is decided according to the steam demand and the efficiency of each boiler. The volume of steam to be extracted from each steam turbine generator is determined according to the demand of electricity and process steam, considering the different characteristics of each turbine.

It is generally observed that energy saving by 2–3 percent of the boiler turbine generator system can be achieved by optimising energy-saving control.

2.5. Optimisation of distillation tower

(1) Distillation tower

Advanced process control (APC) technology, based on the multivariable-model predictive control, has been adopted by many oil refinery and petrochemical plants for improving the yield of output and for stabilising the quality.

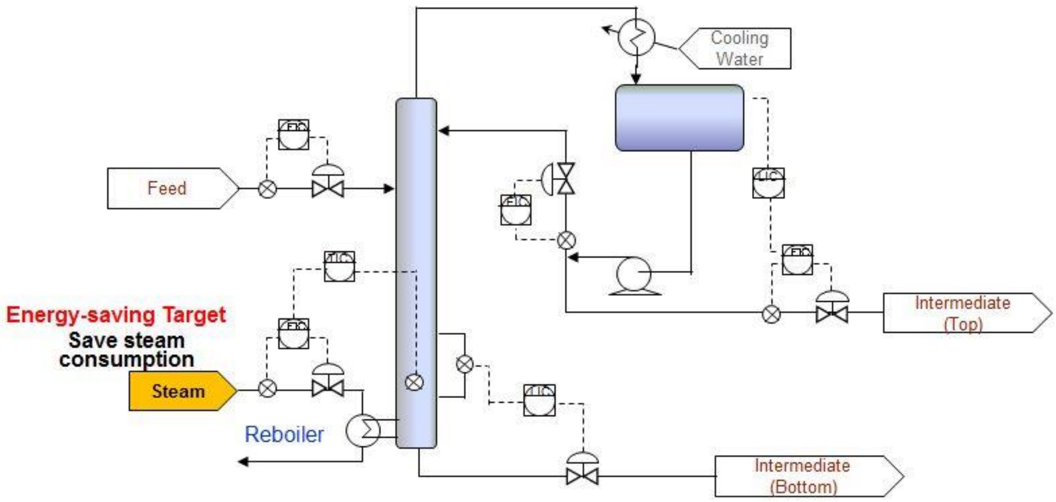
APC has also been recognised as a useful tool for energy saving. The following are its advantages, compared with the conventional control system.

(1) Excellent controllability and

(2) Elimination of control variable interference.

The following diagram, which is an example of distillation tower, shows energy-saving control using APC.

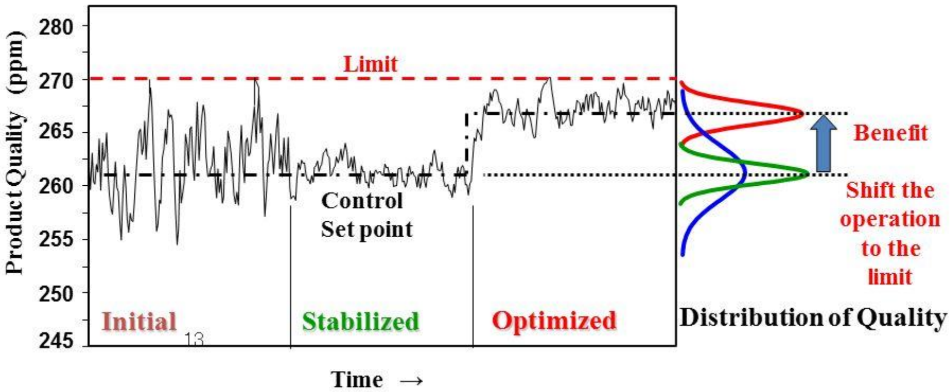
Figure3.14 Distillation Tower System



Source: Azbil Corporation (2016), Exhibition material for 'Sustainable Energy& Technology Asia' 2016.

APC stabilises the variance in impurity concentration compared with conventional PID control. This helps reduce the reboiler steam flow and the reflux flow, thus resulting in energy efficiency, by shifting the operation point closer to the upper limit of product impurity.

Figure 3.15 Product Quality Control



Source: Azbil Corporation (2016), Exhibition material for 'Sustainable Energy& Technology Asia 2016'.

It is generally observed that energy saving by 5–8 percent of the distillation tower system can be achieved by optimising energy-saving control.

3. Selection of Case Study Sites

To confirm the applicability of energy-saving technologies discussed in the previous section, case studies were conducted at sites: (i) Cogeneration plant operated by GPA, Singapore and (ii) Air compressor system at Proton City, Malaysia. These two sites were selected considering their relevance for the study and the site owners' willingness to accept the site survey.

The table below locates the position of these two sites on the matrix of energy-saving technologies for each type of industry. It shows that 'compressed air system optimisation' and 'optimisation of boiler, turbine, and generator system' are commonly used by various types of industry. In terms of types of industry, automobile and food and beverage are among the industries that widely exist in Southeast Asia.

Figure 3.16 Positioning of Case Study Sites in the Mapping of Energy-Saving Technologies

			Industry								Proton (Malaysia)						GPA (Singapore)	
			Pulp & Paper	Textile	Steel mill	Non-ferrous metals	Oil Refinery	Petrochemical, Olefins	Chemical	Ammonia, Fertiliz	Automobile	Mechanical assembly	Electric, Home appliance	Cement, Ceramic	District cooling system	Water treatment	Medium size co-gene	Food & Beverag	Pharmaceutical
FEMS Function	1	Energy Monitoring, Visualization	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	2	Energy Management, Performance Analysis	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	3	Demand Prediction		○					○		○	○	○		○	○	○	○	○
	4	Operation Schedule		○					○		○	○	○		○	○	○	○	○
Energy-saving buit into FEMS	1)	Compressed Air System Optimization	○	○	○	○	○	○	○	○	○	○	○	○				○	○
	2)	Combustion & Steam Supply Optimization	○		○	○	○	○	○	○				○	○			○	○
	3)	Heat-source Equipment Optimization							○		○	○	○		○			○	○
	4)	Boiler Turbine Generator Optimization	○		○	○	○	○		○					○		○	○	
	5)	Distillation Tower Optimization					○	○	○	○									

FEMS = factory energy management system.

Source: Azbil Corporation (2016), Exhibition material for 'Sustainable Energy & Technology Asia'.

It is worth noting also that gaining acceptance by the site owner of the site survey was a big hurdle unlike in the case study for buildings. As for the building sector, power utility companies in Indonesia, Thailand, and Viet Nam, the members of the Working Group of this ERIA study, offered their own buildings as the case study site and willingly provided data for the survey. These are public utility companies and are less reluctant to disclose their own data for promoting energy efficiency.

The case study for the industrial sector, on the other hand, had to negotiate with the site owners who are not the stakeholder of this ERIA study and were generally reluctant to disclose information about their operation. However, some of the owners of these two sites were very cooperative and provided the information for the survey as much as they could, which kind support the team greatly appreciated.

The following Sections 4 and 5 discuss the result of the case study on GPA (Singapore) and Proton (Malaysia), respectively.

4. Case Study 1: Green Power Asia Pte Ltd Cogeneration Plant, Singapore

4.1. About the case study site

Green Power Asia Pte Ltd (GPA) is an energy service provider based in Singapore. According to its website, the company provides the following various services.

(1) Onsite generation for electricity, steam, chilled water, and gases supply;

(2) Utilities supply and distribution services environmental asset and risk management;

(3) Performance guaranteed operation management;

(4) Environmental portfolio management;

(5) Carbon and renewable energy projects development;

(6) Power scheduling and settlement;

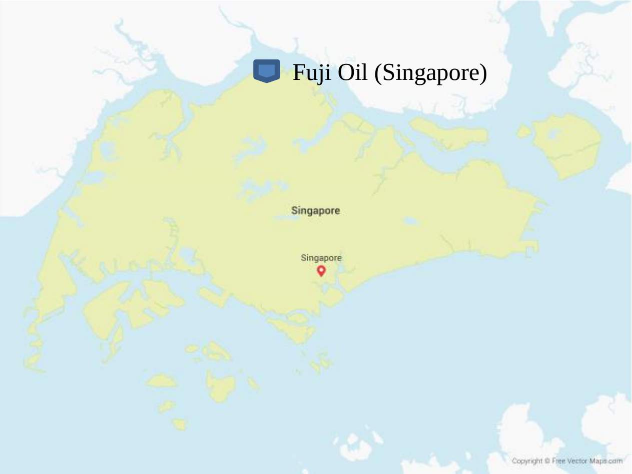
(7) Demand management integration with energy efficiency improvement; and

(8) Liquefied natural gas or compressed natural gas and natural gas supply management.

At the case study site, GPA is the provider of utility services, i.e. electricity and steam, using its own cogeneration plant. This cogeneration plant is located within the premises of Fuji Oil (Singapore) Pte Ltd, Senoko Road, Singapore, which is the manufacturer of vegetable oil.

Fuji Oil and GPA signed a build–operate–transfer contract in which GPA supplies electricity and heat to Fuji Oil for 15 years from 2011 using this cogeneration plant, and thereafter the ownership of the plant is transferred from GPA to Fuji Oil.

Figure 3.17: Case Study Site



Source: Author. (using map data from freevectormaps.com).

4.2. Observations from the survey

(1) Overview of the cogeneration plant

The site survey, which consists of the interview on plant operators and walk-through, was conducted on 25 of July 2016.

The capacity of this cogeneration system is 6.4 megawatt (MW) gas turbine for electricity and 30 tonne/hour for 13 bar gauge (barG) steam. All the exhaust heat from the gas turbines is recovered by a heat recovery steam generator. The natural gas used as fuel is purchased from Keppel Gas.

Figure 3.18: Cogeneration Facility Overview

Figure 3.19: Gas Turbine

Source: Site survey at Green Power Asia Pte Ltd (GPA) and Cogeneration Plant (25 July 2016).

Before the installation of this cogeneration system, Fuji Oil purchased electricity from the grid, and the steam was supplied by its own boilers. According to GPA, the introduction of the cogeneration system contributed to the reduction of annual energy costs by 31 percent. Currently, the main challenge for GPA is to further minimise operation costs and to maximise profit while satisfying the demand of power and steam.

(2) Operational profile

Besides the cogeneration system consisting of gas turbine (6.4 MW) and heat recovery steam generator (HRSG) as the main system, gas engine (mono-generation, 2 MW) and auxiliary boilers (two units) are installed on the site as backup for the maintenance of the main system.

Usually the gas turbine generator is operated constantly at maximum load. The power demand of Fuji Oil is, in general, 4.5 MW or less, hence, there is an excessive power generation over the demand. Since GPA is a licensed power wholesaler, it sells the excess of power generation to the grid. The excessive power generation is simply sold to the wholesale market at a spot market price called 'uniform Singapore energy price'. GPA has no long-term contract of power wholesale with an external counterpart, hence, GPA has not taken measures for hedging the price volatility. According to GPA, the wholesale price is not sufficiently high to recover the fuel cost. However, operating the cogeneration system at full capacity and selling the excess to the grid is better than adjusting the output to meet the demand in real time to avoid excessive generation considering that operating at partial load may impair the efficiency of power generation.

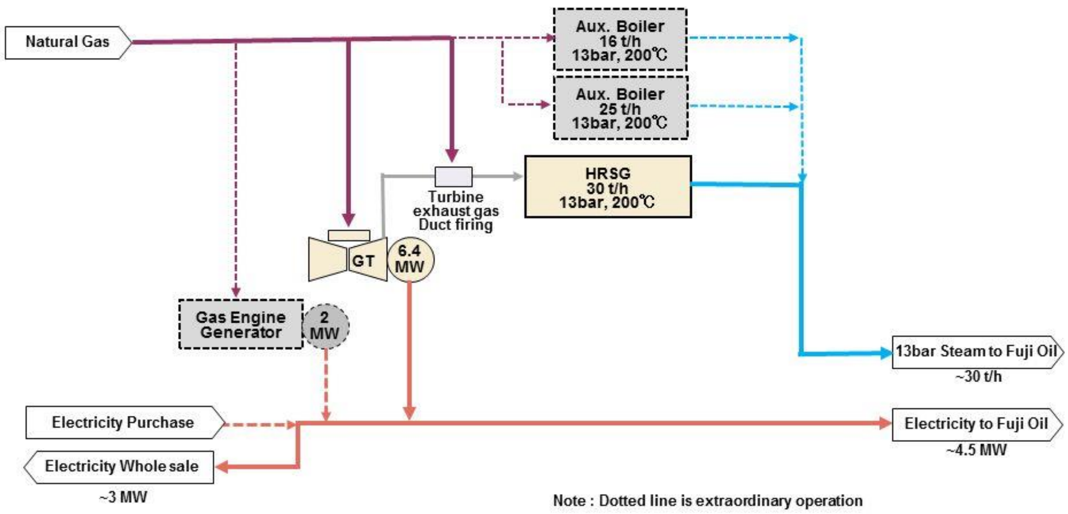
Steam is produced by HRSG. If the steam from HRSG is not enough to cover the demand, duct firing is used to increase steam generation.

GPA sets up an operational plan of the cogeneration plant by receiving from Fuji Oil its plant operational plan and making forecast of electricity and steam. Based on this, GPA calculates the necessary volume of natural gas to be procured from Keppel Gas. To have a benefit of preferential price, GPA is requested to inform Keppel Gas of the planned natural gas consumption three days ahead. In exchange for the favourable gas price, GPA is bound to a 'take-or-pay' contract. That is, in the case of consuming more gas than planned, the penalty has to be paid for the excessive consumption, and in the case of consuming less than planned, the cost of gas for the initially reserved volume, including the unconsumed, has to be paid. Therefore, when the steam load is lower than planned, the amount of duct firing is reduced, and surplus of gas is consumed in the gas engine generator (mono-generation) and generates more electricity to be sold to the grid.

This constraint of gas procurement contract is another reason GPA prefers operating the cogeneration system constantly at full capacity rather than adjusting to the actual demand. When the actual steam demand is lower than expected and the cogeneration system is not able to consume the full volume of gas supply of the day, the surplus gas is consumed by the gas engine generator to generate electricity to be sold to the grid.

It is also noteworthy that GPA is an external supplier of electricity and steam for Fuji Oil. It is only requested to supply these utility services to meet the demand of Fuji Oil and has no authority to adjust the demand side for optimising the cost of these services. The study team also contacted Fuji Oil to try to grasp the details of demand-side facilities and to discuss the potential of energy efficiency through optimised plant operation, but was declined because Fuji's operational data are confidential.

Figure 3.20: Diagram of Green Power Asia Pte Ltd's Cogeneration System



GT = gas turbine, HRSG = heat recovery steam generator, MW = megawatt, t/h = tonne per hour.

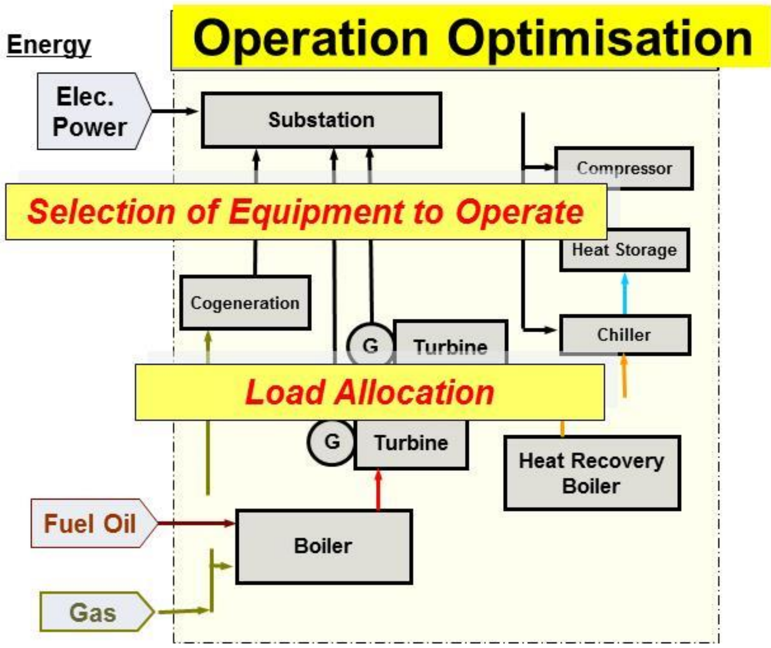
Source: Author.

4.3. Discussion on possible solutions

(1) Application of operation optimisation system

This study assumed to propose the application of operation optimisation system (Figure 3.21) to deal with the challenge of GPA for improving energy efficiency and profitability.

Figure 3.21: Operation Optimisation (sample)



G turbine = gas turbine.

Source: Author.

However, for this case assumptions should be extended beyond the actual situation in proposing the solution. Although FEMS may be able to deal with the optimisation of supply-side operation only, the optimisation would be achieved more effectively by analysing thoroughly the comprehensive system covering both the supply side and the demand side and applying the adjustment, as illustrated in Figure 3.3. In the case of GPA, the operators are separated between the supplier of utility services and the user, and the supplier (GPA) is only requested to provide these services to meet the demand, i.e. it has no authority to intervene into the operation of the demand side. Details about the demand-side operation in this case are not available and if the analysis is confined to the supply side, the structure of GPA's utility supply system using cogeneration system and its operational pattern are rather simple that there is little space for adjusting its configuration for optimisation. In addition, its operation is also bound to constraints, such as the inflexible contract of gas procurement, hence, GPA's gas turbine generator is operated at maximum load and the excessive electricity generation is sold to the grid. Despite these constraints observed from current situation, this study assumes that there is a potential of improving the energy efficiency by optimising the operation of the entire system covering both the supply side and the demand side holistically.

One thing to note about the current system is that the steam is supplied to the demand through one supply line at 13 bar gauge (barG). It is conceivable from general practices that the necessary pressure of steam varies depending on the types of demand. There is also a possibility, in this case, that lower steam pressure may be sufficient for some parts of the demand.

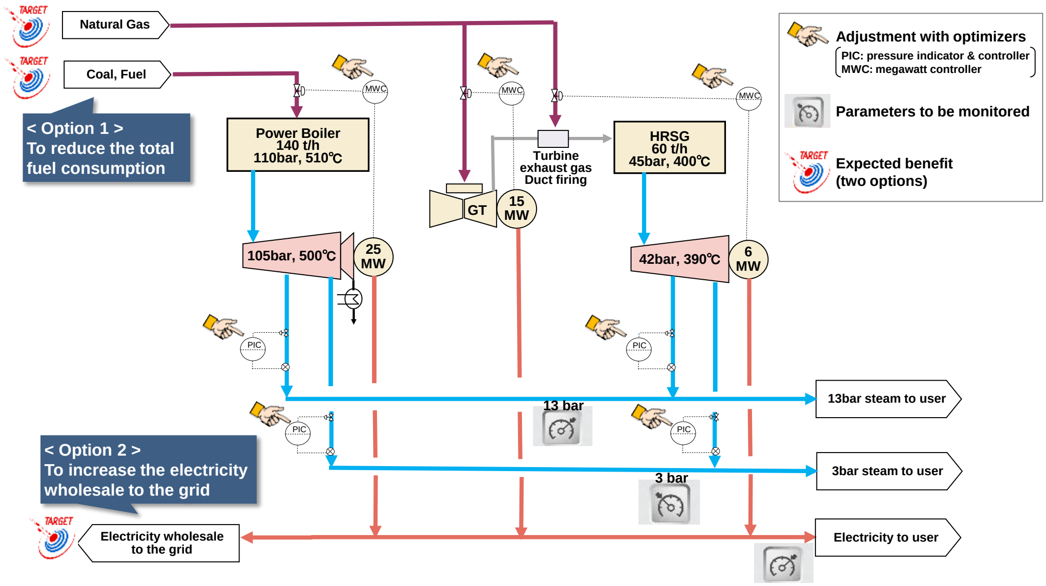
Hence, this study proposes to divide the supply of steam into two lines, i.e. newly installing a low-pressure line (3 barG) besides the existing medium pressure line (13 barG). Compared with the supply with a single line with medium pressure (13 barG) only, the addition of low-pressure line is expected to achieve the reduction of steam supply, i.e. the reduction of energy consumption for producing the steam.

Because the demand of low-pressure steam and medium-pressure steam changes from time to time, it should be monitored real time. Utilisation of pressure indicators and controllers helps maintain the optimised balance of supply between these pressure levels. In combination with megawatt controllers, the balance between electricity generation and steam production can be adjusted.

(2) Estimation of energy-saving potential and revenue-increase potential

There are two options to benefit from the reduction of energy consumption for producing steam: (i) to reduce the total fuel consumption in line with the saving of steam production and (ii) to maintain the total energy consumption but to use more for power generation so that the electricity wholesale to the grid can be increased. In the case of GPA, which is bound to a take-or-pay contract of natural gas procurement and will also prefer operating the cogeneration system constantly at maximum load to attain the best performance of efficiency, probably the second option is preferred as far as the wholesale price outperforms the marginal costs of electricity generation.

Figure 3.22: Two Options to Benefit from Reducing Steam Production



HRSG = heat recovery steam generator, MW = megawatt, t/h = tonne per hour.

Source: Author.

In a very rough estimation, the expected effect of energy saving by taking the first option is about 1–2 percent (reduction against the total fuel consumption), and the expected effect of increased revenue of electricity wholesale by taking the second option is about 2–5 percent (increase against the revenue from electricity wholesale to the grid).

5. Case Study 2: Proton Air Compressor System, Malaysia

5.1. About the case study site

Perusahaan Otomobil Nasional (Proton) is a Malaysian automobile manufacturer founded in 1983 with headquarters in Shah Alam, Selangor. Sales of automobiles in 2015 reached 102,175 units. This puts the manufacturer in second place domestically, with a 15.3 percent market share.

Figure 3.23: Proton Perdana

Proton = Perusahaan Otomobil Nasional.

Source: Proton website http://www.perdana.proton.com/

Proton has two major factories near Kuala Lumpur, one is located in Shah Alam near the head office and another in Proton City, Tanjung Malim, Perak, Malaysia. For this case study, Proton City factory was selected. The site area is 1,280 acres (5.2 km^2).

Figure 3.24: Location of Proton Tanjung Malim Sdn Bhd

Proton = Perusahaan Otomobil Nasional.

Source: Author. (using map data from freevectormaps.com)

5.2. Observations from the survey

(1) Overview of the air compressor system

The site survey, which consists of interview on plant operators and walk-through survey, was conducted on 22 July 2016.

Proton has air compressor facilities supplying compressed air to the stamping (press) shop, body (welding) shop, paint shop, trim and final (assembly) shop, and engine plus transmission shop in accordance with their demand for compressed air.

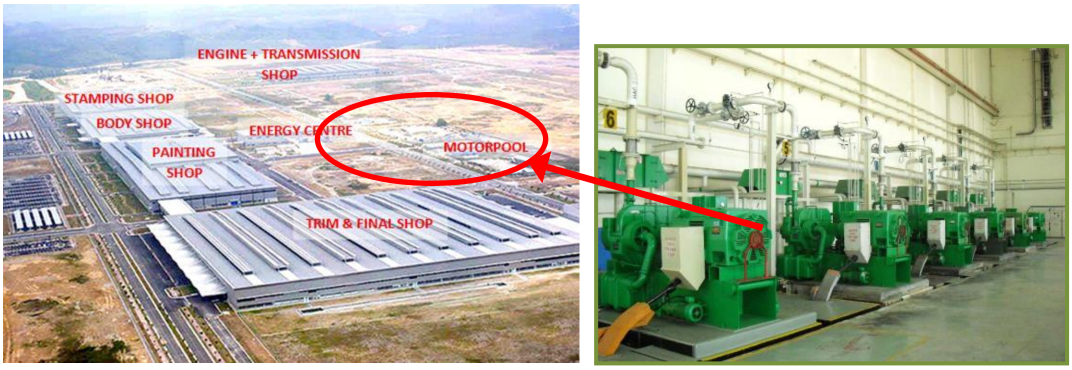
There are two places within the premises where the compressor room is located. One is in the energy centre and another in the engine plus transmission shop. The compressor system in the energy centre supplies to all except for the engine plus transmission shop, while the compressor system in the engine plus transmission shop supplies to its own use. The following are the installed air compressor systems in each room.

(1) Energy centre: 6 turbo compressors, 522 kilowatts (kW) x 6,000 normal cubic metres per hour (Nm^3/h); and

(2) Engine plus transmission shop: 2 turbo compressors, 336 kW x 3,400 Nm^3/h.

In total, these compressor systems generate 700 kilopascal (kPa) gauge of compressed air. Receiver tank is installed at each shop.

Figure 3.25: Bird’s-Eye View of Proton Tanjung Malim Sdn Bhd and Its Compressor System

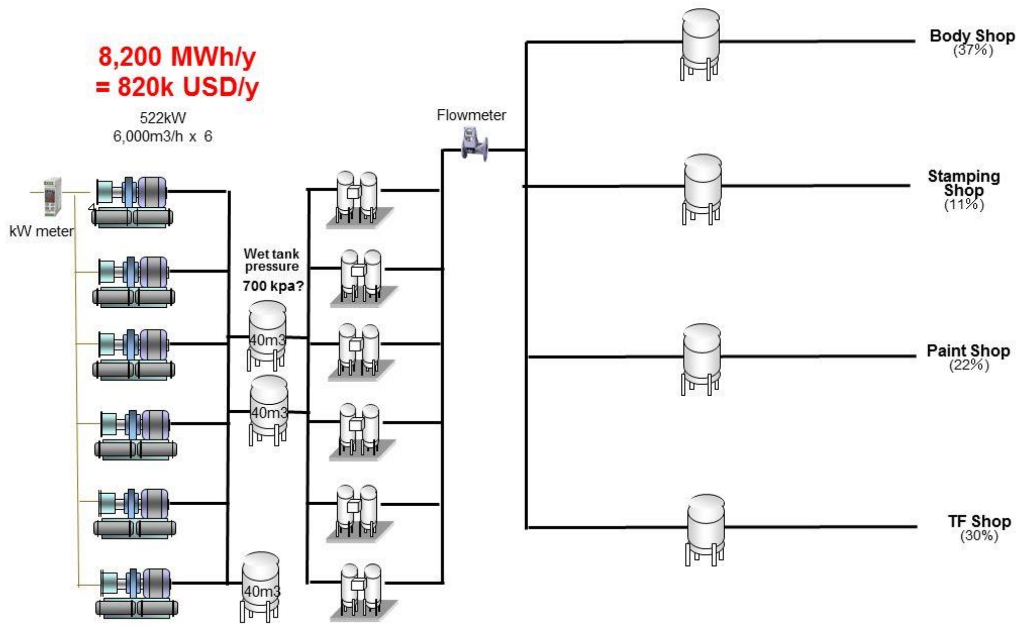


Source: Proton Tanjung Malim Sdn Bhd Compressed Air System Optimisation.

(2) Operational profile

The survey focused on the air compressor system in the energy centre. According to the plant operators of Proton, six units of compressor system in the energy centre in total consume 8,200 megawatt-hour electricity per year.

Figure 3.26: Diagram of Compressed Air Supply System in the Energy Centre



kPa = kilopascal, KW = kilowatt, m^3/h = cubic metre per hour, Wh/y = megawatt-hour per year, USD/y = United States dollar per year.

Source: Presentation material of Proton Tanjung Malim Sdn Bhd, 'Compressed Air System Optimization'.

Since compressors account for 17 percent of energy use for the entire plant, Proton is also aware that energy-saving measures for compressors can contribute significantly to overall cost improvement. According to Mr Abdul Azeem Bin Mohamed Mohideen, energy manager of Proton, Proton has taken initiative, called 'compressed air system optimisation' (CASO), since April 2014. According to Mr Mohideen, CASO initiatives have so far dealt with the following measures:

(1) Air leak repair,

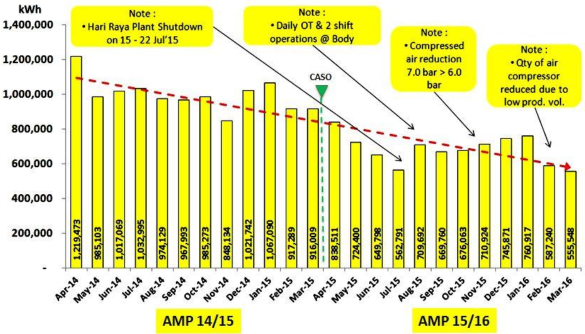
(2) Supply pressure reduction,

(3) Panel cooler improvement, and

(4) Air compressor optimisation.

These energy-saving measures have had the results of reducing the electricity consumption of air compressor system significantly as shown in Figure 3.27.

Figure 3.27: Proton's Energy Savings by Compressor Optimisation



AMP = (fiscal year of) annual management plan, KWh = kilowatt-hour.

Source: Presentation material of Proton Tanjung Malim Sdn Bhd, 'Compressed Air System Optimization'.

5.3. Discussion on possible solutions

(1) Application of compressed air system optimisation

Although CASO initiatives have achieved good results in energy efficiency, this study observed that there are still several energy-saving measures for compressed air systems, especially focusing on the energy saving related to the demand. This study proposed the following measures for further improving the energy efficiency of compressed air system as shown in Figure 3.28.

(1) Apply a group control of air-compressors;

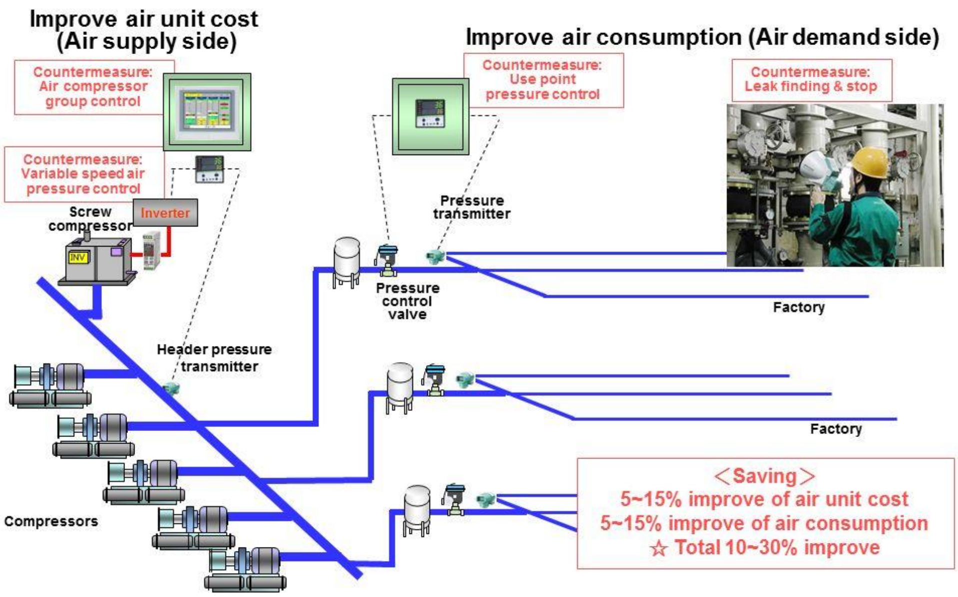
(2) Apply a control of variable speed air pressure;

(3) Install an air pressure control device at the downstream to monitor and control the air pressure also at the demand side; and

(4) Strengthen the leak detection to stop air leakage.

Above all, this study considers that the third item, i.e. installation of an air pressure control device at the demand side, is expected to yield energy-saving effect although certain initial costs may be required.

Figure 3.28: Compressed Air System Energy-Saving Solution



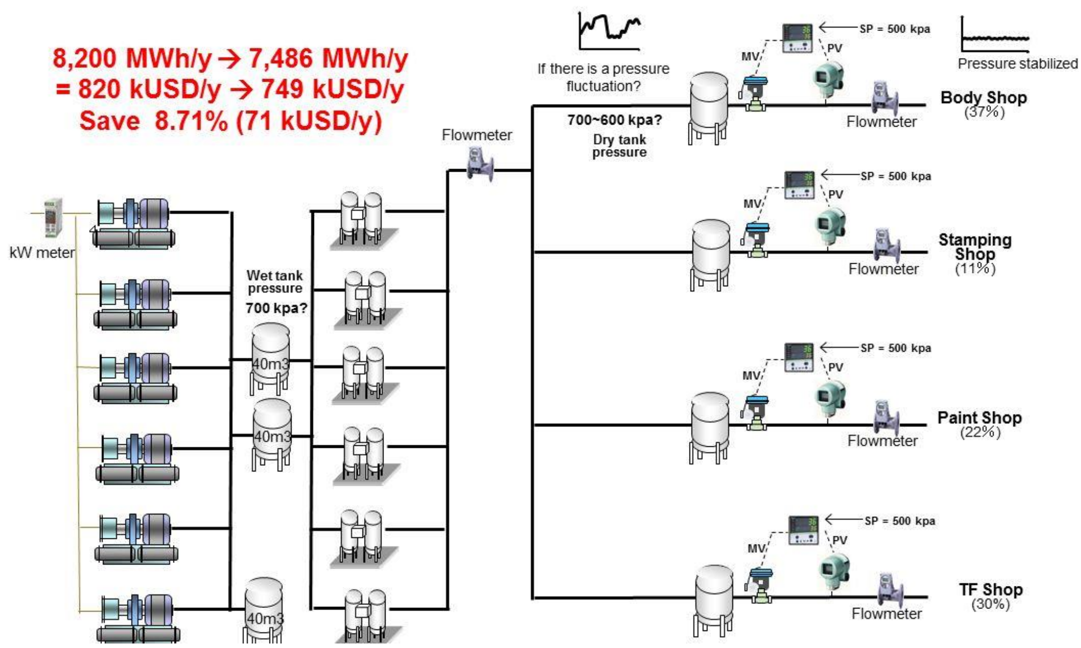
Source: Azbil Corporation (2016), Exhibition material for 'Sustainable Energy & Technology Asia 2016'.

(2) Estimation of energy-saving potential

Here the energy-saving potential of introducing a pressure reduction control device to each receiver tank is estimated.

Figure 3.29 shows the installation of pressure control devices at each of the four branch lines of air supply. If there is a pressure fluctuation at the upstream, the air pressure at the downstream will be adjusted to be constant. By reducing the excessive pressure supply, energy consumption for producing compressed air is expected to be saved.

Figure 3.29: Reduction of Compressed Air by Controlling Air Pressure at Branch Lines



kPa = kilopascal, kUSD/y = thousand US dollars per year, KW = kilowatt, MW = megawatt, MWh/y = megawatt-hour per year.
Source: Author.

This study estimates that if the original supply pressure is 600 kPa and is reduced to 500 kPa, air compressor system energy savings of 8.71 percent is expected.

Figure 3.30 Estimation of Energy-Saving Potential

	Shop	Present			Improvement Estimation						
		Air Consumption (hourly-average)	Annual Air Consumption (Present)	Supply Pressure (Present)	Supply Pressure (Reduction)	Annual Air Consumption (Estimate)	Blow Percent age	Oerating hours	Estimated Air Saving (Improvement)	Estimated Power Saving (Improvement)	Annual Cost saving	Improvement
		(m3/h)	(m3/yr)	(kPa)	(kPa)	(m3/yr)	(%)	(h/day)	(m3/yr)	(kWh/yr)	(MYR/yr)	(%)
1	Body-Shop	5,000	31,680,000	600	500	28,919,751	95	16	1,748,158	205,666	73,011	8.71%
2	Paint-Shop	3,000	19,008,000	600	500	17,351,851	80	16	883,280	103,915	36,890	8.71%
3	Stamping-Shop	1,500	9,504,000	600	500	8,675,925	95	16	524,447	61,700	21,903	8.71%
4	TF-Shop	4,000	25,344,000	600	500	23,135,801	70	16	1,030,493	121,234	43,038	8.71%
5	ETM-Shop	5,000	31,680,000	600	500	28,919,751	95	16	1,748,158	205,666	73,011	8.71%
										total	**247,854**	8.71%
											¥7,435,624	

Conditions		
Net Working-day	264	(days/yr)
Electricity Price	0.355	(MYR/kWh)
Compressor COP	8.50	(m3/kWh)

kPa = kilopascal, KWh/yr = kilowatt-hour per year, m^3/h = cubic metre per hour, MYR = Malaysian ringgit, ¥ = Japanese yen.

Source: Author.

The estimated costs of implementing these measures are US$160,000 (about 533,000 Malaysian ringgit [RM]). Comparing between the estimated costs and the economic benefits (about RM248,000 per year), this study expects that the payback period is about 2.2 years, which shows that the investment for these measures is economically feasible.

6. Key Findings from the Case Studies

As shown in Figure 3.16, this study identified five types of energy-saving technologies that could be widely applicable for the industrial sector. Two out of these five types were chosen for the case study, i.e. optimisation of compressed air system and optimisation of boiler, turbine and generator. Thereafter, the field case study was conducted for each of them to confirm the applicability of assumption, namely Proton's compressed air system in Malaysia and GPA's cogeneration system in Singapore.

Since there are various types of industries, and each uses various types of appliances, conducting only two case studies may not be sufficient to grasp the status of energy consumption of the industrial sector in Southeast Asia in depth. However, as discussed in Section 3, compressed air system and boiler, turbine, and generator are commonly used by various types of industry. In terms of types of industry, automobile and food and beverage are among the industries that widely exist in Southeast Asia. Therefore, roughly speaking, this study considers that these two sites represent the characteristics of energy consumption of the industrial sector in Southeast Asia.

From these case studies, it can be generally implied that the factory appliances are maintained rather well and that the owners are conscious about improving energy efficiency to a certain extent. Another reason may be that the case study sites are located in Malaysia and Singapore, which have rather high income level. It is also worthy of note that the case study sites were chosen upon the suggestion of government agencies of these countries that may be apt to select a good practice of their country.

However, even considering the aforementioned leanings, this study has observed that there is still a space for improving energy efficiency by optimising the system configuration. Following the observations from the site survey, this study raises three issues commonly applicable to the industrial sector in the ASEAN region. Also, dealing with these issues is expected to pave the way for the deployment of FEMS in this region.

The first issue is the practice of detailed measurement. Meanwhile, increasing the points of measurement and adjustment complicates the data analysis and the adjustment of operation, and FEMS is expected to be a tool to provide solution.

The second issue is the process of repeated trial and error. Since the structure and the condition of manufacturing system is different from site to site, the optimum configuration of parameters also differs among the sites, and finding the solution a priori is far from easy. The trial-and-error process of changing parameters is indispensable for reaching the optimum configuration.

On the other hand, facility owners are reluctant of changing the parameters because wrong configuration may affect the productivity of manufacturing and quality control although it may be transitional. These kinds of trial might be more difficult for the case of GPA in Singapore, where the supplier and the user of utility services (electricity and steam) are different, thus, the integrated approach covering both supply side and demand side is not easy. Utilisation of FEMS, which helps analyse the conditions of the entire system, is expected to facilitate the process of identifying the optimum solution without impairing the productivity and quality.

It has to be noted that human capacity development of expertise that versed in energy and statistics is also necessary to handle the huge volume of operational data although the utilisation of FEMS can be a strong tool for data analysis. Since it takes certain time and cost to develop human resources with the aforementioned expertise, it is strongly recommended that appropriate policy measures to promote this, such as qualification system for energy managers and training programmes, should be in place.

The third issue is to establish a commonly acceptable methodology to evaluate the cost and benefit. In general, the percentage of energy-saving potential against the total energy consumption is small for the industrial sector compared to office buildings. In the industrial sector, considerable portion of energy is used for the manufacturing process which is directly related to the products and, thus, is rather easily visible. Whereas at the buildings certain volume of energy, such as air conditioning, air circulation, and lighting, is apt to be used in an unmanned or scarcely manned manner. As explained in Section 2, the expected energy saving is around 5 percent of total consumption or less in many cases. However, because the energy consumption per one site of manufacturing is, in general, far larger than that of office buildings, energy saving per site can be large although the percentage appears to be small.. Therefore, a meticulous methodologies to evaluate the effect of energy saving measures should be established so that the results can be accepted not only by the suppliers of energy-efficiency technologies but also by their users and those who provide financial resources. This helps promote energy-efficiency technologies, including FEMS, and determine policy intervention necessary for their promotion, such as subsidies for initial investment.

Challenges for the deployment of EMS (not only FEMS but also BEMS) in the ASEAN region and a set of policy recommendations for its promotion briefly described in this section are discussed in detail in Chapter 5.

Chapter 4

Case Study of EMS Deployment for Office Buildings

1. Summary of the First-Year Study

1.1. Good practices of BEMS implementation

During the first year, the study discussed the applicability of BEMS referring to the actual cases of BEMS implementation. The following six cases were introduced as examples of good practices in the first-year report.

(1) Omotesando Hills (Tokyo, Japan)

Omotesando Hills, a shopping mall located in the Shibuya district of Tokyo, at first arranged the operational schedule of the air-conditioning system around the business hours of the shops and restaurants in the complex. However, it was determined, through the use of BEMS, that air conditioning could be cut back 30 minutes each day.

In addition, the frequency of the air-conditioning units was adjusted by using the inverter system for harmonising with that of the ventilation unit of restaurants, where the outside air exchange units were originally operated at a constant, unchanging rate. It was discovered that the amount of intake of external air was excessive. Adjusting the system frequency makes a substantial contribution to energy conservation, because the amount of electric power demanded is proportional to the cube of the electrical frequency.

As a result, Omotesando Hills successfully reduced its energy consumption by about 40 percent.

The Intelligent Energy System Project, which is a pilot smart grid project in Singapore administered by Energy Market Authority, Singapore Power, and Nanyang Technological University, aims to investigate the potential for behavioural change by residents if provided real-time electricity consumption information.

In this pilot project, it was studied how residential energy-use patterns are affected by providing consumption information to customers, through the use of smart metres with in-home display and web-portal services provided by Singapore Power Service.

The results showed that customers who received in-home display reduced energy consumption by 3.8 percent, whereas customers who had access only to web portal had no change in energy consumption. This shows the potential to further influence consumption behaviour through information, but the information should be easy to access.

(2) Sengokuyama Mori Tower (Tokyo, Japan)

Sengokuyama Mori Tower, which is a multipurpose complex located in the Minato district of Tokyo, uses BEMS technology to monitor the energy systems and collect data. Mori Building, owner of the complex, uses an energy-efficiency indicator, called the 'water transportation factor' for controlling the water flow through the chilled water system. By adjusting the amount of cooling water in the system, the operator saved about 10 percent of the energy consumption.

In addition, Sengokuyama Mori Tower saved 30–60 percent of energy for the hot water system by adjusting the pressure of hot water. The all-out use of the efficient LED fixtures saved its tenants a significant amount although it required a higher upfront cost.

(3) ECOZZERIA, Shin-Marunouchi Building (Tokyo, Japan)

The Shin-Marunouchi Building was completed in 2007 by Mitsubishi Estate, a major Japanese real estate company. Its tenants are all members of ECOZZERIA, which is a space to showcase the diverse environmental efforts.

ECOZZERIA equips LED lighting system with a switch and a lux metre with which you can change the intensity of the lighting. While most offices set the intensity of overhead light at 700 lux (lx), it is set at 300 lx to 500 lx in this office. According to them, setting the lux at those levels enables workers to watch screens for a longer time without feeling discomfort. The initial investment cost is about 3 times more expensive, but the energy used for lighting is 70 percent of the benchmark (=30 percent less) compared that used for normal offices.

ECOZZERIA also installed a radiation air-conditioning system, which uses cool water sent through an innovative tubing system integrated into the ceiling. By using heat exchanger, the temperature of the fresh air taken from the outside is almost the same as room temperature, and carbon dioxide (CO_2) sensors control it. Compared with the regular air-conditioning system, the initial cost of radiation air-conditioning system is about 1.5 times more expensive, but energy consumption is saved by 25 percent.

(4) Marunouchi Heat Supply (Tokyo, Japan)

Marunouchi Heat Supply is one of the advanced cases of district heating and cooling system in Japan. The system controls boilers and chillers, reducing significant amount of CO_2 emissions. One of the major advantages is the efficient operation due to the centralisation of boilers and chillers. It reduces primary energy consumption by 20–25 percent compared with stand-alone heating and cooling system.

The company uses and installs both turbo and absorption chillers to realise the best mix of electricity and gas consumption. It mainly uses turbo chillers for making cold water because the coefficient of performance of turbo chiller, combined with inverters, is as high as 25. However, during peak day-time hours, it uses absorption chillers that are low in coefficient of performance (between 5 and 6) but do not consume electricity. By doing this, the company saves the demand charge of its electricity tariff.

(5) Amari Water Gate Bangkok and Amarin Plaza (Bangkok, Thailand)

Azbil Corporation, an energy solution provider, started an ESCO pilot project at Amari Watergate Bangkok and Amarin Plaza in Thailand. BEMS, combined heat power VWV (variable water volume) control, CDP (constant differential pressure) VWV control, and cooling tower fan VSD (variable speed drives) control are applied at these buildings. During the first year, they checked the data on a monthly basis. On the second year, they checked the data every quarter. They do not have its staff constantly on-site, and only look at BEMS data from Japan. When the target was not achieved, they tried to find and revise the causes. As a result, an annual energy consumption of 663,483 kilowatt-hours (KWh) and an annual cost of THB3,498,347 were saved through those projects, saving 15 percent energy at Amari Watergate Bangkok.

Since it was a pilot project, Azbil gained no profit from it. The understanding for ESCO has not been enough in the ASEAN countries, so educating customers about the concept is indispensable for promoting ESCO business.

1.2. Case studies in Indonesia and Thailand

The first-year study also analysed the potential of dissemination and deployment of EMS technologies in the ASEAN region, especially focusing on BEMS.

The examples in the EAS countries showed that the key factors of energy saving through EMS deployment were: (i) visibility (to grasp the actual situation of energy consumption), (ii) accessibility (to easily check the collected data), and (iii) comparability (to compare with other users with similar load profiles). Thereafter, the set of the most efficient measures was selected to optimise the economic benefit against cost.

To grasp the real situation to serve for the aforementioned factors, a case study was conducted in two sites during the first year, one in Indonesia and another in Thailand. The case studies were carried out in the manner that desk research on energy-saving actions or behaviours was first conducted. Thereafter, the effectiveness of energy-saving measures was examined through the field survey on the actual status of energy consumption to confirm the energy-saving effect more in detail.

Based on the results of a case study conducted at the two sites, it was observed that office buildings in high-temperature and high-humidity environment had a great deal of room for saving energy by improving air conditioning and that two main points should be improved for air conditioning in office buildings: (i) to adjust the intake volume of fresh air from outdoors and (ii) to adjust the frequency of motor power by using inverters.

(1) To adjust the intake volume of fresh air from outdoors

For the first point, the solution dealt with a problem that excessive ventilation caused load increase through the energy loss of chillers and refrigerators by unnecessarily exhausting cold air outside. The study suggested that the optimised volume of ventilation can be identified by monitoring the number of people in the office and CO_2 density periodically. The adjustment of the intake volume of fresh air was to be made via adjustment of air intake and of air exhaust.

The case study results showed that it was a common practice in the EAS countries that air exhaust of each floor was led to the washroom or the hot water supply room. Air exhaust was made regardless of the CO_2 density and, thus, it was not feasible to control air exhaust at these points. Therefore, this study suggested that adjusting air intake by introducing motor damper in the ventilation would contribute to the decreasing electricity load of chillers and refrigerators. Although a little costlier, an advanced step to follow is to install a variable air volume system to reduce the energy consumption of fans.

Figure 4.1: Air Intake at Machine Room

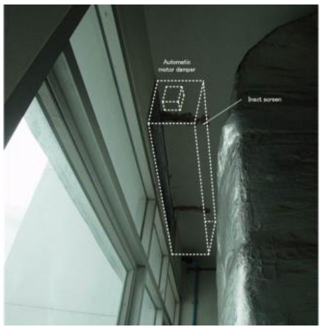
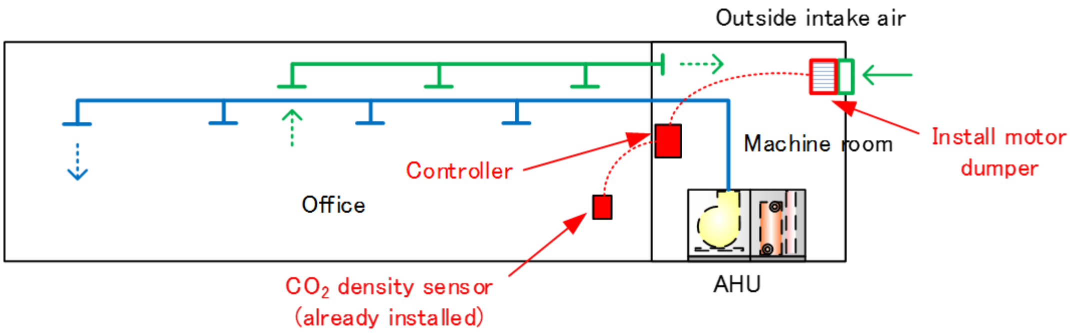


Figure 4.2: Image of Motor Damper

Source: Author (Left), Wikimedia Commons [Damper (flow)] (Right).

Figure 4.3: Recommended Schematics of Air flow with Motor Damper



AHU = air handling unit, CO_2 = carbon dioxide.
Source: Author.

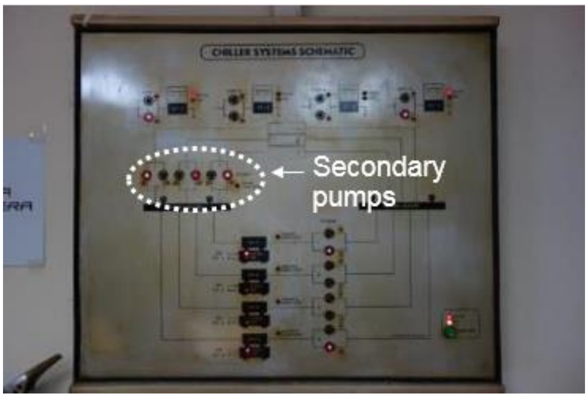
(2) To control the frequency of motor power of compressors using inverters

For the second point, the solution was to reduce the energy consumption of compressors by controlling the frequency of motor power by using invertors. The first-year study identified the benefit of introducing induction motors and synchronous motors, and inverters were an essential part. By adjusting the setting for the frequency of inverters and optimising the rotation, high effects of energy saving were expected. In the study, it was observed that the energy consumption of motor power was reduced remarkably by decreasing the rotation by half. In the field study, it was also found that the motor was operated at maximum output even in sites where inverters were already installed, i.e. no practice of adjustment has been done.

In the ASEAN region, the diffusion of inverters for air conditioning was still not common enough, but the study suggested that the combination of optimising air ventilation and adjusting the frequency of inverters (depending on circumstances, by introducing automatic variably controlling) can help actualise the potential of energy saving to the maximum.

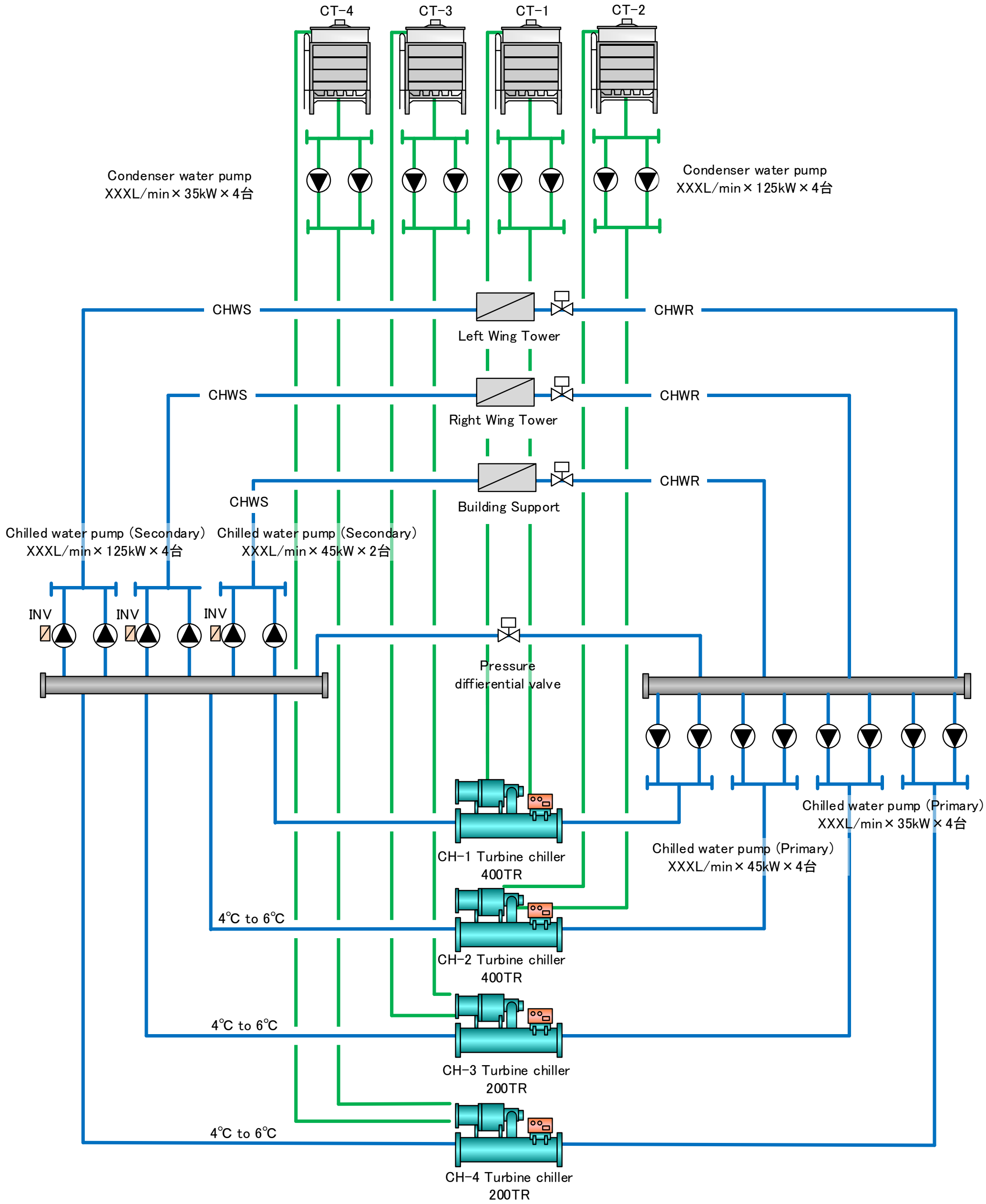
In addition, the study also argued that, on a longer-term basis, more attention should be paid to energy efficiency through the introduction of advanced building structure. For example, the Green Building program in the United States, the regulation of energy saving in new buildings by the Ministry of Land, Infrastructure, Transport and Tourism of Japan, and the Top Runner Program were discussed in the study.

Figure 4.4: Monitor Panel



Source: Author. .

Figure 4.5: Diagram of Chilled Water Supply System



CH = chiller, CHWR = chilled water return, CHWS = chilled water supply, CT = cooling tower, INV = inverter, kW = kilowatt, TR = ton of refrigeration.

Source: Author.

2. Case Study at EVN Head Office, Hanoi, Viet Nam

In the second-year study, an additional case study of EMS deployment was conducted in Viet Nam, where the climate conditions that strongly affect the air-conditioning demand and the status of economic development are different from those in Indonesia and Thailand.

Most of the land area in the ASEAN region is located in tropical climate. Northern Viet Nam is positioned in subtropical climate, and because of the seasonal fluctuation of temperature, energy consumption deriving from air conditioning is supposed to be relatively small compared with that in tropical climate where air-conditioning demand is constantly high throughout the year. The case study in Viet Nam looks more at the potential of energy efficiency in lighting than that in air conditioning.

It should be noted also that electricity price in Viet Nam is lower than that in other four ASEAN countries as discussed in Section 1.6. A case study in Viet Nam, therefore, helps evaluate the applicability of BEMS in a more conservative condition.

With the support of energy auditing experts, a walk-through was carried out at the EVN Head Office in Hanoi.

2.1. About the case study site

EVN is a state-owned electric company in Viet Nam, whose head office is located in the central district of Hanoi. It proposed to show EVN Head Office building complex for the case study. The buildings were completed in April 2014. Hereunder is EVN's general consumption information.

Table 4.1: Overview of EVN Head Office

Name	EVN Building – A Tower
Year Operated	2014
Total floor area	93 351 m^2
Air-conditioned floor area	72 970 m^2
Number of floor	Overground: 33 Underground: 3
Number of daytime workers	1 050
Maximum demand	5 300 kW
Supply voltage	22 kV
Total capacity of Heat source: AC etc.	2 114 kW

AC = air conditioner, kV = kilovolt, kW = kilowatt, m^2 = square metre.

Source: Study Team, using EVN data.

2.2. Observations from the survey

(1) Overview of the installed facilities

A site survey, which consists of interview with the facility manager and walk-through survey, was conducted on 23 December 2015 to extract potential energy-saving measures. The building was completed in March 2014, and the equipment and systems installed are new.

Hereunder is a list of all items checked for each system: chilled water supply, cooling and ventilation, and lighting, as well as outline diagrams.

Chilled water supply system:

(1) Daily operating hours: 9 hours (7:00 to 18:00).

(2) Chillers: 4 No 900RT units installed, but only 2 units are normally in operation.

(3) Chilled water supply temperature is set at 7°C during the hottest months (June–July), but the setting is relaxed during other months, ranging from 8°C to 12°C.

(4) Condenser water supply temperature setting is variable, ranging from 32°C to 37°C.

(5) Chilled water delivery primary pump system is composed of 5 units (1 unit as standby), 9 secondary pump units (3 units as standby).

(6) Chilled water secondary pumps and condensate water pump have speed converter control installed for energy saving.

Cooling and ventilation system:

(1) Temperature control and ventilation for standard floor space offices is provided by air handling units.

(2) Temperature control and ventilation for common areas on lower levels is provided by fan coil units.

(3) Air-conditioning units are installed on machine rooms on each floor and have built-in variable ventilation volume control depending on the indoor temperature and the variable rotation of the inverters. A check inside the twenty-third floor machine room confirmed that the inverter rotation was at 14 Hz.

(4) Sensors are installed within the air-conditioning unit return ducts to detect the CO_2 and control intake of fresh air.

(5) 2 Supply air fan units (1 unit as standby), 2 extraction fan units (1 unit as standby) are installed to provide ventilation for the drive-in car park, operating hours at 7:30–18:30 (9 hours).

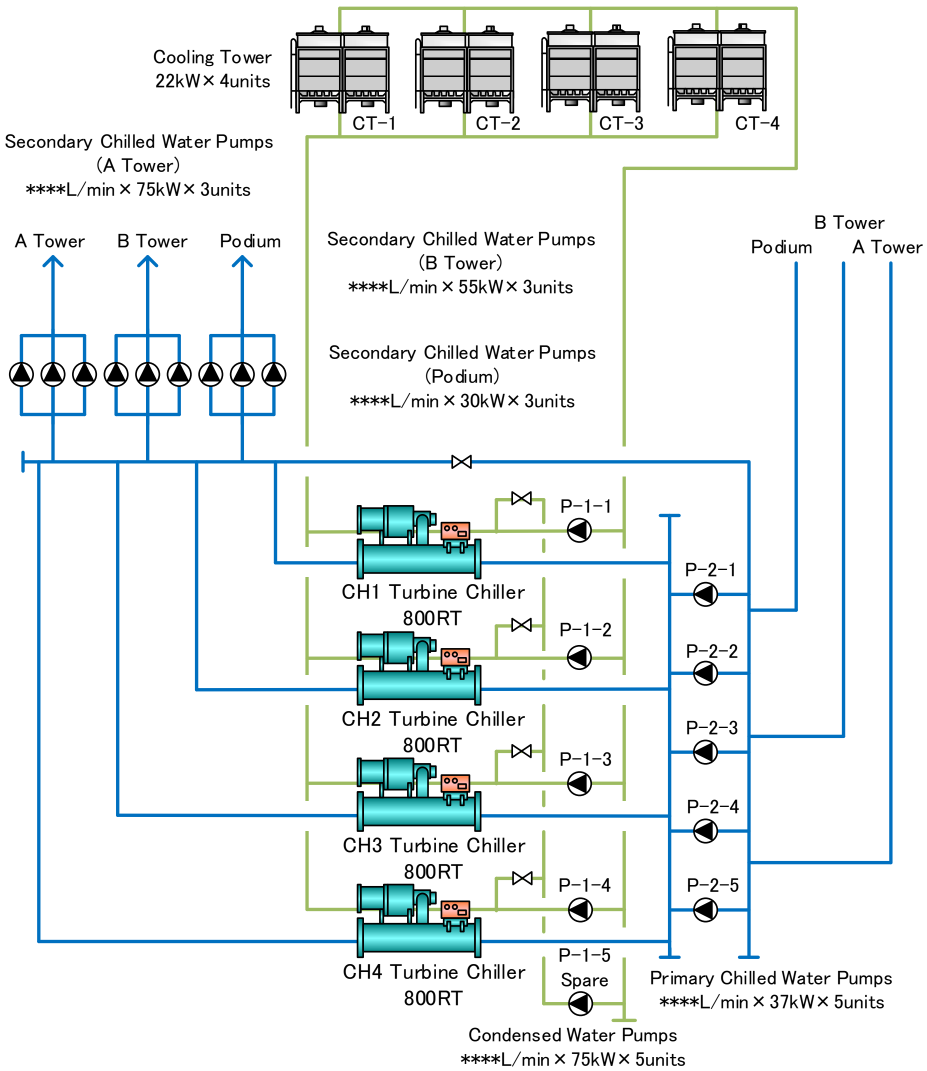
Lighting system:

(1) 1 40-watt fluorescent tube per lighting unit is deployed to provide lighting for standard floor space offices, with switches for window and indoor lights on a separate circuit.

(2) Window lighting is normally on although there is sufficient illumination indoors.

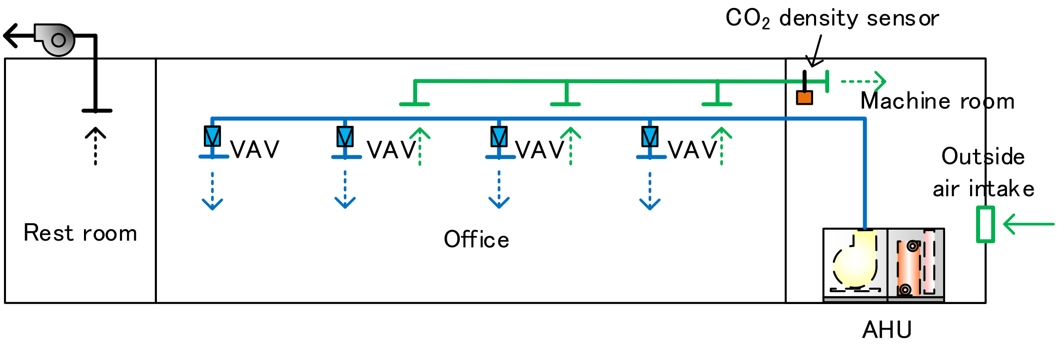
(3) 3 fluorescent lamp units each at 40 watts are deployed for corridor lighting. Lighting units have been disabled for energy saving.

Figure 4.6: Simplified Diagram of Chilled Water Supply System



kW = kilowatt, min = minute, RT = refrigeration ton .
Source: Author.

Figure 4.7: Simplified Diagram of Air Conditioning and Ventilation



AHU = air handling unit, CO_2 = carbon dioxide.
Source: Author.

(2) Energy use conditions

The table below gives an overview of the energy consumption in this building. This is an assessment of the annual amount of energy used and the proposed energy savings as calculation conditions.

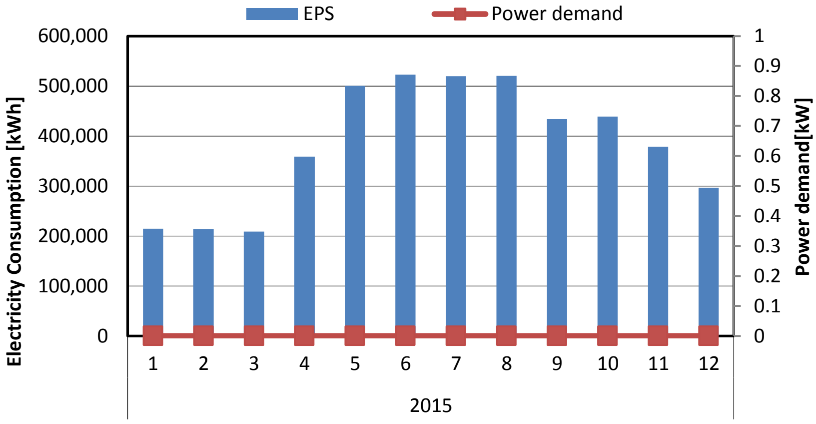
As regards the amount of energy for 2015, January–March is the minimum and May–August is the maximum.

Table 4.2: General Information on Annual Energy Use

Items	Conditions	Remarks
Annual electricity consumption (Jan 2015–Dec 2015)	4,607,301 kWh	Including power consumption by servers in the computer block
Electricity consumption density	43 kWh/m2/year	Total floor area: 93,351 m2
Electricity unit price	1,600 VND/kWh	Unit price for energy reduction calculations

kWh = kilowatt-hour, m^2 = square metre, VND = Vietnamese dong.
Source: Author.

Figure 4.8: Annual Electricity Consumption, 2015



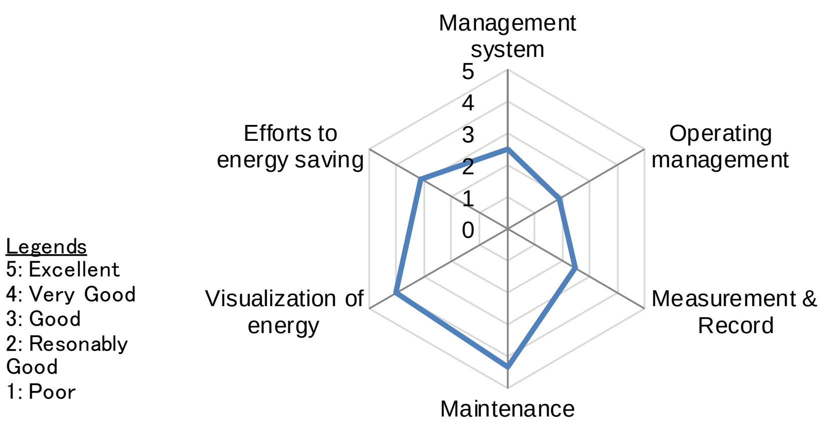
EPS = external power supply, kWh = kilowatt-hour.
Source: Author.

(3) Energy management conditions

During the interview with the facility manager and walk-through survey on site, a five-stage evaluation was carried out on six categories regarding the energy management conditions at the facility. There are four to five concrete items for evaluation in each category, the details of which are shown in the diagram below.

The visible representation of energy management shows that it is good in terms of maintenance but falls short in the other four categories.

Figure 4.9: Energy Management Conditions



Source: Author.

Table 4.3: Evaluation on Energy Management Conditions

	Items	Question	Answer	Score	Sum
Management system	Organisation in place?	Is there a designated person or post with responsibility for energy management	Under review	0.50	2.5
	Announcement of main goals	Any promotion by posters, slogans etc.	No action	0.00	
	Coordination with related posts	Are several members of personnel actively participating?	In practice	1.00	
	Record of activities	Are energy management activities recorded?	No action	0.00	
	Systematic training of personnel	Is training provided for personnel working on energy management?	In practice	1.00	
Operating management	Operating standard	Are there any operating standards for main systems?	In practice	1.25	1.9
	Operation managers	Are there any designated operation managers in accordance with standards?	Under review	0.63	
	Peak power management	Is attention paid to peak power using demand meter etc?	No action	0.00	
	Review of standards	Are operating standards revised on an as needed basis?	Under review	0.00	
Measurement & Record	Energy consumption	Are there records (paper chits, memos etc.) of energy usage?	In practice	1.00	2.5
	System operation period	Are operating times recorded for main combustion, cooling, lighting systems etc.	In practice	1.00	
	Separate energy measurements	Knowledge of energy usage according to different departments or application?	No action	0.00	
	Data on system operation conditions	Are measurements of temperature, illuminance, current etc. taken?	No action	0.00	
	Quality control	Is there any precision management, calibration of main meters?	Under review	0.50	
Maintenance	Maintenance and inspection standards	Are there any standards for maintenance and inspection of main systems?	In practice	1.25	4.4
	Maintenance and inspection log	Are there any records of maintenance and inspection of main systems?	In practice	1.25	
	Drawing maintenance	Are as-built and system drawings maintained?	Under review	0.63	
	Scheduling of repairs and renewals	Are scheduled repairs or renewals planned based on the inspection records?	In practice	1.25	
Visualization of energy	Energy graph preparation	Are graphs showing energy data prepared?	In practice	1.00	4.0
	Previous year's data comparison	Is there energy data from the previous year?	Under review	0.50	
	Distribution of data	Is there internal distribution of energy usage conditions?	In practice	1.00	
	Energy intensity management	Is there any management of energy intensity?	In practice	1.00	
	Data analysis	Is analysis of increases or decreases in energy usage carried out?	Under review	0.50	
Efforts to energy saving	Target setting	Are there any target settings for energy saving?	In practice	1.25	3.1
	Target review	Is there a review of energy saving targets?	In practice	1.25	
	System improvement	Is there any implementation or review of system improvements or remedial measures?	Under review	0.63	
	Results of improvement	Is there any verification of the efficacy of improvements or remedial measures?	Under review	0.00	

Source: Author.

(4) Implemented energy-saving measures in past years

Implemented Measures	Result	Comments
Disable selected office corridor lighting units	○	The corridors were safely navigable with units disabled with lighting level at 100 lx, and reduced power consumption
Change chilled water supply temperature	◎	Increased the chilled water supply temperature setting on the turbine chiller in periods with low cooling demand. Increase of 1°C in supply temperature can reduce chiller power consumption by approximately 2 percent.
Reduce condenser water supply temperature	◎	A lower temperature setting for condenser water can reduce chiller power consumption. A reduction of 1°C can reduce power consumption by approximately 2.5 percent.
Control rotation of secondary chilled water pump	△	Introduce rotation control based on pump discharge pressure value. On the day of the inspection, the cooling demand was low, but the frequency was changed to approximately 40–45 Hz, and by changing the pressure setting value it is possible to reduce power consumption.
Control rotation of condensate pump	△	1 chiller unit was in operation on the day diagnostics were carried out, and the frequency was 50 Hz. There is the possibility that rotation control did not work properly but the instrumentation diagram was not checked so the reason is unclear.
Air handling unit (AHU) variable volume control	○	With variable air volume units deployed around the office and AHU fan rotation speed was changed but the upper limit was reduced to 30 Hz, and it was operated at 14 Hz on days with low cooling or heating loads. It was possible to drastically reduce the power consumption of the large number of AHU fans.

2.3. Discussion on possible solutions

The following is a list of energy-saving proposals drafted during the site survey. Proposals are divided into three categories, with proposals in A and B requiring no investment or where costs can be recovered within five years, so it is hoped that these can be implemented promptly.

No.	Energy saving measures	Electricity consumption saving [kWh/year]	Saving cost [1000VND]	Initial cost [1000VND]	Pay back period [Year]
A No Cost Measures (Improvements in usage)					
A-1	Reduce pump discharge pressure setting	43,300 kWh (0.9%)	69,280	—	—
A-2	Intermittent operation of parking lot fans	118,800 kWh (2.6%)	190,080	—	—
A-3	Turing off lights by windows (daylight use)	138,500 kWh (3.0%)	221,600	—	—
Sum		300,600 kWh	259,360		
B Low Cost Measures (Remodling to recover investment capital within 5 years)					
B-1	Automatic lighting control by occupancy sensors	41,300 kWh (0.9%)	66,080	228,500	3.5
Sum		41,300 kWh (0.9%)	66,080	228,500	
C High Cost Measures (Large scale remodeling)					
C-1		kWh (0.0%)			#DIV/0!
Sum		0 kWh	0	0	

Note1: Values in parentheses indicate energy saving ratio compared to annual consumption.

Note2: Initial cost is approximate estimate and should be considered further prior to the implementation.

Energy Saving Measures (A and B)		
Reduced Energy Consumption		
Electricity	341,900 kWh/year	(7.4%)
Annual Saving Cost	325,440 1000VND/year	

(1) Adjusting the settings of discharge pressure of pumps (A-1)

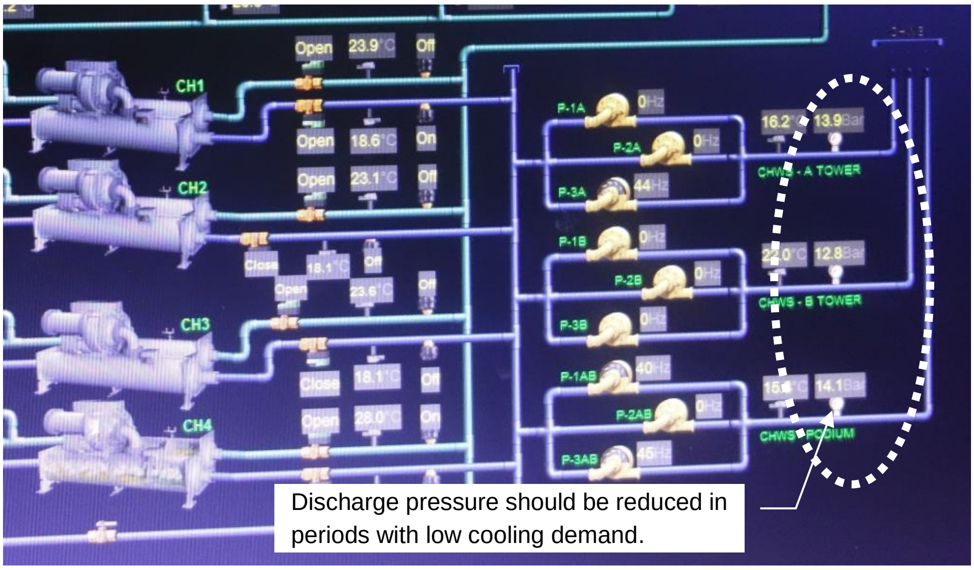
Target systems	Secondary chilled water pumps
Energy saving effect	43,300 kWh/year

Present condition

Cooling demand was low on the day of the inspection (23 December), but the secondary chilled water pump frequency was 40 Hz to 45 Hz. Discharge pressure was detected and the pump rotation speed was controlled.

Measures

In periods (December–April) with low cooling demand, reduce pump discharge pressure setting and pump rotation speed to decrease pump power consumption.



Calculation of effectiveness

Secondary pumps operation (assumed)

	Dec	Jan	Feb	Mar	Apr
Secondary Pumps to A Tower					
No.of units in operation (assumed)	1	0	0	0	1
Capacity per unit [kW]	75	75	75	75	75
Current pump frequency [Hz]	44	0	0	0	44
Improved pump frequency [Hz]	30	0	0	0	30
Secondary Pumps to B Tower					
No.of units in operation (assumed)	0	0	0	0	0
Capacity per unit [kW]	55	55	55	55	55
Current pump frequency [Hz]	0	0	0	0	0
Improved pump frequency [Hz]	0	0	0	0	0
Secondary Pumps to Podium					
No.of units in operation (assumed)	2	1	1	1	2
Capacity per unit [kW]	30	30	30	30	30
Current pump frequency [Hz]	43	40	40	40	43
Improved pump frequency [Hz]	30	30	30	30	30

Electricity reduction

	Dec	Jan	Feb	Mar	Apr	Sum
Secondary Pumps to A Tower						
Current electricity consumption [kWh]	12,778	0	0	0	12,778	
Improved electricyty consumption [kWh]	4,050	0	0	0	4,050	
Electricity reduction [kWh]	8,728	0	0	0	8,728	17,455
Secondary Pumps to Podium						
Current electricity consumption [kWh]	9,541	7,680	7,680	7,680	9,541	
Improved electricyty consumption [kWh]	3,240	3,240	3,240	3,240	3,240	
Electricity reduction [kWh]	6,301	4,440	4,440	4,440	6,301	25,922
Total electricity reduction [kWh]						43,377

Calculation condition ↓

Operation hours: 180 hours per month (9 hours × 20 days/month) **43,300**

Inverter efficiency: 0.9

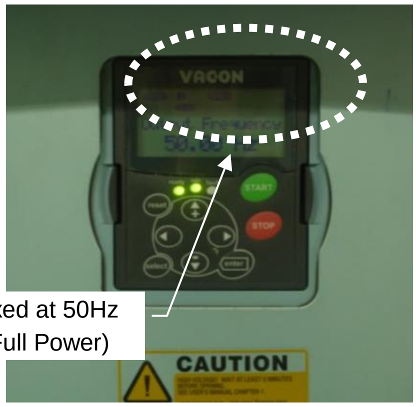
Pump efficiency: 0.8

Electricity unit price (assumed) 1,600 VND/kWh

Annual saving cost 69,280,000 VND/year

Matters that should be noted

Inverters used for pump rotation speed control make it possible to set the frequency variable band. To further reduce pump power consumption, the lower limit of the frequency value to be set at approximately 30 Hz, should be checked beforehand. When this lower limit is at a high value (e.g. 40 Hz), then the value cannot drop below 40 Hz, even if the reduce signal is output from the control unit, and there may be no reduction in pump energy use.



(2) Intermittent operation of parking lot extraction fans (A-2)

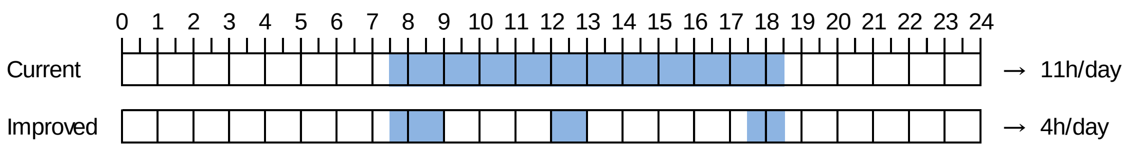
Target systems	Supply fans and exhaust fans
Energy saving effect	118,800 kWh/year

Present condition

The purpose of the ventilation in the parking lot is to exhaust fumes from vehicles. Presently, the fans operate continually during business hours.

Measures

Operate the fans only during the morning and evening commuting periods of approximately 1.5 hours each and lunch hours, providing ventilation only during cars' arrival at and departure from the parking lot. Shutting down the fans beyond these periods will reduce power consumption.



Calculation of effectiveness

Supply fan capacity 11 kW×1 unit×3 floors

Exhaust fan capacity 11 kW×1 unit×3 floors

Operation hours (current) 11 hours×240 days/year

Operation hour (improved) 4 hours×240 days/year

Electricity unit price (assumed) 1,600 VND/kWh

Electricity reduction 11 kW×2 units×3 floors×(11h-4h)×240 days/year

= 118,800 kWh/year

Annual saving cost 190,080,000 VND/year

Matters that should be noted

Before implementing this proposal, the conditions during morning and evening rush hours when vehicles are arriving or leaving should be checked and CO_2 concentrations measured, with a final check on the exhaust fan operating periods.

(3) Turning off lights near windows (daylight use) (A-3)

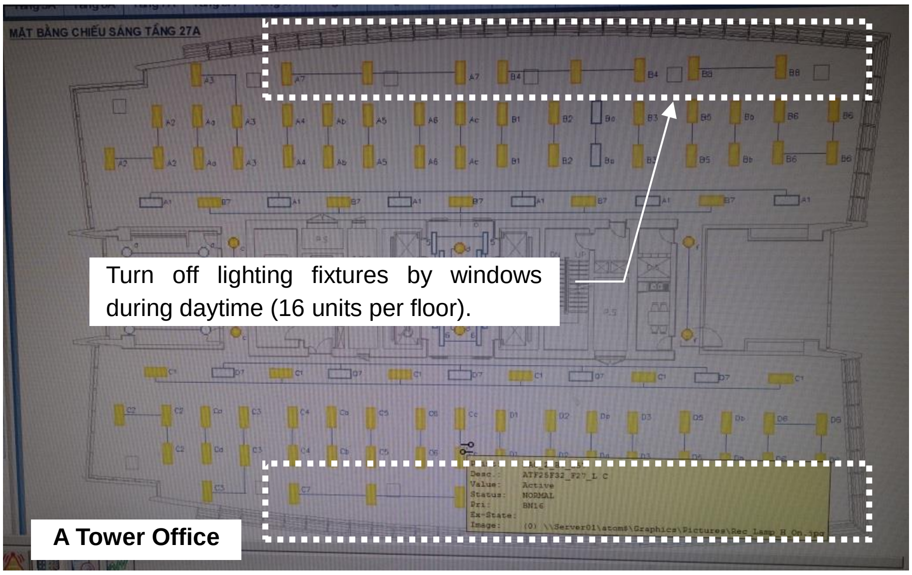
Target systems	Fluorescent lighting fixtures
Energy saving effect	138,500kWh/year

Present condition

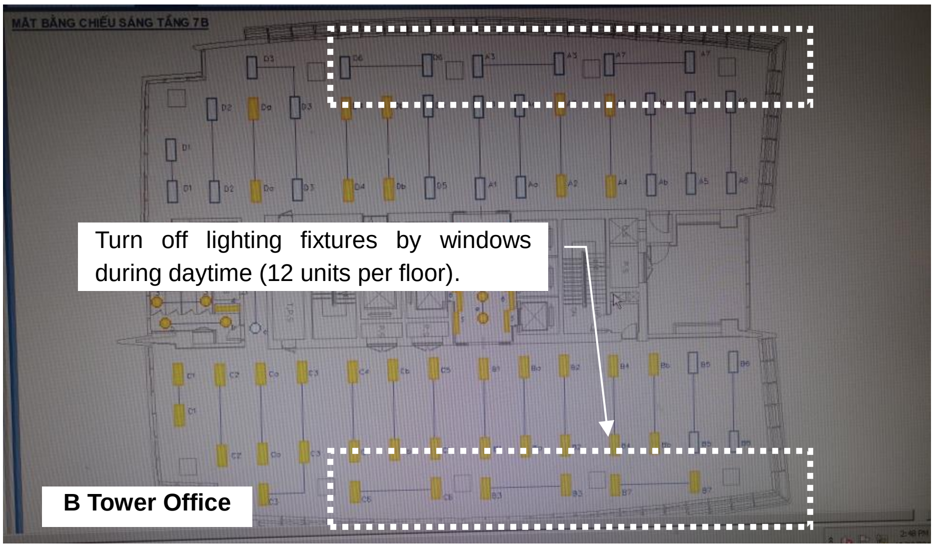
The surface area of office window glazing is large, providing sufficient daylight, but the lighting fixtures by the windows are usually on. On the day of the survey, the sky was cloudy and there was sufficient illumination of around 860 lx, suitable for normal working conditions at desks even with all the lights turned off.

Measures

Turn off lighting fixtures by windows to reduce power consumption.



Source: Author.



Source: Author.

Calculation of effectiveness

Lighting fixture by windows A Tower: (40 W×3 bulbs)×16 units×29 floors (5th to 33rd)

B Tower: (40 W×3 bulbs)×12 units×25 floors (5th to 29th)

Annual lighting hours 9 hours×240 days/year=2,160 hours/year

Usage rate of the fixtures (assumed) 70%

Electricity unit price 1,600 VND/kWh

Electricity reduction A Tower (40 W×3)×16 units×29 floors×2,160×0.7=84,100 kWh

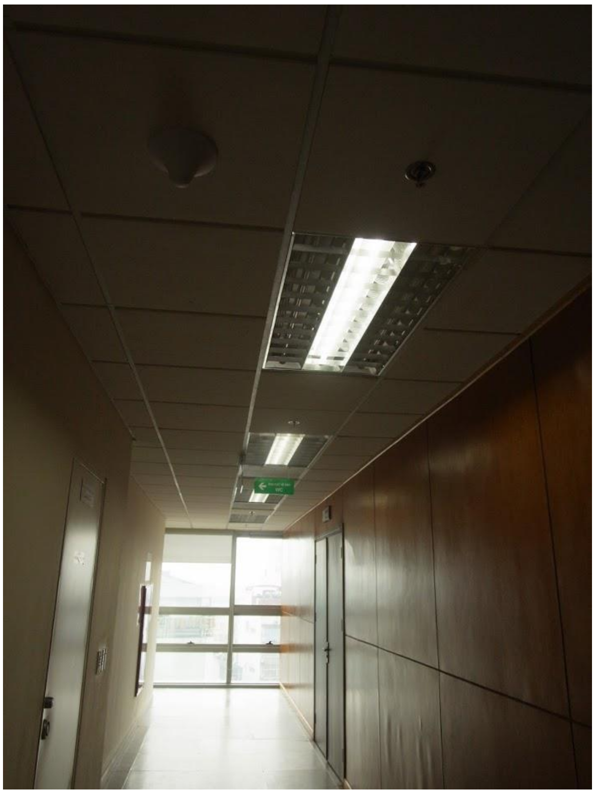
B Tower (40 W×3)×12 units×25 floors×2,160×0.7=54,400 kWh

Sum 138,500 kWh/year

Annual saving cost 221,600,000 VND/year

Matters that should be noted

Conditions vary depending on the arrangement of the office equipment and the direction of seats. All conditions near all windows inspected, implementation of this proposal is possible by changing the schedule of BEMS on possible floors.



Source: Author.

(4) Automatic lighting control by occupancy sensors (B-1)

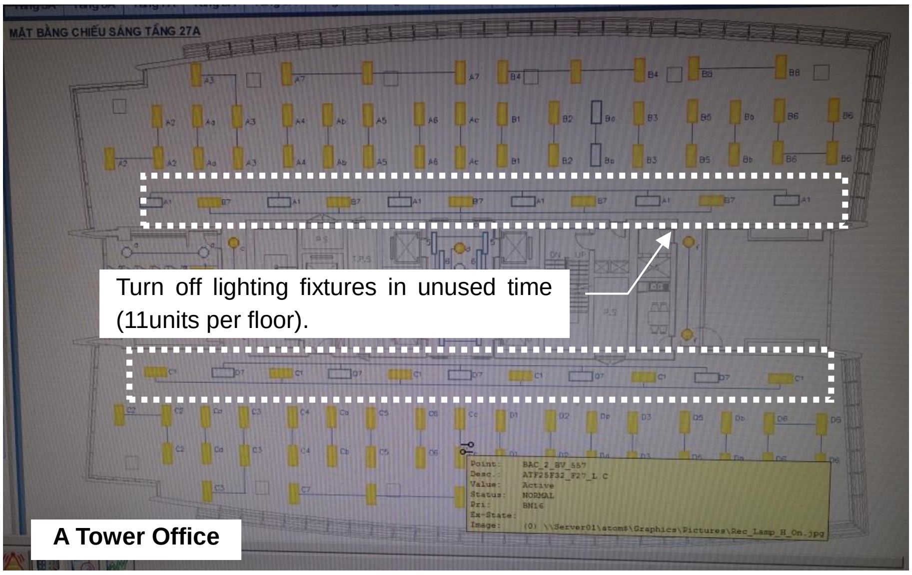
Target systems	Fluorescent lighting fixtures
Energy saving effect	41,300 kWh/year

Present conditions

The lighting along office corridors is normally on. In Japan, there is an increasing installation of occupancy sensors.

Measures

Install occupancy sensors in office corridors in tower blocks to be turned on only when occupants are present to reduce power consumption.



Source: Author.

Calculation of effectiveness

Lighting fixture by windows A Tower: (40 W×3 bulbs)×11units×29 floors (5th to 33rd)

Annual lighting hours 9 hours×240 days/year=2,160 hours/year

Light-out rate 50%

Electricity unit price 1,600 VND/kWh

Electricity reduction A Tower (40 W×3)×11 units×29 floors×2,160×0.5=41,300 kWh

Annual saving cost 66,080,000 VND/year

Investment cost (estimate) 228,500,000 VND

Recovery period 3.5 years

3. Key Findings from the Case Studies

The results of the three case studies show that air-conditioning load is a major energy consumption at office buildings in the ASEAN region and that lighting optimisation is also an effective energy-saving measure, except uncontrollable load (i.e. personal computers and servers). This study identified the following three main points for improving energy efficiency for office buildings in the region.

First point: To optimise the ventilation of intake outdoor air and discharge indoor air. The amount of energy consumption is caused by the distribution of cool and dry air in the ASEAN region where the atmosphere is high-temperature and humid. Many buildings still cannot control air intake and discharge. Most often, intake and discharge is set to full power even inverter-driven motors are implemented. As a result, surplus energy is required for heat source machine power (i.e. chillers) and cooling water transporting power (i.e. pumps) to cool and dehumidify the outdoor air, instead of discharge cool and dry air.

To optimise ventilation, one effective measure is to monitor CO_2 density in office floor. Approximately 400 parts per million (ppm) to 700 ppm shall be excessive because the standard CO_2 density of outdoor air is around 450 ppm. It is better to find optimum value up to a ceiling of 1000 ppm due to human health and comfort.

In addition, the intermittent operation of exhaust fans at a car park can be an energy-saving measure because of enough apertures or because of fixed office hours. For buildings which cannot control continuous ventilation, it is also effective to install motor dampers which installation is relatively inexpensive compared with other energy-saving measures.

Second point: To optimise the setting of inverter frequency. Inverter-driven motors are now installed in various places in air-conditioning system (i.e. chillers and pumps). Inverter-control driving force can be reduced to 25 percent when rotation speed is reduced in half because driving force is proportional to the square of the rotational speed. Moreover, electricity consumption can be reduced to 12.5 percent (−87.5 percent) because power consumption is the product of flow rate and driving force, This means that inverter-driven motor shall be a key function for energy conservation at office buildings.

However, in the field, operation frequency is often set to maximum and is stable regardless of the condition of the buildings, even if inverter-driven motors are installed. In this case, electricity consumption shall be almost the same with or without inverter-driven motors. Installing inverter-driven motors and setting appropriate frequency by the administrator are necessary to recover the investment. Also, the setting should vary depending on the outdoor temperature, season, humidity, and characteristics of the buildings. For this reason, the first step for improving the setting is to measure the parameters by human resources or BEMS.

Third point: To optimise the office lighting by dimming lighting bulbs or continuous lux control. In general, enough sunlight is continuously derived through the windows during the business hour. In this case, intermittent lighting near the windows shall be considered. Use of human sensors for lighting becomes reasonable to disseminate in recent years, which sensors automatically turn on and off using infrared. These sensors are applicable along passages or in washrooms.

Moreover, optimisation of lighting shall be performed for promoting energy conservation to employees. Several demonstrations are carried out for implementing human sensors, LED lightings, and lux metres to integrate acquired data by BEMS. Some of the systems have already implemented feedback-control mechanism. However, it is effective enough for the employees to make it a habit to turn on and off the lighting when necessary.

Chapter 5

Policy Measures to Promote EMS Deployment

Following the first-year report of this study, this second-year report reviewed the possibility of EMS deployment in Southeast Asian region from technical aspect, including the results of the case studies at five sites. As discussed in Chapters 0 and 4, this study observed that there is a good space for energy efficiency by improving and advancing the operational practices of facilities at factories and office buildings.

These recommended energy-efficiency measures can be managed to some extent only with human efforts. However, as also discussed in the previous chapters, to identify and apply an optimised configuration of these facilities, a support from data analysis tool, in combination with meticulous data measurement, is indispensable. Especially for large factories that have a huge energy demand and a complicated structure of energy-consuming facilities, support from advanced technologies for managing these energy-related data is indispensable. EMS is expected to play an important role. The function of energy monitoring and analysis underlines the advanced stage of EMS, i.e. automated energy control.

However, despite these benefits of implementing EMS for promoting energy efficiency, the pace of its dissemination is very slow in many Southeast Asian countries. In some countries, the energy prices are very low and this hampers the investment for energy efficiency in general. However, this study also considers that there are some other reasons to discourage the investment on EMS even in the case where the benefit of energy efficiency will possibly recover the initial cost in the long run. Hence, there is a necessity for policy intervention to mitigate the factors that discourage the investment and to bridge between the current situation and the future dissemination.

As a conclusion, this study proposes a set of policy recommendations especially for Southeast Asian countries to facilitate the promotion and deployment of EMS. This chapter reviews the policies related to energy efficiency in Southeast Asian countries to identify the characteristics commonly observed in this region and tries a rough estimation of the potential of EMS deployment. Thereafter, it discusses the challenges for the deployment of EMS technologies.

1. Current Status of Energy-Efficiency Policy in Southeast Asia

Policies relating to energy efficiency include laws on energy conservation, energy- efficiency targets, requirements for appointment of energy managers, labelling or certification scheme, and financial incentives. It is also important to note that policy for electricity tariff is a key for promoting energy-efficiency measures.

In the following subsections, the current status of policies for energy efficiency in Southeast Asian region is described, especially focusing on Indonesia, Malaysia, Singapore, Thailand, and Viet Nam, the WG members.

1.1. Basic laws for energy efficiency and conservation

It is important for energy-efficiency and conservation laws to both set the requirements for energy efficiency and prepare the necessary incentives for achievement of these goals. Many of these laws mandate the energy management of large energy consumers, while at the same time preparing financial incentives for promotion and utilisation of energy-efficiency measures. Such requirements will raise the need for energy-efficiency measures, while preparation of financial incentives will increase accessibility to such technologies, including xEMS.

In many countries, laws for energy efficiency and conservation are usually established at the national parliament level. Many of these laws determine the responsible entities for energy efficiency and their obligations, including requirements and schemes for energy management. These laws often state the necessity of setting targets for energy efficiency and conservation, placement of energy managers, schemes for standard and labelling, and incentives for deploying energy-efficiency measures.

Thailand, for example, was one of the first countries in the ASEAN to establish a law for energy conservation (Energy Conservation Promotion Act B.E. 2535, revision B.E.2550) in 1992. The law was established to better manage energy-consuming sectors for energy conservation and to promote utilisation of energy-efficiency measures. It also provides for the necessity of providing financial incentives for deployment of such measures.

Singapore has different energy conservation laws for different sectors. Its Energy Conservation Act was established in 2012 to require energy management for large energy consumers in the industrial and transport sectors, and regulations for energy consumptions were added to the Building Control Act in 2012, targeting the building sector.

Indonesia, similarly, established its Government Regulation on Energy Conservation in 2009; Malaysia established its Efficient Management of Electrical Energy Regulations in 2009; and Viet Nam issued its Decree on Energy Efficiency and Conservation in 2003 (renewed by Law on Energy Efficiency and Conservation in 2011).

Detailed provisions of each policy measure related to energy efficiency based on these basic laws are described in the following subsections.

1.2. Energy-efficiency targets

(1) Current status in ASEAN countries

Based on laws for energy efficiency and conservation, energy-efficiency targets are established. Some targets include sector-wise goals for achieving the overall target. These targets may be in the form of energy intensity or, in other cases, in the form of energy consumption.

In Indonesia's National Energy Conservation Master Plan, for example, energy-efficiency targets are established both as energy intensity and energy savings with a target reduction of 1 percent per annum in energy intensity up to 2025 and of 17 percent in energy consumption in the industrial, transport, commercial, and household sectors. The target further establishes energy saving goals for each sector: 17 percent for the industrial sector, 20 percent for the transport sector, and 15 percent for the commercial and household sectors.

Viet Nam's energy-efficiency targets are defined in its Master Plan for Power Development 2011−2020, which establishes electricity savings target of 8–10 percent by 2020 (compared with BAU). The master plan notes that deployment of equipment with high-energy efficiency and advanced standards will be needed to accomplish the 10 percent target.

Energy-efficiency targets are determined in other ASEAN countries as well: For example, Malaysia in its National Energy Efficiency Action Plan 2016−2025, with the goal of reducing electricity consumption by 8 percent by 2025 (compared with BAU); Singapore in its Sustainable Singapore Blueprint 2009, with the goal of reducing its energy intensity by 35 percent from 2005 levels by 2030; and Thailand in its Energy Efficiency Plan 2015 (EEP2015), with the goal of reducing its energy intensity by 30 percent by 2036 (compared with that in 2010).

(2) General observations

These energy-efficiency targets serve as an important basis in determining target sectors for promoting energy efficiency and implementing appropriate programs for promotion of energy efficiency. As was the case in Viet Nam, it may be effective to consider energy-efficiency targets comprehensively with power development plans. Outlook for power demand should incorporate such energy-efficiency targets, and power development plans should be formulated with consideration to such power-demand outlook.

1.3. Nomination of energy managers and reporting

(1) Current status in ASEAN countries

Energy conservation regulations mandate the appointment of energy managers for facilities with more than certain amount of energy consumption.

Malaysia, for example, mandates the placement of energy managers for energy consumers of 3 million kWh or more for six consecutive months. The standard may be set as energy consumption in tonne of oil equivalent (toe) unit, as is the case in Indonesia of 6 kilotonne (ktoe) per year and Viet Nam 1 ktoe for agriculture and transport sectors and 500 toe for facilities). The standard in Singapore is either 15 GWh/year or 1.29 ktoe/year. Thailand's minimum standard for appointment of energy managers is set in terms of peak demand, for consumers with peak demand of 1 megawatt (MG) or higher.

In general, energy managers are required to monitor and report the use of energy, give advice for improving energy efficiency, and develop a plan for energy conservation. Energy managers must be certified by competent authorities. For certification, they need to satisfy various qualifications usually consisting of academic degree and work experiences in the energy-efficiency field, attend necessary training programs, and pass examinations. Viet Nam, for example, prepares different standards for certification of energy managers according to the sector they work in. To be appointed as energy manager in the field of industrial production, construction works and business services, college degree on energy specialty, and completion of energy management training course with a certificate are necessary. In the field of transportation and agriculture, intermediate level technical certificate or higher and the completion of energy management training course with a certificate are necessary.

The roles of energy managers include developing an energy-conservation plan; monitoring, evaluating, and reporting energy consumption data; and giving recommendations for improvements in energy consumption. The required frequency for reporting of energy-consumption data varies among countries: Singapore requires annual reporting of such data, while Viet Nam requires energy audit once in every three years.

(2) General observations

While the standards for appointment of energy managers vary among countries, it is important to set a standard for all so that energy managers can be appointed for the building and the industrial sectors. The energy consumers have relatively high potential for improved energy efficiency, but to recognize such benefits periodical collection of energy-consumption data is necessary so that quantified assessment of the benefits of xEMS technologies can be conducted to ratify the capital expenditures associated with their deployment.

Furthermore, scheme for training and recertifying existing energy managers will be effective in promoting energy-efficiency measures. Such training program should provide energy managers with new trends in energy-efficiency measures so that they would be able to incorporate them in their energy-conservation plan.

1.4. Labelling and certification schemes and minimum energy performance standard

(1) Current status in ASEAN countries

Most target countries have a certification or a rating scheme or both for energy-efficiency performance. To maintain the minimum standard of energy efficiency in the market, many countries have implemented a mandatory MEPS for certain designated appliances. Voluntary labelling schemes for high energy-efficiency appliances are implemented with an intention of promoting their purchase and utilisation in the application for various government incentives.

The labelling scheme in most countries takes the form of a star-rating scheme. Other than the rating mark, these labels often show information on energy consumption in kWh per year. Energy-efficiency label in Malaysia also shows the amount of energy saving in percent compared with an average appliance. In most cases, for appliances to which MEPS is applied, at least one-star rating must be acquired for them to be able to enter the market. (In Malaysia, two-star rating is the minimum standard.) Appliances with higher energy efficiency can acquire a higher star rating.

In many countries, MEPS have been established in the domestic sector mainly for air-conditioning units, refrigerators, and lightings. In Singapore, for example, manufacturers supplying air conditioner, refrigerator, clothes dryer, television, and lamp (incandescent, compact fluorescent lamp, and LED) must receive the certificate of registration for the model to enter the market.

(2) General observations

While some countries have already established mandatory MEPS in the household sector, other countries are still on their way. MEPS for building and industrial sectors are more underdeveloped than that for household sector. To be able to certify large appliances, testing laboratory capable of testing such certification criteria is necessary, and capacity building for the institutions and workers is also important.

In addition, comprehensive certification scheme, such as the building certification scheme in Singapore, will be effective in the promotion of xEMS technologies. The buildings are given a 'Green Mark' if they satisfy certain criteria for certification, including standards for energy efficiency, water efficiency, environment conservation, internal environment quality, and green innovation. The government is aiming to achieve 80-percent certification in all of the buildings by 2020. Such comprehensive certification will promote the deployment of xEMS technologies since these technologies contribute to the overall management of energy consumers.

1.5. Financial incentives for energy-efficiency measures

(1) Current status in ASEAN countries

Financial incentives are provided by the government for energy-efficiency measures. Some major schemes include tax reduction, low-interest loan, and subsidies.

In Singapore, for example, various tax incentives and subsidy programs are provided for energy-efficiency measures. Tax schemes include investment allowance, which provides additional 30 percent of investment allowance to encourage investment in energy-efficiency equipment.

In Malaysia, similarly, green investment tax allowance is provided for capital expenditures for energy-efficiency improvement in companies. It provides a 100-percent tax allowance for capital expenditure for five years. Also, it provides a 100-percent income tax exemption of 10 years for companies providing energy-efficiency improvement services.

Low-interest loan programs are provided by the government to promote investment in energy-efficiency projects. Malaysia, for example, offers green technology financing scheme, which is a low-interest loan program for companies that are supplying or utilising green technologies. The government bears 2 percent of the total interest or profit rate in the financing, so that a guarantee of 60 percent can be provided to the companies.

Thailand, similarly, provides a low-interest loan programs for local banks for them to be able to lend money for energy-efficiency or renewable-energy projects at a maximum interest rate of 4 percent.

The government can provide subsidies for various energy-efficiency measures. It can provide direct subsidy for implementation of energy-efficiency equipment. In Thailand, for example, a 20–30 percent direct subsidy is provided for the replacement of equipment with an energy-efficient one. In other cases, subsidies are provided for conducting energy audits, as is done in the Partnership Program on Energy Conservation in Indonesia, where buildings and industries can receive energy audits funded by the government if they introduce energy-saving measures as described in the audit.

Such financial incentives, focusing on the five ASEAN countries − Indonesia, Malaysia, Singapore, Thailand, and Viet Nam – are summarised in the table below.

Table 5.1: Summary of Financial Incentives in Some ASEAN Countries

Tax Incentives	• Investment tax allowance scheme (e.g. green investment tax allowance in Malaysia, Thailand, Singapore) • Income tax exemption (Malaysia, Thailand) • Depreciation allowance scheme (Singapore) • Waiver of import taxes (Thailand)
Subsidy	• Partnership Program on Energy Conservation (Indonesia) • Direct subsidy (Thailand) • Bidding mechanism subsidy (Thailand) • Energy-efficiency improvement assistance (Singapore) • Design for efficiency scheme (Singapore) • Grant for energy-efficiency technologies (Singapore)
Low-interest loan	• Green technology financing scheme (Malaysia) • Interest-rate cap for EE or RE projects (Thailand)
Others	• Co-investment scheme (Thailand) • Training for energy efficiency audit, project, and financial products (Viet Nam)

ASEAN = Association of Southeast Asian Nations, EE = energy efficiency, RE = renewable energy.

Source: Study Team.

(2) General observations

It is often the case for xEMS technologies that the initial investment cost and feeling of uncertainty for their benefits serve as barrier for deployment. ESCO business would lower such barriers; ESCO provides energy-management service to energy consumers by guaranteeing a certain amount of energy savings. It is important to provide incentives for financial institutions to grant loans to ESCO businesses. Thailand offers a co-investment program called ESCO fund, which is funded by the Department of Alternative Energy Development and Efficiency. The purpose of the fund is to promote investments in energy efficiency (EE) or renewable energy (RE) projects by sharing their risks among public and private entities. The budget is allocated to the non-profit organisation responsible for managing and co-investing a maximum of 50 million Thai baht per project in such EE or RE projects. Such scheme will promote the understanding of financial institutions towards EE or RE projects and is extremely important in accelerating investment for energy-efficiency measures.

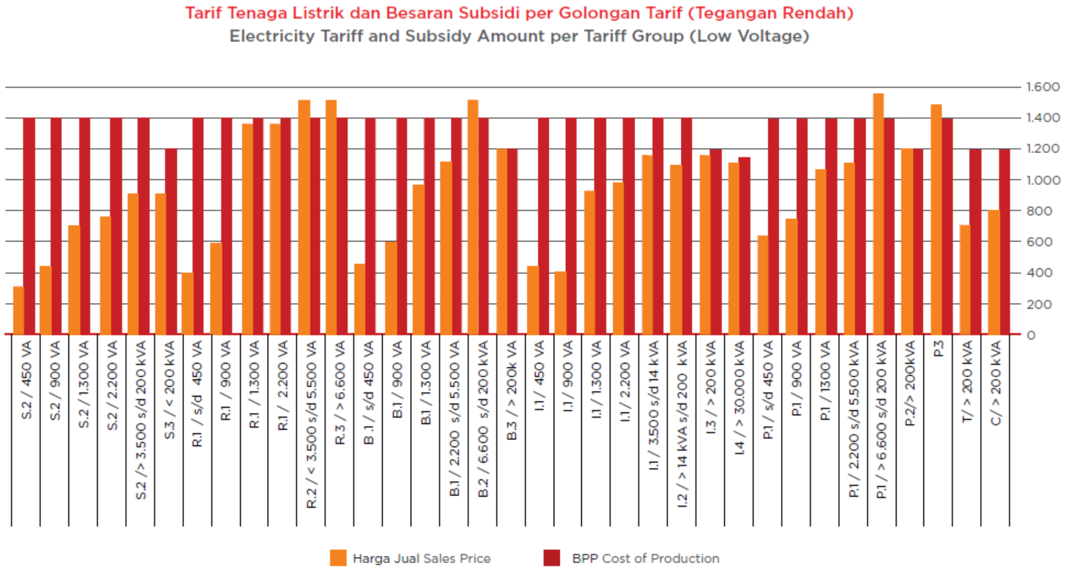
1.6. Electricity price

(1) Current status in ASEAN countries

In some countries, subsidies are applied to electricity prices to cover for the low domestic electricity tariff. In other words, it is difficult in such cases to recover the capital investment of energy-efficiency measures.

There are two types of subsidies pertaining to electricity tariff. The first type is a subsidy in tariff rates, given from the government to utilities to attain profitability. Perusahaan Listrik Negara, for example, provides data for such subsidy as shown in its annual report (Figure 5.1). This type of subsidy has been seen in many countries in Southeast Asia, but its amount is in a decreasing trend.

Figure 5.1: Example of Subsidy in Tariff Rates



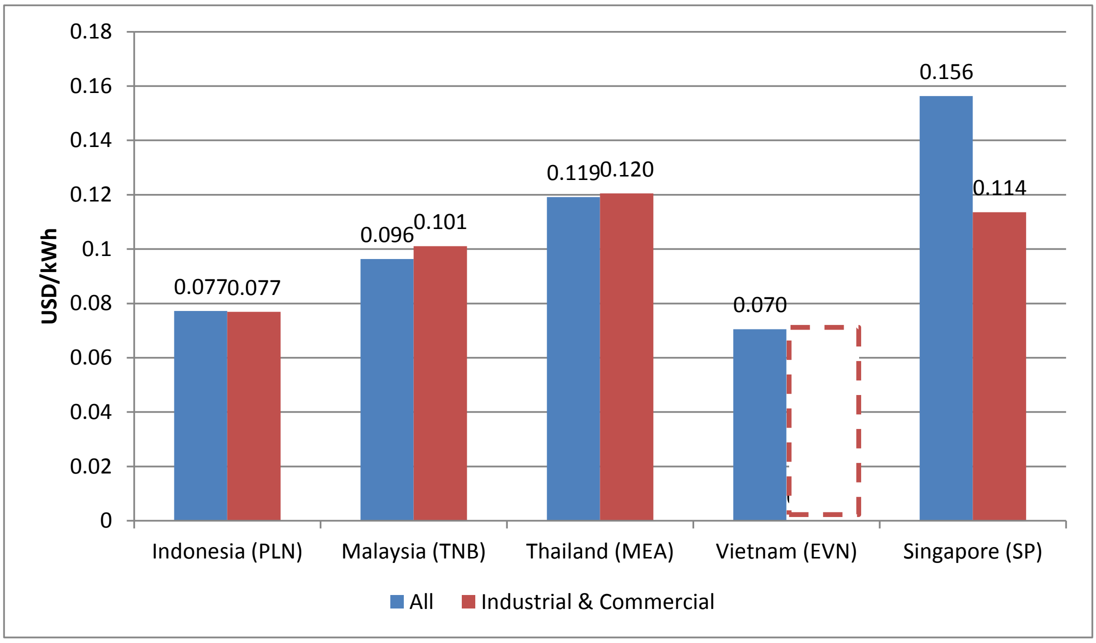
Source: Perusahaan Listrik Negara (PLN) Annual Report 2015.

The second type is the gap between the international fuel price and the domestic fuel price for power generation. This type of subsidy is often seen in countries that can produce fuels domestically. It would gradually be driven away as well. Malaysia, for example, has started implementing imbalance cost pass-through as part of its incentive-based regulation starting from 2015. The purpose of this regulation is to establish competitive electricity tariff, which can cover for the electricity supply cost incurred in utilities. The pass-through mechanism allows Tenaga Nasional Berhad to reflect fluctuations in fuel and generation costs in electricity tariff every six months. Under this mechanism, if there is a net savings in fuel and generation costs, rebate is given to customers; if there is a net increase in fuel and generation costs, Tenaga is allowed to raise its electricity tariff for the following period. In this way, fuel price will be properly reflected in the electricity tariff.

(2) General observations

A comparison of an average electricity selling price for ASEAN countries, focusing on Indonesia, Malaysia, Singapore, Thailand, and Viet Nam, is shown below. The average electricity selling price was estimated for the overall sector, particularly for the industrial and commercial sectors.

Figure 5.2: Average Electricity Selling Price (USD/kWh)



EVN = Vietnam Electricity, MEA = Metropolitan Electricity Authority, PLN = Perusahaan Listrik Negara, SP = Set Point, TNB = Tenaga Nasional Berhad, USD/kWh = United States dollar per kilowatt-hour.

Notes:

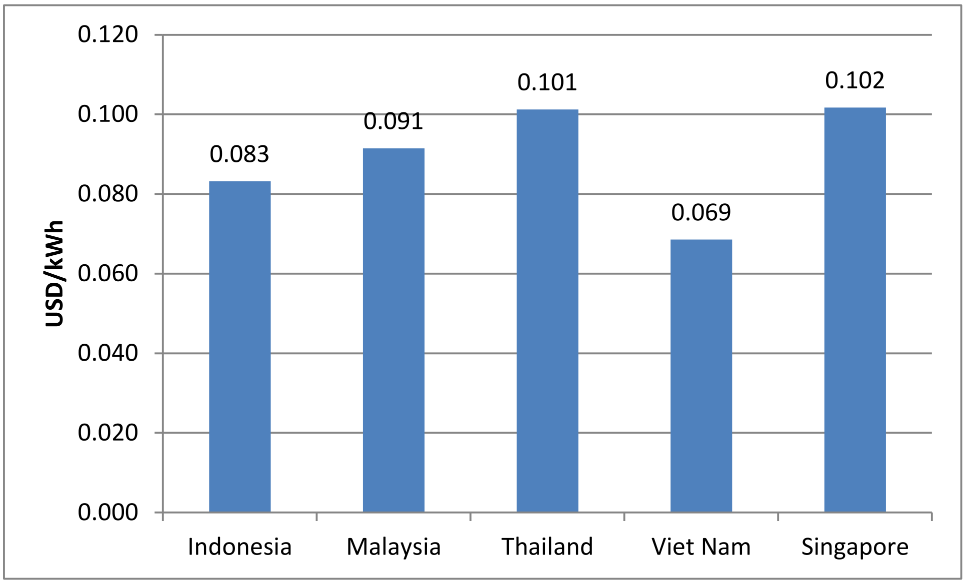
1. The figure was prepared by the study team using the following sources. Indonesia: PLN 2015 Annual Report; Malaysia: TNB 2015 Annual Report and Energy Commission Data; Thailand: MEA 2015 Annual Report; Viet Nam: EVN 2015 Annual Report; Singapore: EMA 2016 Annual Report.
2. Currency exchange rate: International Monetary Fund (IMF) and World Bank (WB) (Viet Nam) data for 2015.
3. Electricity selling price for the industrial sector in Viet Nam was not provided, therefore, its industrial and commercial average selling price is shown as almost equal to its overall average selling price, following the trends of other countries.

Source: Study Team.

The average selling price of electricity in Singapore, which mainly relies on imported fuel for electricity generation, is higher than that in Indonesia and Malaysia, which are able to procure some of its fuel domestically. From the figure, it can also be observed that Viet Nam has a significantly lower electricity selling price compared with other countries.

Furthermore, the average electricity price for a model factory was estimated for each country. The model factory was assumed to have a peak demand of 2,000 kW, an annual consumption of 15 million kWh, and a voltage of 22 kilovolts. The factory was assumed to maintain its full load during its operating hours.

Figure 5.3: Electricity Price for a Model Factory (USD/kWh)



USD/kWh = United States dollar per kilowatt-hour.
Note: Currency exchange rate: International Monetary Fund (IMF) and World Bank (WB) (Viet Nam) data for 2015.
Source: Study Team (prepared based on electricity tariff of major utilities of each country).

While the average electricity selling price of Singapore was significantly higher than that of other countries, the average electricity price for a model factory in Singapore is more comparable with that in other countries. The reason is that Singapore provides much lower electricity tariff for the industrial and commercial sectors. It can also be pointed out that the electricity price for a model factory in Viet Nam is much lower than that in other countries, which follows the trend seen for the average electricity selling price.

It should be noted that when electricity tariff is set at a low level, it disincentivises the electricity consumer to implement energy-efficiency technologies, since low electricity prices would provide only limited benefit for electricity savings.

2. Estimated Potential of Energy Efficiency through EMS Deployment

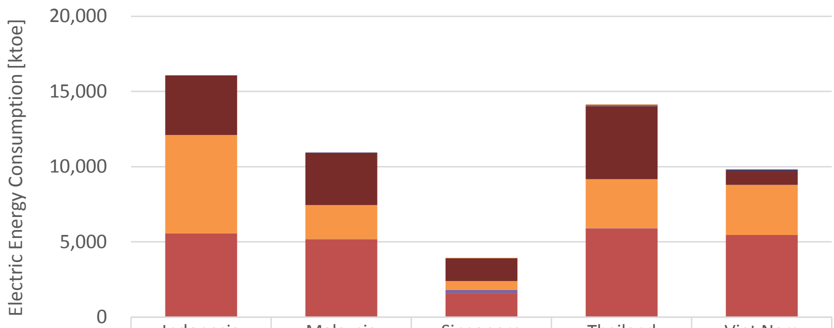
The statistical overviews of related energy macro data in five target countries − Indonesia, Malaysia, Singapore, Thailand, and Viet Nam − were conducted in last year’s study. Based on these studies, the potential of energy efficiency through the deployment of EMS is estimated in this fiscal year.

2.1. Background

The current electric energy consumption by each sector in the five target countries is shown in Figure 5.4. EMS technologies contribute for energy saving, especially reducing electricity consumption by introducing BEMS in the building sector and FEMS in the industry sector. In the five target countries, the most electricity is consumed in those introduced potential sectors, such as industry, residential, and commercial or public services sectors.

The countries' electricity consumptions in the industry sector, excluding Singapore's, are almost the same level, around 5 million toe, while the tendency in building sector is different by countries. Indonesia, for example, has the highest electricity consumption in the residential sector because of its big population in the city. In contrast, in Thailand, electricity consumption in commercial and public services sector is higher than that in the residential sector because of its more-developed commercial and urban areas.

Figure 5.4: Electric Energy Consumption by Sector, 2013 (ktoe)



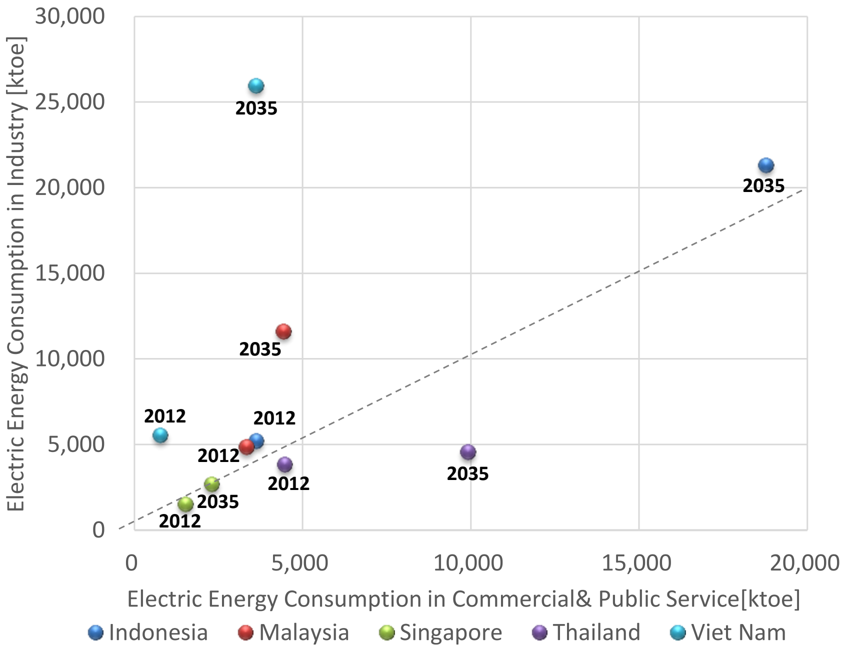
	Indonesia	Malaysia	Singapore	Thailand	Viet Nam
Non-specified	0	0	30	85	0
Agriculture/forestry	0	32	0	30	135
Commercial and public servises	3,970	3,467	1,520	4,853	887
Residential	6,539	2,262	582	3,250	3,336
Transport	0	21	204	14	0
Industry	5,562	5,171	1,603	5,900	5,454

ktoe = kilotonne of oil equivalent.
Source: International Energy Agency (IEA) (2015), 'Energy Balances of Non-OECD Countries, 2015'.

The publication by the Economic Research Institute for ASEAN and East Asia (ERIA), 'Energy Outlook and Energy Saving Potential in East Asia', summarises the current and future electricity consumption in the target sector of introducing EMS. Based on the above-mentioned International Energy Agency data (Figure 5.4), there is little electricity consumption in the agriculture sector, therefore, these data are treated and regarded as negligible. The following is the trend in each country.

- Indonesia: One of the highest growth rates of electric energy consumption, and most consumption in the industry and commercial and public service sectors.
- Malaysia: The middle growth rate of electric energy consumption, and larger consumptions in the industry sector.
- Singapore: Lower electric energy consumption compared with other countries.
- Thailand: Similar growth of electric energy consumption as Malaysia, however, larger consumption in the commercial and public service sector.
- Viet Nam: The same level of growth rate of electric energy consumption as Indonesia, however, larger consumption in the industry sector compared with Indonesia.

Figure 5.5: Electric Energy Consumption in Industry and Building and Agriculture Sectors, 2013, and 2035 as BAU Scenario (million toe)



BAU = business as usual, ktoe = kilotonne of oil equivalent.
Source: Economic Research Institute for ASEAN and East Asia (ERIA) (2015), 'Energy Outlook and Energy Saving Potential in East Asia'.

The 'Energy Outlook and Energy Saving Potential in East Asia' examines the BAU scenario and against alternatives called Alternative Policy Scenario (APS). The following scenarios are used for estimation (Figure 5.2). The difference between the BAU scenario and the APS in both final and primary energy consumption represents potential energy savings.

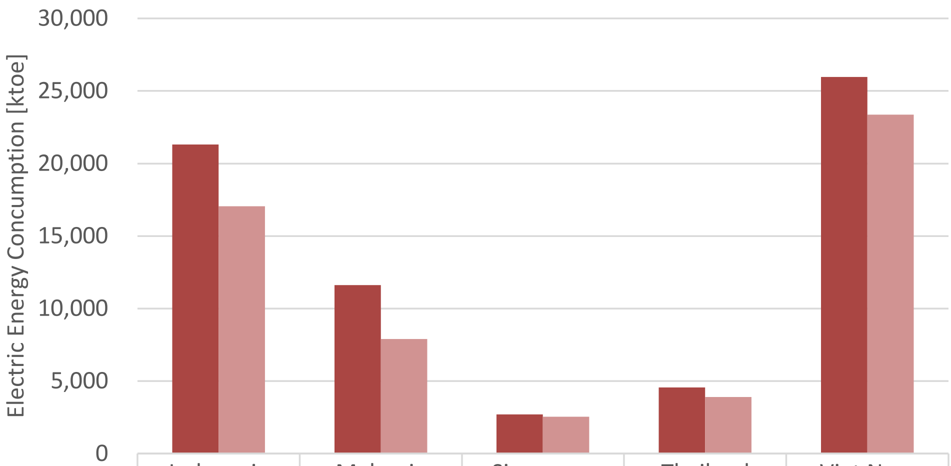
Table 5.2: Assumptions of Alternative Policy Scenario

	Improved Efficiency Scenario
APS1	More efficient final energy demand
APS2	More efficient thermal power generation
APS3	Higher consumption of new and renewable energy (NRE) and biofuels
APS4	Introduction or higher utilisation of nuclear energy
APS5	Included all APS

APS = alternative policy scenario.
Source: Economic Research Institute for ASEAN and East Asia (ERIA) (2015), 'Energy Outlook and Energy Saving Potential in East Asia'.

Electric energy consumption by the industry and commercial and public service sectors in 2035, each scenario compared, is shown in Figure 5.6.

Figure 5.6: Electric Energy Consumption in Industry Sector, 2035 (BAU Scenario vs APS)

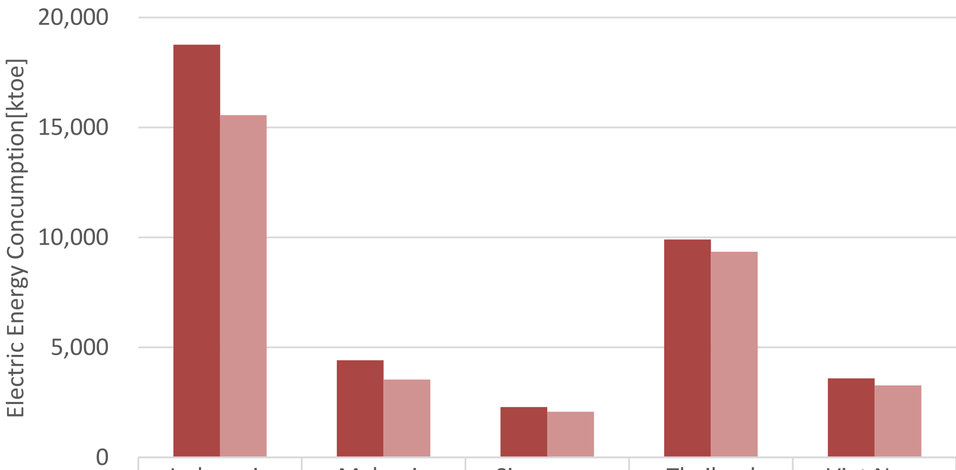


	Indonesia	Malaysia	Singapore	Thailand	Viet Nam
BAU	21,311	11,612	2,689	4,564	25,970
APS	17,049	7,896	2,547	3,904	23,370

APS = alternative policy scenario, BAU = business as usual, ktoe = kilotonne of oil equivalent

Source: Economic Research Institute for ASEAN and East Asia (ERIA) (2015), 'Energy Outlook and Energy Saving Potential in East Asia'.

Figure 5.7: Electric Energy Consumption in Commercial and Public Service Sector 2035 (BAU Scenario vs APS)



	Indonesia	Malaysia	Singapore	Thailand	Viet Nam
BAU	18,767	4,425	2,294	9,911	3,601
APS	15,557	3,540	2,080	9,358	3,272

APS = alternative policy scenario, BAU = business as usual, ktoe = kilotonne of oil equivalent.
Source: Economic Research Institute for ASEAN and East Asia (ERIA) (2015), 'Energy Outlook and Energy Saving Potential in East Asia'.

2.2. Results of estimation

The potential of energy savings through the deployment of EMS in the industry and commercial and public service sectors was estimated against electrical energy consumption forecast in 2035 based on the BAU scenario.

Assumptions:

(1) Potential of energy savings by EMS per unit set at 10 percent based on the case study.

(2) Potential of energy savings through the deployment of EMS is estimated using the following equation: electric energy consumption × potential energy savings by EMS per unit × market penetration rate of EMS.

Table 5.3 Estimated Potential of Energy Saving through the Deployment of Energy Management System (Mtoe/year)

Country	Sector	Market Penetration Rate of EMS				(c.f.) Energy saving potential *1
		10%	30%	50%	70%	
		Estimated potential of energy efficiency through EMS				
Indonesia	Industry	0.2	0.6	1.1	1.5	4.3
	Building	0.2	0.6	0.9	1.3	3.2
Malaysia	Industry	0.1	0.3	0.6	0.8	3.7
	Building	0.0	0.1	0.2	0.3	0.9
Singapore	Industry	0.0	0.1	0.1	0.2	0.1
	Building	0.0	0.1	0.1	0.2	0.2
Thailand	Industry	0.0	0.1	0.2	0.3	0.7
	Building	0.1	0.3	0.5	0.7	0.6
Viet Nam	Industry	0.3	0.8	1.3	1.8	2.6
	Building	0.0	0.1	0.2	0.3	0.3

*1: Energy saving potential is calculated as 'BAU scenario' minus 'Improved Efficiency scenario'
Source: Author.

3. Promoting the Deployment of EMS in ASEAN Countries

3.1. Challenges for the EMS deployment

Despite the benefits of implementing EMS for promoting energy efficiency, the pace of its dissemination is very slow in many of the Southeast Asian countries. Installation of EMS requires certain costs for investment, and the user's little confidence on the economic benefit of investing in EMS may discourage the investment in EMS and the promotion of its deployment.

Hence, this study identifies the challenges for the deployment of EMS, i.e. main factors that may hamper the investment in EMS, for discussing the solutions to deal with these challenges.

(1) Identifying the benefit of EMS implementation

(a) Role of EMS in energy efficiency

First, it has to be pointed out that the role of EMS is to provide data of energy consumption of the installed appliances for monitoring and analysis to determine their optimised operation. In other words, EMS itself does not contribute to energy saving, but provides tools for energy saving of energy-consuming appliances (e.g. turbo chillers and air compressors). This indirect role of EMS for energy efficiency, compared with the direct investment to replace these energy-consuming appliances with more energy-efficient ones, makes the economic benefit of investment less clear.

Certain efforts for enhancing the awareness of the role of EMS may be needed to promote its deployment.

(b) Methodology to measure the energy-saving effect

In relation to the indirect role of EMS as aforementioned, the economic benefit of installing EMS may not be easily determined without establishing a methodology to measure its effect.

Usually, the effect of energy efficiency by optimising the operation referring to the data analysis from EMS is measured by comparing the actual performance of energy consumption with that in the past when the basic conditions are similar (e.g. the same period in the previous years) or with the estimated energy consumption of the without-EMS scenario considering the difference in operational parameters.

However, since the energy consumption of an appliance is affected by various factors, such as weather conditions, operational hours, number of people working in the building, and production volume, comparison with the historical record or the without-EMS scenario may sometimes be difficult because of the differences in various factors that can affect the energy consumption although these differences are not related to the installation of EMS.

A sophisticated methodology to evaluate the energy-saving effect by using EMS, which is clearly formulated and quantitatively cogent, should be prepared for its diffusion.

(2) Financial support and incentive for EMS installation

Since the installation of EMS requires initial cost for investment, financial support and incentives to this investment cost will facilitate EMS deployment. However, although some countries in the Southeast Asian region have established institutional schemes of providing financial support and incentive to the investment in implementing technologies related to energy efficiency, such as tax reduction, low-interest loan, and subsidies, these schemes usually do not cover the installation of EMS.

There may be some reasons for this. As previously explained, the effect of energy efficiency by installing EMS may not be estimated easily compared with the case of direct investment in energy-consuming appliances, i.e. the baseline of financial support and incentive for the expected effect of energy efficiency may not be easily determined. Further, installation of EMS is supposed to be a relatively advanced step towards energy efficiency, thus, the policymakers are apt to consider that this should be disseminated totally in a commercial manner without policy intervention from the government.

However, the installation of EMS, as well as the replacement of energy-consuming appliances with more energy-efficient ones, can explore potential of energy saving but necessitates certain initial costs for implementation. Hence, it is worth considering the provision of financial support and incentive to any kind of investment that serves for energy efficiency and certain financial support helps, improving the cost-benefit balance and facilitating the owner's decision on investment.

In fact, the investment in EMS is not a separate activity from the investment in energy-efficient appliances in actual practices, and they are often implemented in combination because EMS also provides tools for measuring the effect of investing in energy-efficient appliances.

(3) Private sector's involvement in energy-efficiency businesses

Although the utilisation of public fund is effective for promoting energy-efficiency technologies, direct policy intervention in the market should be eradicated gradually and be taken over by commercial-based businesses in the long run. Hence, even in the stage where policy support for promoting energy-efficiency technologies is still needed, the support should be gradually shifted from directly providing subsidies to capital investment to a more indirect approach, such as establishing institutional framework for supporting private sector's businesses to promote energy efficiency.

(4) Economically irrational energy prices

The promotion of energy-efficiency technologies is also affected by energy prices because the benefit of energy-efficiency technologies, i.e. the return on investment, is determined by the saved energy cost, which is the product of energy-saving volume and unit price of energy.

In some countries that are abundant in domestic production of energy sources, domestic energy prices are, in general, lower than those in countries that rely on imported energy sources. Also, if a country's value chain of energy supply from upstream (i.e. primary energy production) to downstream (i.e. end-consumption) is closed domestically, the domestic energy prices are less volatile to international energy prices. This little volatility often results in government subsidies to maintain the prices at low level if the prices have upward rigidity for some reasons.

In ASEAN countries that have abundant domestic production of energy sources, such as Indonesia and Malaysia, domestic energy prices have been set at lower than international prices and like the case of Perusahaan Listrik Negara in Indonesia, government subsidies are also provided directly.

There are several problems about uneconomically low energy prices.

(1) The loss of price elasticity of energy demand that leads to the waste of energy consumption and the depletion of domestic reserve of energy sources.

(2) The loss of wealth that would be gained if energy sources were sold at higher prices, not only for the energy suppliers directly but also for the entire national economy indirectly.

(3) The waste of subsidies to energy prices that would have been used for other purposes for sustaining the national economy.

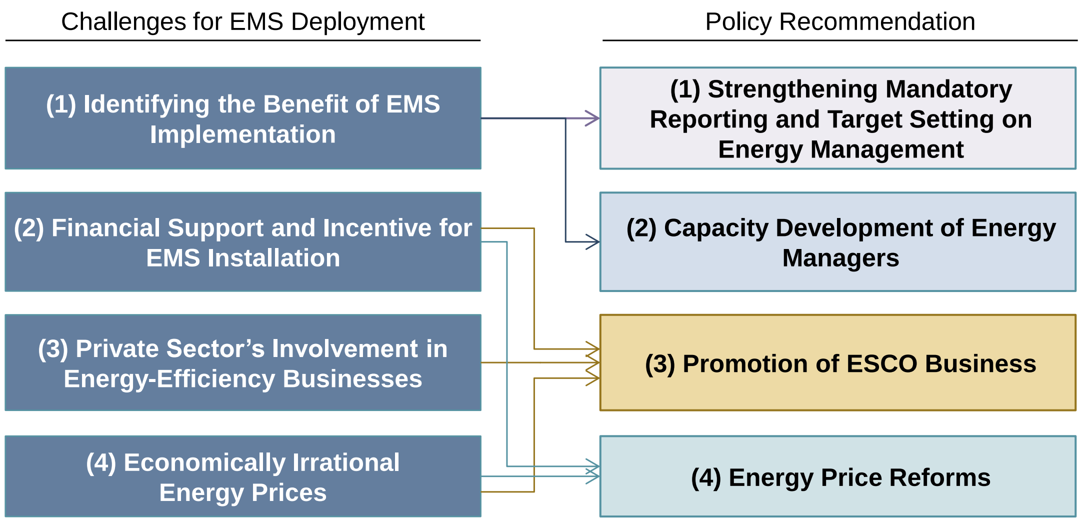
Recently, the importance of adjusting the domestic energy prices to the international prices has been accepted by many countries, and policy measures have been taken for mitigating the gap between domestic and international prices.

However, raising energy prices often stirs up national discontent and can be a politically sensitive issue. Hence, a cautious and gradual approach to deal with this should be taken.

3.2. Policy recommendation for promoting EMS deployment

To deal with the aforementioned challenges, this study proposes the following policy recommendations that will facilitate the deployment of EMS and energy-efficiency technologies.

Figure 5.8: Challenges for EMS Deployment and Policy Recommendation



Source: Author.

(1) Strengthening mandatory reporting and target setting on energy management

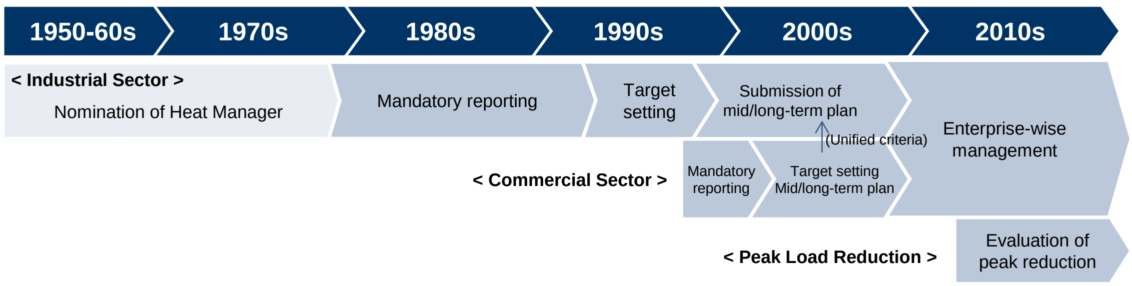
As the prerequisite for promoting the deployment of EMS, large energy consumers, such as factories and buildings, should be motivated to monitor the status of their energy consumption. Consumers with large consumption of energy who are conscious about cost management may voluntarily monitor their energy use. However, policy intervention to oblige consumers, who utilise a certain volume of energy or more in a year, to report on their status of energy management periodically is recommended, extending this practice to a larger number of consumers. Introduction of mandatory reporting is expected to enhance the consumers' awareness to monitor the status of their energy use and to reduce their consumption as needed.

Mandatory reporting of large energy consumption to a government agency also helps the government to grasp the status and the historical trend of energy consumption of a country as a whole.

The next step is the mandatory target setting, i.e. obliging these large energy consumers to develop a short-, mid-, and long-term plan of energy efficiency with quantitative target. Japan's Energy Saving Act mandates the designated business organisations to define a benchmark index for comparison with the standard of the same or similar industrial sector and to set mid- and long-term targets for improving their energy intensity (more than 1 percent per annum). In this stage, large energy consumers need not only to fill the data in the designated reporting format but also to conduct more detailed works of data recording and analysis. This is expected to help promote the utilisation of advanced energy management technologies.

As discussed in Section 1.3, mandatory reporting for large energy consumers has become a common practice in the ASEAN countries, more or less, hence, these countries should consider strengthening mandatory reporting and mandatory target setting. It has to be noted that an all-out implementation is not realistic, and moving to this direction may take time considering human limitation. In fact, Japan has taken a long history of developing mandatory reporting and target setting (Figure 5.9). Governments in the ASEAN region are also suggested to prepare a long-term plan of evolving the mandatory reporting for advancing energy management.

Figure 5.9: History of Mandatory Reporting on Energy Management in Japan



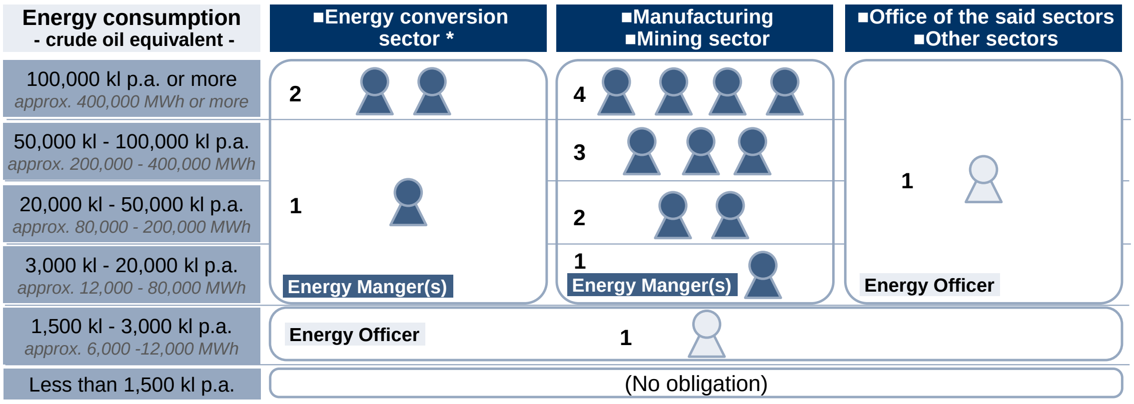
Source: Author (referring to various sources).

(2) Capacity development of energy managers

As discussed above, developing the capacity of human resources is a key for advancing energy management, especially those who assume the responsibilities of energy manager on behalf of large energy consumers.

Along with mandatory reporting, nomination of qualified energy managers has been mandated to large energy consumers not only in Japan but also in other ASEAN countries. In Japan, the requirements for nominating energy managers and energy officer vary depending on the type of business and the volume of energy consumption (Figure 5.10).

Figure 5.10: Requirements for Nominating Energy Manager(s) and Energy Officer



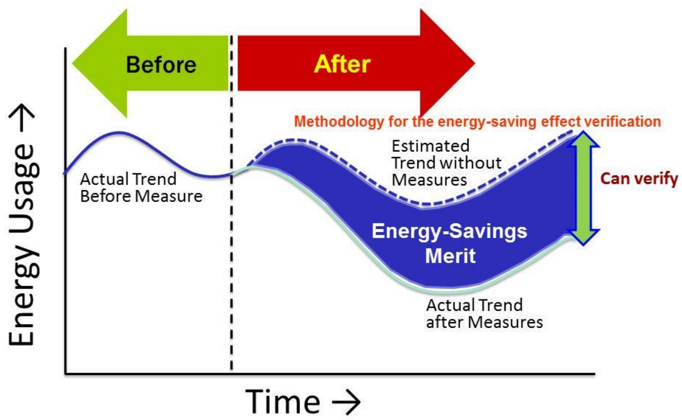
Note: *Energy conversion sector includes coke production, electricity supply, gas supply, and heat supply.
The main difference between energy manager and energy officer is the ease of acquiring the qualification.

Source: Author (referring to various sources).

These energy managers and energy officer are requested to be versed not only in technical matters of energy efficiency but also in developing plans of energy efficiency so that they can apply appropriate performance indicators to measure the effect of energy efficiency.

Developing the capacity of energy managers so that they can devise meticulous methodologies of evaluating the effect of energy efficiency helps verify the benefit of implementing EMS. Advancing capacity development of energy managers is especially essential for large-scale manufacturers that have a complicated internal structure of energy supply and demand, thus needing a sophisticated approach for identifying the benefit of EMS quantitatively and accurately.

Figure 5.11: Methodology of Verifying Energy-Saving Effect



Source: Azbil Corporation (2016), 'Abu Dhabi Energy Efficiency Improvement Forum, 2016'.

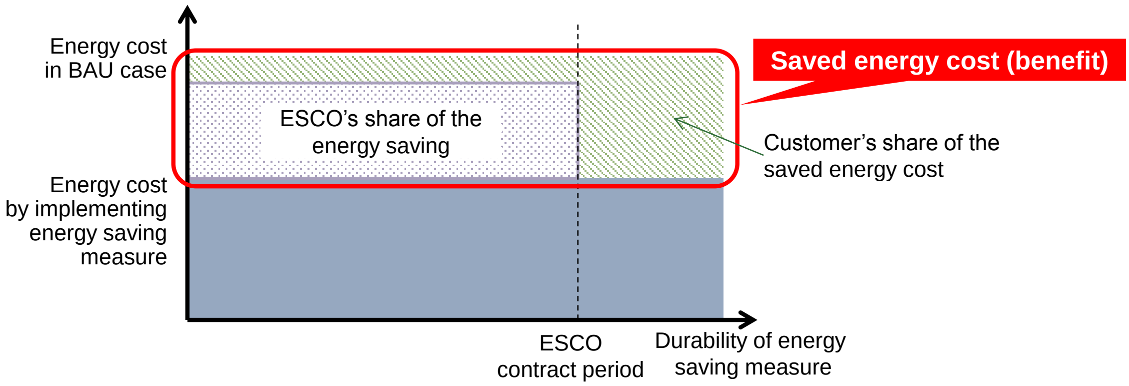
(3) Promotion of energy service company business

It may be ideal if all the large energy consumers have their internal energy manager who is versatile in energy-efficiency technologies and can provide the best-ever solutions for energy efficiency for the employer.

However, all the internal energy managers may not have such highest-end skills, hence, it is better, especially for medium and small enterprises, to ask for the expertise of external energy managers in making a decision on implementing energy-efficiency measures that require certain initial cost for investment. Also, there is a potential for promoting the ESCO business.

In an ESCO business, ESCO and the customer go into energy-saving performance contract under which ESCO provides energy saving measures and receives from the customer a portion of the benefit that derives from saved energy cost. The basic concept of the ESCO business is illustrated in Figure 5.12.

Figure 5.12: Basic Concept of Energy Service Company Business



BAU = business as usual, ESCO = energy service company.
Source: Author.

Implementing energy saving measures requires certain costs, such as the initial investment cost for installing devices and operation, whereas it is not certain how much benefit, i.e. saved energy cost, will be brought to the customer until actual implementation. Therefore, the key point of ESCO business is that ESCO takes the risk of this uncertainty so that the customer is motivated to take energy-efficiency measures without the risk.

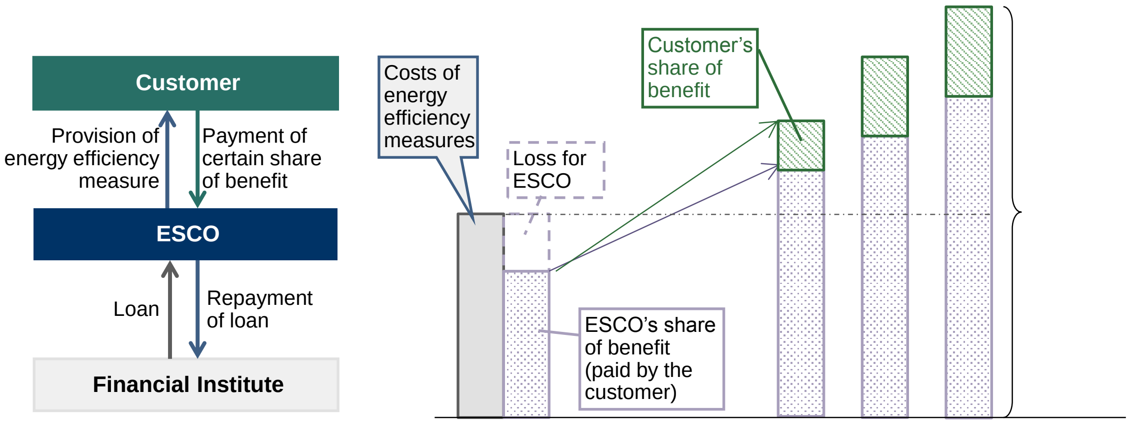
ESCO's business model can be roughly classified into two types: (i) shared saving model and (ii) guaranteed saving model, depending on who bears the costs of energy-saving measures.

In the shared saving model, ESCO bears the costs of energy-efficiency measures, including the initial investment and depending on the actual performance of energy saving (i.e. benefit) by implementing the measures, and the customer pays ESCO a certain share of the benefit. If the benefit fails to cover the costs of energy-efficiency measures, the customer does not have to pay ESCO the amount exceeding the benefit.

In the guaranteed saving model, the customer bears the costs of energy-saving measures, and ESCO usually assists the customer in arranging the loan for the initial investment. ESCO assures the customer of the guarantee of energy-saving performance. If the actual performance of energy saving (i.e. benefit) fails to cover the costs, ESCO compensates for the loss. When the benefit outperforms the costs, the customer pays ESCO a certain share of the excess benefit.

Images of the shared saving model and the guaranteed saving model are illustrated in Figure 5.13 and Figure 5.14 respectively.

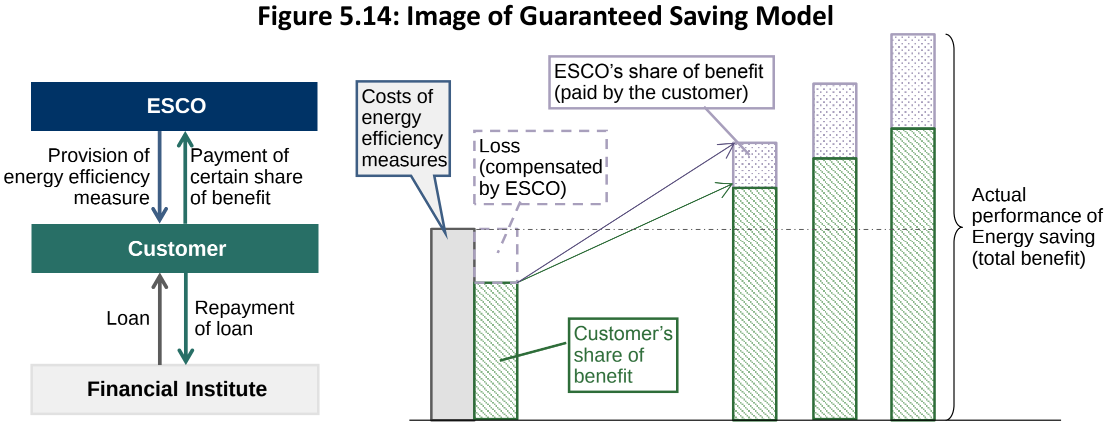
Figure 5.13: Image of Shared Saving Model



ESCO = energy service company.

Source: Author.

Figure 5.14: Image of Guaranteed Saving Model



ESCO = energy service company.

Source: Author.

Promoting ESCO business is expected to boost the deployment of EMS because, to confirm the benefit of energy-efficiency measures agreeable between the customer and the ESCO, sophisticated tools for measuring and monitoring the customer's energy consumption are needed. In fact, ESCO proposes that the customer install EMS as part of energy-efficiency measures, along with the investment in the energy-efficient appliances.

From the viewpoint of EMS suppliers, ESCO business is an opportunity for developing their business from simply selling the EMS system alone to providing the customer with various kinds of services. The four stages summarise the evolution of EMS-related business model.

Stage 1: Sales model

Simply selling EMS together as the tool for measuring energy efficiency.

Stage 2: Solution model

Providing customers advices on energy efficiency and proposing to install appliances that serve for energy efficiency in relation with EMS.

Stage 3: Life-cycle solution model

Assisting the customers with analysing the operational data and providing advices for improving the performance of operation on a long-term basis (as a kind of operation and maintenance contract).

Stage 4: ESCO model

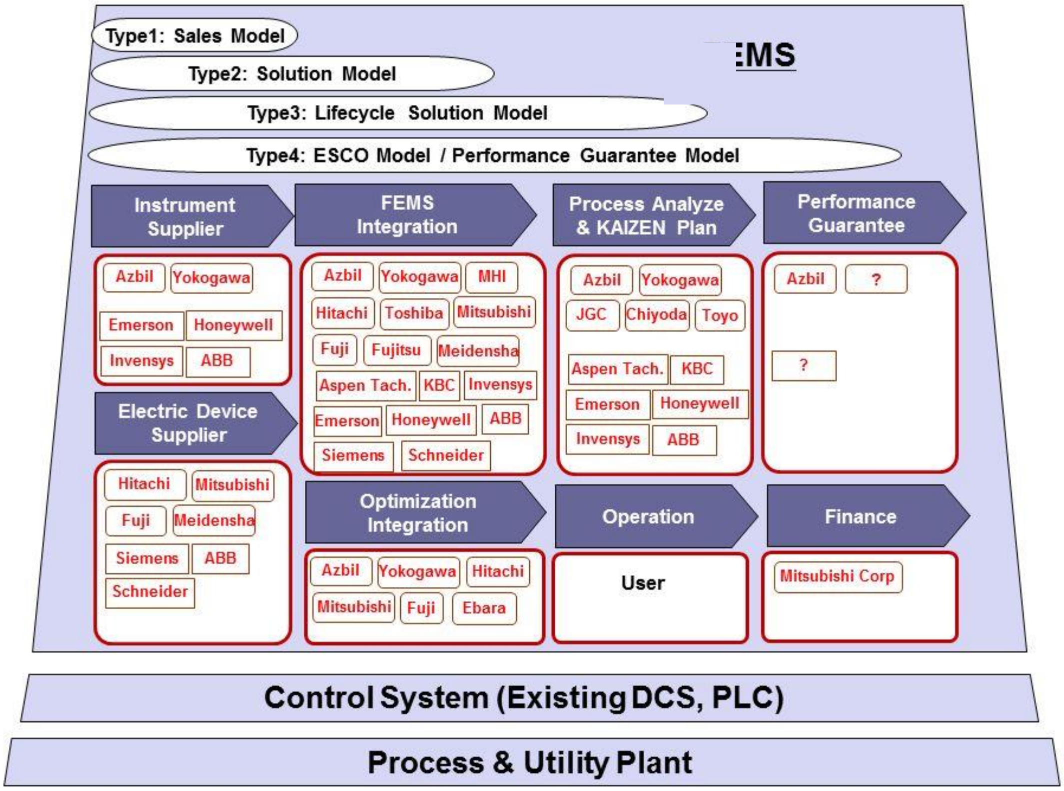
Besides the aforementioned services, providing also the customers with guarantee to mitigate their financial risk.

Figure 5.15 illustrates the stages of evolution of EMS-related business models with main players in each stage.

In terms of policy support, regulations, like mandatory reporting and target setting, are expected to motivate the consumers to be aware of solution services, like ESCO, that help them to comply with these regulations, even disregarding the evaluation of cost-and-benefit balance of these services.

In a more advanced stage, policy support should be advanced, not only imposing legal obligations but also providing incentives for facilitating the energy-efficiency-related businesses to be commercially sustainable. Also, the financial incentives should be sophisticated with stages, e.g. shifting from directly providing subsidies to investment to indirectly supporting the investment, such as low-interest loan and tax reduction.

Figure 5.15: Development of EMS-Related Business Model



DCS = distributed control system, ESCO = energy service company, EMS = energy management system, FEMS = factory energy management system, PLC = programmable logic controller.

Source: Azbil Corporation (2016), 'Abu Dhabi Energy Efficiency Improvement Forum, 2016'.

(4) Energy price reforms

(a) Shift from energy-price subsidies to energy-efficiency subsidies

The last, but not the least, to be pointed out is the importance of energy price reforms since the financial feasibility of implementing EMS, as well as any other kinds of energy-efficiency technologies, depends on how the costs for implementing these technologies are recovered by the saved costs of energy. Thus, if the energy prices are low, the payback period for implementing EMS becomes longer.

As discussed in Section 3.1, energy prices are apt to be low in countries that domestically produce fossil fuel, because the energy price are set based not on the international market price but on the conventionally determined rules that may not be supported by economically reasonable formula. The gap between the domestic energy price and the international market price is regarded as subsidies borne by the national economy. Although these kinds of subsidies may be justified to some extent in terms of social consideration, modifying the prices from actual costs of supply by subsidisation may deteriorate the price signal that may control the demand in an economically rational way.

Ideally, the energy prices in these countries should also be adjusted to meet the market price that reflects the supply and demand of energy in the market. As a general trend, even in the countries where the domestic energy prices are still low, the governments recently have been trying to raise the prices to mitigate the gap from international market price. However, adjusting the prices is made gradually and completely eradicating may take certain period since energy price is a politically sensitive issue.

For the countries where the domestic energy prices are set lower than the international prices − and it is not easy to adjust the prices in a short term − this study recommends to provide subsidies for implementing energy-efficiency technologies as the compensation for reducing the subsidies to prices of energy consumption. The maximum amount of subsidies to implementing energy-efficiency technologies thus can be formulated as follows.

Subsidies to implementing energy-efficiency technologies = Σ(volume saved energy) x (international market price – domestic energy price), where □ stands for the duration of cost recovery (e.g. 15 years).

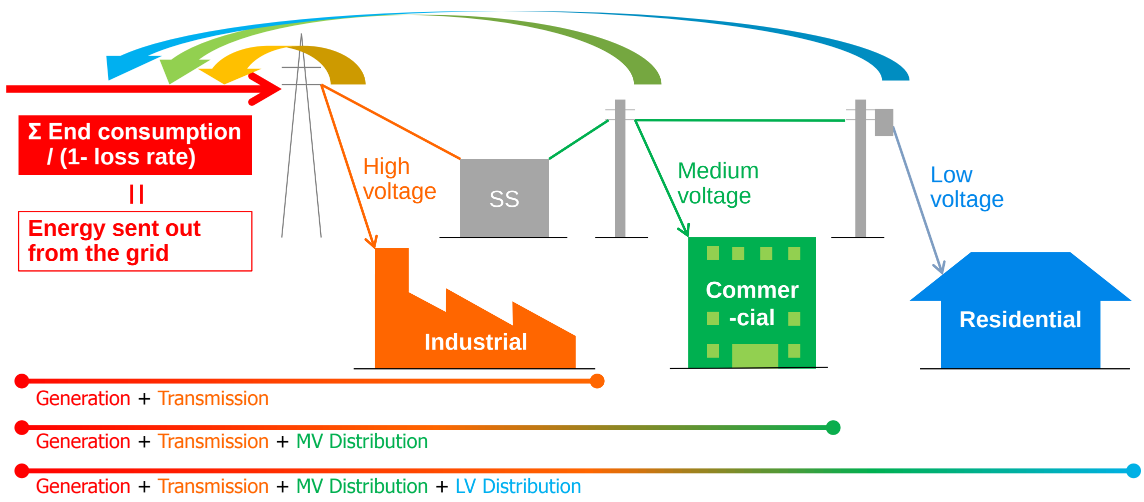
Reduced carbon costs deriving from reduced energy consumption can also be added to the formula if the country’s energy supply relies on fossil fuel combustion.

(b) Designing economically rational energy prices

The ultimate stage of price reforms is total liberalisation where government regulation on prices is removed and every transaction between supplier and consumer is traded at a market price. However, the volatility of market price may impair the stability of national economy and hence, maintaining price regulation may be justified, especially when the market is still immature and is vulnerable to price fluctuation. Even in this situation, price regulation should be designed so that the pricing is made in accordance with the actual cost of supply not only entirely (matching the total revenue with the total cost) but also sector-wise and time-wise.

Sector-wise pricing means that the cost is allocated to different sectors, e.g. residential, industrial, and commercial, appropriately to determine which customers need more or who needs less cost for energy supply, e.g. low-voltage consumers.

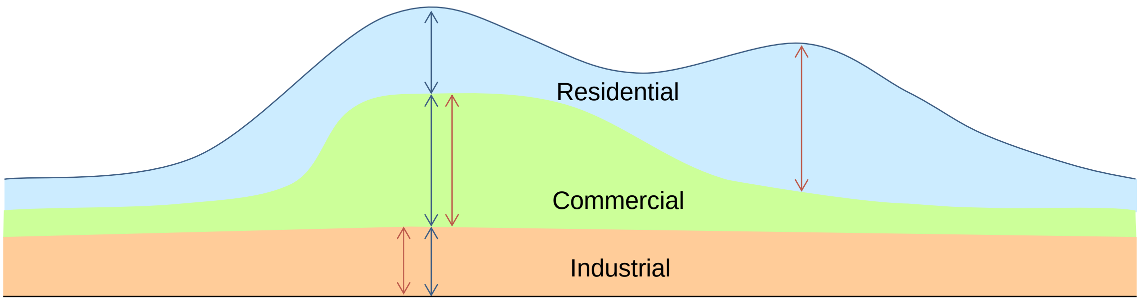
Figure 5.16 Sector-Wise Pricing



Source: Author.

Time-wise pricing means that the prices vary depending on the load level in each time zone considering that energy supply infrastructure should be prepared to meet the peak demand, hence, the costs of infrastructure that is used only in peak hours should be borne only by those who use the energy in peak hours. In the case of the following figure, the commercial sector should take the largest responsibility for the costs of energy supply in peak hours.

Figure 5.17: Time-Wise Pricing



Source: Author.

Designing energy prices based on these concepts will motivate the customers to control their energy demand in an economically rational way, and helps the deployment of EMS-related investment that assists in identifying the solution for lowering energy costs.

References

Asia Pacific Energy Research Centre (APERC) (2015), 'Compendium of Energy Efficiency Policies of APEC Economies, 2015'.

Asia Pacific Energy Research Centre (APERC) (2016), *APEC Energy Demand and Supply Outlook*, 6th ed. Tokyo: APERC.

Azbil Corporation (2016), Exhibition material for 'Sustainable Energy & Technology Asia, 2016'.

Azbil Corporation (2016), 'Introduction of RENKEI Control System, Jointly Promoted by METI – Case Studies for True Energy-Saving Through Utilizing BEMS & FEMS'. Presentation material for 'Abu Dhabi Energy Efficiency Improvement Forum, 2016'.

Azbil Corporation, 'EneSCOPE Catalogue'.

Azbil Corporation, 'Utility Facility Optimization Package Catalogue'.

International Energy Agency website, Policies and Measures Indonesia, 'National Master Plan for Energy Conservation (RIKEN)'. www.iea.org/policiesandmeasures/pams/.../name-23643-en.php (accessed 31st August 2016).

International Energy Agency (2015), 'Energy Balances of Non-OECD Countries, 2015'.

International Energy Agency, 'Energy Balances and Statistics'. www.iea.org/statistics/topics/energybalances/ (accessed 31st August 2016).

Japan Electronics and Information Technology Industries Association (JEITA) (2016), ‘Concepts of RENKEI Control for Energy Optimization’, an article from the technical journal *Keiso Instrumentation & Control Engineering* No. 3. (Original text in Japanese)

Perusahaan Otomobil Nasional (Proton) (2016), ‘PROTON Tanjung Malim Sdn Bhd (PTMSB) Compressed Air System Optimization’. Presentation material, not officially published.

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”’. (Original text in Japanese)

National Environment Agency, Singapore (2012), ‘Energy Conservation Act & Singapore Certified Energy Manager Programme’, *PT PLN (Persero) Annual Report*. Singapore: National Environment Agency.

The Energy Conservation Center, Japan (2014).World Bank, ‘World Development Indicators’. Washington: World Bank. data.worldbank.org (accessed 31st August 2016).