Advancing the Energy Management System in the East Asia Summit Region

edited by

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September 2015

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ERIA Research Project FY2014 No. 39
Published September 2015

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Preface

Anyone aware of and concerned about our depleting natural resources and the effect of energy consumption on the environment agrees to the need for energy efficiency. However, because energy efficiency covers a wide spectrum of issues and measures on dealing with the concerns, discussions on the promotion of energy efficiency may only result in a catalogue of measures that is just too general for practical application.

Because every part of the energy supply-and-demand system involves technologies, energy efficiency cannot be achieved without any kind of technology. However, any energy efficiency measure can never be successful without considering its effect on human activities. Therefore, among the various types of technologies on energy efficiency, those that interface with human activities play the most important role, and we assume that Energy Management System (EMS) technologies, which help visualise, monitor, and control energy supply and demand, can be the foundation in this context.

Needless to say, deploying EMS itself is not simply the solution because it is a rather costly investment that has to be assessed vis-a-vis the expected benefits (i.e. its energy efficiency) from both macro and micro perspectives.

Last but not the least, we need to consider the institutional framework. In general, costly investments—even when economic benefits are expected in the end—are apt to be avoided if they involve a long period for cost recovery. This is more conspicuous in a market that is not mature enough for the price mechanism to work perfectly. Thus, appropriate policy interventions are needed to help promote EMS technologies.

This study aims to suggest possible ways to promote EMS technologies to policy planners in the East Asia Summit region. We hope that the findings here will bring new insights to those involved in energy issues.

Yasushi Iida
On behalf of the Study Team
August 2015

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Executive Summary

This study aims to analyse the potential for deployment of the Energy Management System (EMS) in the East Asia Summit (EAS) region, and to propose, upon identifying the policy challenges common in the region, policy recommendations for the promotion of EMS. The first year of this two-year study focused on analysing the needs of the EMS and grasping the details of their current status through case studies. Based on these results, additional case studies were carried out. Based on the first year study, the second year will identify specific challenges for the advancement of EMS in the EAS region, and propose policy options.

This study chose five Association of Southeast Asian Nations (ASEAN) countries—Indonesia, Malaysia, Singapore, Thailand, and Viet Nam—as the targeted countries. These have common characteristics in terms of energy consumption, although they have some differences in other aspects such as country size, economic conditions, and how much their energy supply relies on domestic resources.

Despite such differences, these five countries—as well as the other countries in the ASEAN region—have seen a sharp increase in energy demand driven by the economic growth, and feel compelled to reduce their energy consumption. The efforts are still under way but they still need to further promote energy efficiency to control the energy demand without affecting their economies' development. The state of EMS deployment varies among these nations although, in general, they are all still at an early stage and thus still far from a full-fledged commercialisation.

Basic and common functions of xEMS technologies have four development steps:

- to visualise the energy demand by using meters or monitors;
- to monitor the energy demand by information and communication technologies;
- to control the energy demand automatically by communication;
- to integrate the distributed energy supply systems (e.g. photovoltaics, energy storage, electric vehicle, etc.).

The development of xEMS technologies started with large energy consumers. Interests in energy saving benefits within factories (i.e. their Factory EMS) and buildings (i.e. Building Energy Management System [BEMS]) are easy to coordinate due to their

small number of stakeholders. These are followed by residential use (i.e. Home Energy Management System, or HEMS) and Community Energy Management System (CEMS), which integrates the facility-level EMS into the community-level EMS.

For the case studies on the potential of BEMS deployment during the first year, the head office (Yayasan Building) of PT PLN in Indonesia and the Nonthaburi Office of the Metropolitan Electricity Authority (MEA) in Thailand were chosen among the list of candidate sites proposed by the study's Working Group members.

The case studies consisted of two steps. First, researchers analysed the potential energy efficiency based on data provided by PLN and MEA and presented their tentative results during the second Working Group meeting in Tokyo. Next, the study team conducted a more detailed site survey consisting of walk-throughs and interviews with facility personnel to identify in detail the potential energy savings.

The site survey results at PLN's Yayasan Building showed that improvements in operational practices such as the adjustments in air ventilation and inverters could lead to a potential energy savings of 4.6 percent of the total electricity consumption. Because the building is over 20 years old already, large-scale remodelling of existing facilities may also need to be considered although cost recovery may take longer. Replacement of turbo chillers is expected to achieve an additional 10 percent reduction in energy consumption.

The MEA Nonthaburi Office, because of its newer infrastructure and facilities, has an energy savings potential that is not as high as that in the PLN Office. Established just in 2012, the MEA Nonthaburi Office's new facilities are in good condition and have maintenance procedures in place. However, the site survey also showed that there is room for improvement in the control of airflow although some additional costs may be required. Improvements in operational practices and deploying these low-cost measures may lead to a total energy savings of about three percent of the total electricity consumption.

The case studies at the two sites, thus, suggest two areas to be improved in the air-conditioning systems of office buildings. One is to adjust the intake volume of fresh air from outdoors; the other is to adjust the motor power's frequency using inverters.

This study also argues that, in the long run, more attention should be paid to energy efficiency by introducing advanced building structures.

Following the results from the first year of study, the second year will proceed to undertake an in-depth analysis of a broader area of energy consumption (i.e. beyond just the office buildings): For example, to study the potential deployment of Factory Energy Management Systems and CEMS.

Finally, this study discusses policy recommendations on the promotion of EMS technologies in the EAS region, with focus on the economic impact of policy options such as subsidies, tax benefits, and tariff incentives that support Energy Service Company businesses.

Chapter 1

Introduction

Along with the rapid economic growth in the East Asia Summit (EAS) countries comes the formation of new industrial and commercial facilities as well as energy supply infrastructure. The demand for energy supply is also expected to rise well into the future. Therefore, concrete plans to control energy consumption is required for the sustainable development of EAS economies.

Experiences of developed countries show that improving the efficiency on the energy consumption side does not come about by promoting the use of highly efficient energy equipment alone. Rather, energy efficiency is also attained when there is an institutional framework for efficient energy use (such as the Energy Conservation Law) at the initial stage of capital accumulation and development of industrial/commercial facilities.

The oil crisis in the 1970s and the increase in climate change issues since the 1990s led developed countries to devise various political and technical approaches for energy management. In particular, the advancement of information and communication technologies since 2000s has greatly helped to develop the energy management system (EMS), which is now widely called xEMS[1] to refer to the various types of EMS technologies available. Furthermore, efforts to relate the load management functions of EMS with the Demand Response[2] concept have been accelerated.

As changes in industrial structure and in energy consumption are expected along economic growth in the EAS countries, it is worthwhile to understand the potential advances in the EMS that meet the specific needs of each country in the region. This study, a project of the Economic Research Institute for ASEAN and East Asia, identifies the common policy challenges to the advancement of EMS in the EAS region and is expected to contribute to the region's sustainable economic growth.

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1 Collective term for HEMS (Home Energy Management System), BEMS (Building Energy Management System), Factory Energy Management System, Community Energy Management System, etc.

2 The mechanism to allow end-use customers to reduce electricity loads at the instruction of electric power utilities during the hours of peak demand and get paid for the reduced loads.

1.1 Objective

This study aims to analyse the potential to deploy EMS technologies in the EAS region and to propose, upon identifying the policy challenges that are common in the region, policy actions that can promote EMS.

1.2 Scope of Works

The study focused on analysing the needs of EMS technologies and understanding the current state of EMS through case studies.

(1) *Analysing the Needs of EMS Technologies in the EAS Region*

Given the global trend in EMS and its technological prospects, this study identified the xEMS technologies applicable in the EAS region and analysed the viability of implementing these technologies in each EAS country.

(2) *Understanding the Current State of EMS through Case Studies*

Case studies on the implementation of EMS for office buildings—particularly called the Building Energy Management System (BEMS)—were conducted to determine the system's viability and challenges.

Chapter 2

Overview of Energy Efficiency in the EAS Region

1. Overview on Target Countries

This study chose five Association of Southeast Asian Nations (ASEAN) countries—Indonesia, Malaysia, Singapore, Thailand and Viet Nam—as the target countries.

Because of their geographical proximity, these nations have some common characteristics in their energy consumption. Except for Northern Viet Nam, which has a subtropical climate, these nations have a tropical climate. The weather is generally hot and humid throughout the year, with the highest temperature at mid-30s degrees Celsius. Thus, the energy demand for air conditioning (cooling) systems accounts for a considerable portion of their total energy consumption, while the energy demand for a heating system is minor.

Significant differences can also be observed in many aspects. Each country's size, both in land area and population, varies. These nations' economic conditions such as their gross domestic product (GDP) and industrial structure differ from each other, which implies some variations in the characteristics of their energy consumption. Whether and how much their energy supply relies on domestic resources affects the energy cost in each country, which also affects the energy consumption.

Despite such differences, all five countries—as well as other countries in the ASEAN region—have seen a sharp rise in their energy demand due to economic growth, and they resolve to reduce energy consumption. To achieve this, government agencies and public utilities in each country have taken on various measures to promote energy efficiency such as regulations, awareness campaigns, model projects that adopt state-of-the art technologies, and economic incentives.

Although the countries have initiated actions along this line, they still need to exert more effort at promoting energy efficiency to control the energy demand without affecting economic development.

The next section provides an overview of the structure of energy supply and demand, as well as the current state of energy efficiency policies and regulations in each of the five countries.

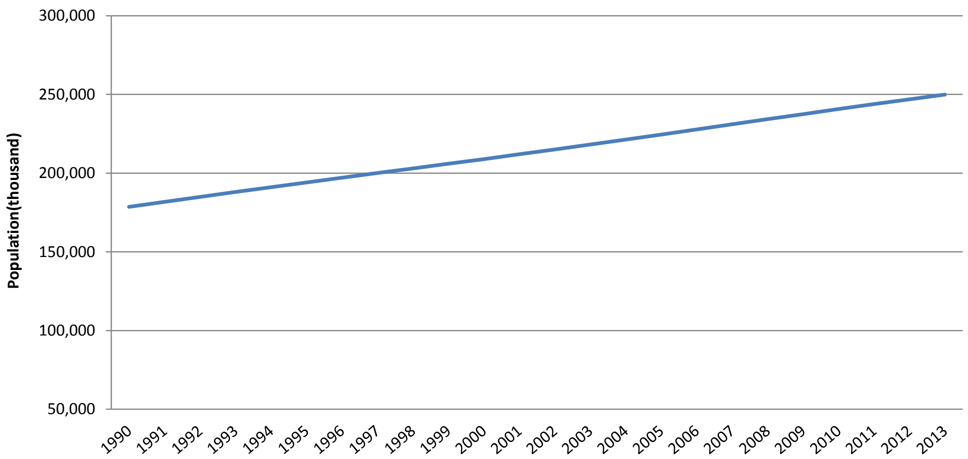
1.1. Statistical overview of five countries

(1) Indonesia

i. Population and GDP

Indonesia's population reached about 250 million in 2013. When compared to 1990 figures, the population has grown by 1.4 times (1.5 percent per annum). Past trends show that such growth rate has been rising consistently (Figure 2-1).

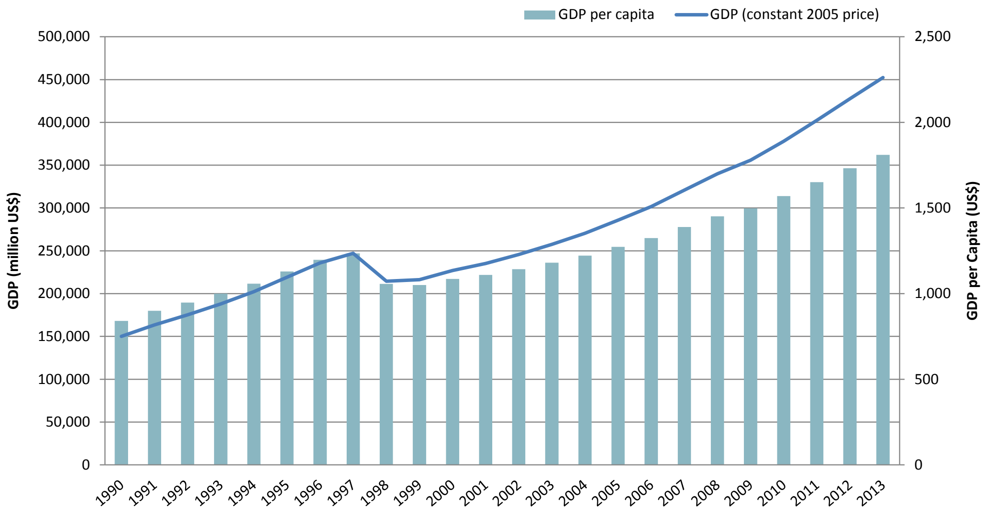
Figure 2-1. Population of Indonesia (1990–2013)



Source: World Bank 'World Development Indicators' (data.worldbank.org).

In the late 1990s, the country's economy was severely affected by the Asian Financial Crisis, as shown in the sharp drop in GDP (Figure 2-2). Afterwards, Indonesia's economy picked up and experienced a steady growth. From 1990 to 2013, GDP (constant at 2005 price) increased by three times (4.9 percent per year.), while GDP per capita rose by 2.2 times (3.4 percent per year).

Figure 2-2. GDP and GDP per Capita of Indonesia (1990-2013, constant at 2005 price)

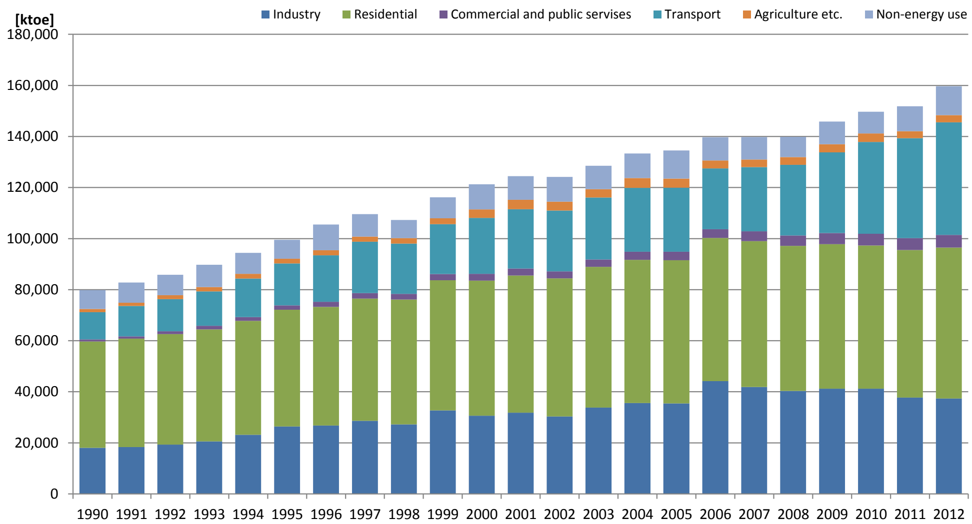


Source: World Bank 'World Development Indicators' (data.worldbank.org).

ii. Energy Balances

Along with economic growth, energy consumption has been rising. The total final energy consumption doubled in 22 years (3.2 percent per year), climbing from 79,808 ktoe in 1990 to 159,664 ktoe in 2012 (Figure 2-3).

Figure 2-3. Total Final Consumption in Indonesia (1990–2012)

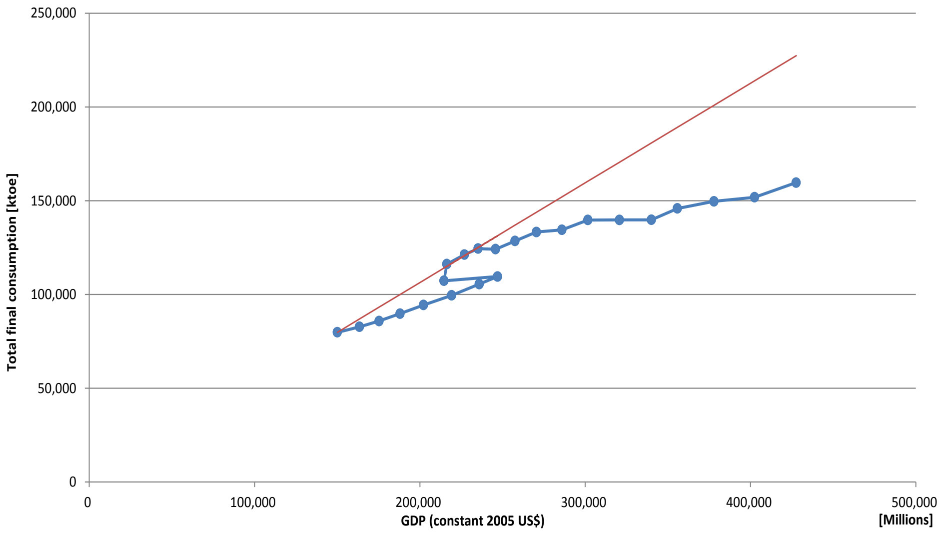


Source: International Energy Agency Energy Balances.

Recently, the energy consumption of industrial and residential sectors has not been increasing significantly (or even slightly decreasing at times), while it is the transport sector that has been the main driver in the rise in Indonesia's energy consumption.

Figure 2-4 plots the GDP and total final consumption in Indonesia from 1990 to 2012. The energy-GDP elasticity, which is the ratio of the growth of energy consumption to the growth of GDP, was 0.54 during the said period (the red line in this figure indicates that elasticity=1).

Figure 2-4. GDP and Total Final Consumption in Indonesia (1990–2012)

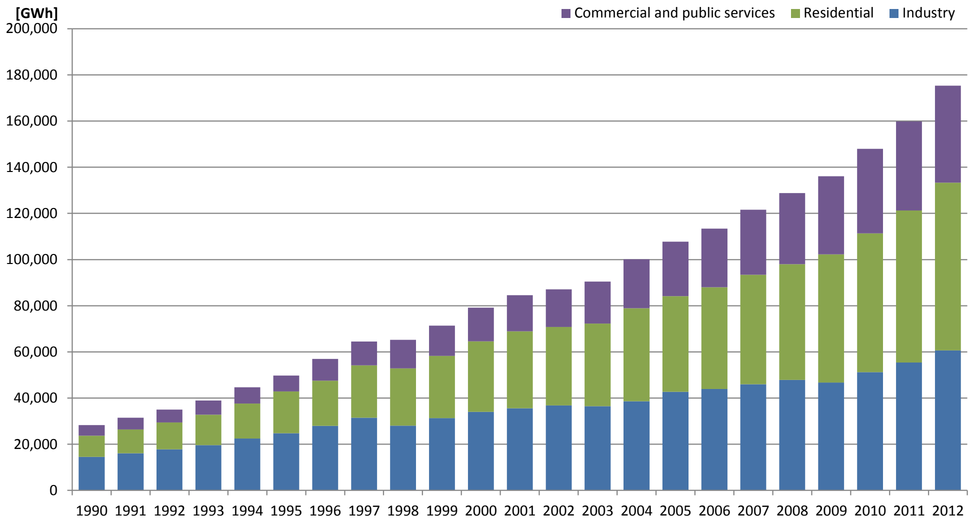


Source: World Bank 'World Development Indicators' (data.worldbank.org), International Energy Agency's Energy Balances.

One possible reason for the moderate increase in energy consumption compared to the GDP growth (especially in industrial and residential sectors), is because the national economy is still at an early stage of development, and the dependence of economic activities on energy consumption is low. If this assumption is true, the energy-GDP elasticity may increase when the economic development reaches a certain level.

Figure 2-5 shows the electricity consumption in Indonesia from 1990 to 2012. During this period, the electricity consumption increased by 6.2 times (8.6 percent per year), which is far higher than the growth of total energy consumption and of GDP. This trend implies that the modernisation (rationalisation) of energy supply through electrification—i.e. the shift from other sources of energy supply to electricity—has contributed to the relatively low energy-GDP elasticity.

Figure 2-5. Electricity Consumption in Indonesia (1990–2012)



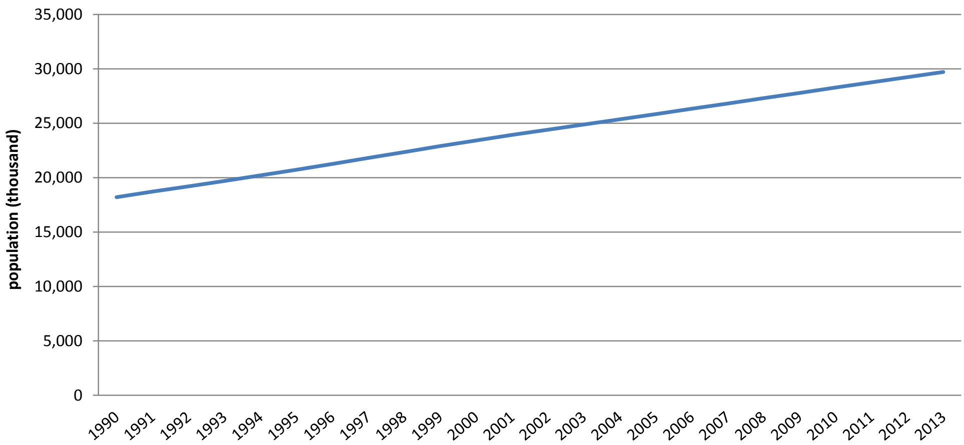
Source: International Energy Agency's Energy Balances.

(2) Malaysia

i. Population and GDP

The population of Malaysia was about 30 million in 2013. Similar to Indonesia, the population growth since 1990 has been almost constant. The population has grown by 1.6 times (2.2 percent per year), which is faster than Indonesia's growth (Figure 2-6).

Figure 2-6. Population of Malaysia (1990–2013)

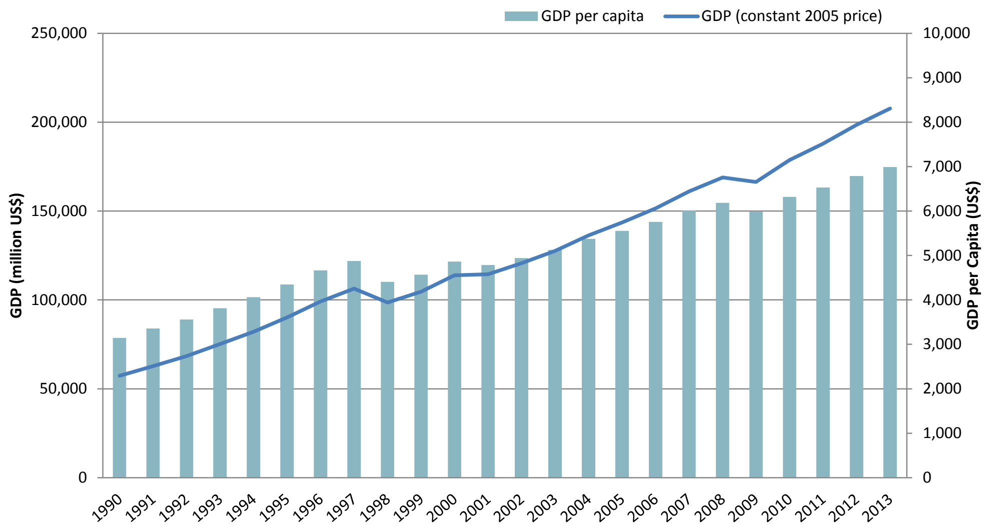


Source: World Bank, 'World Development Indicators' (data.worldbank.org).

The Malaysian economy was also affected by the Asian Financial Crisis in the late 1990s although not as much as the impact on Indonesia. Figure 2-7 (which provides the GDP and GDP per capita values in US dollars) shows another dip in GDP growth in the late 2000s due to the Global Financial Crisis.

These notwithstanding, Malaysia's economy has been growing steadily. From 1990 to 2013, its GDP (constant at 2005 price) increased by 3.6 times (5.8 percent per year), while GDP per capita climbed by 2.2 times (3.5 percent per year).

Figure 2-7. GDP and GDP per Capita of Malaysia (1990–2013, constant at 2005 price)



Source: World Bank 'World Development Indicators' (data.worldbank.org).

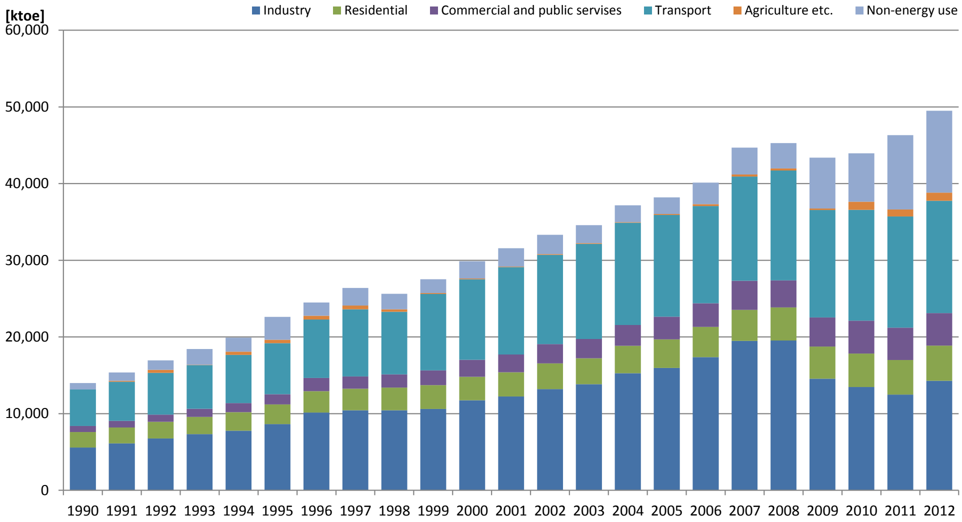
ii. Energy Balances

The growth in the national energy consumption followed almost the same trend as the GDP growth. That is, the energy consumption has been growing almost constantly except in the late 1990s and late 2000s, when financial crises caused an economic slump.

As seen in Figure 2-8, the total final consumption of energy rose by 3.5 times—from 13,991 ktoe in 1990 to 49,493 ktoe in 2012—in 22 years (5.9 percent per year).

There were no major changes in the share of each sector's energy consumption up until 2009, when the share of 'industry' decreased and 'non-energy use' increased instead. Because 'non-energy use' is mostly for chemical/petrochemical feedstock (i.e. for industrial use), the recent structural change may be merely a statistical correction.

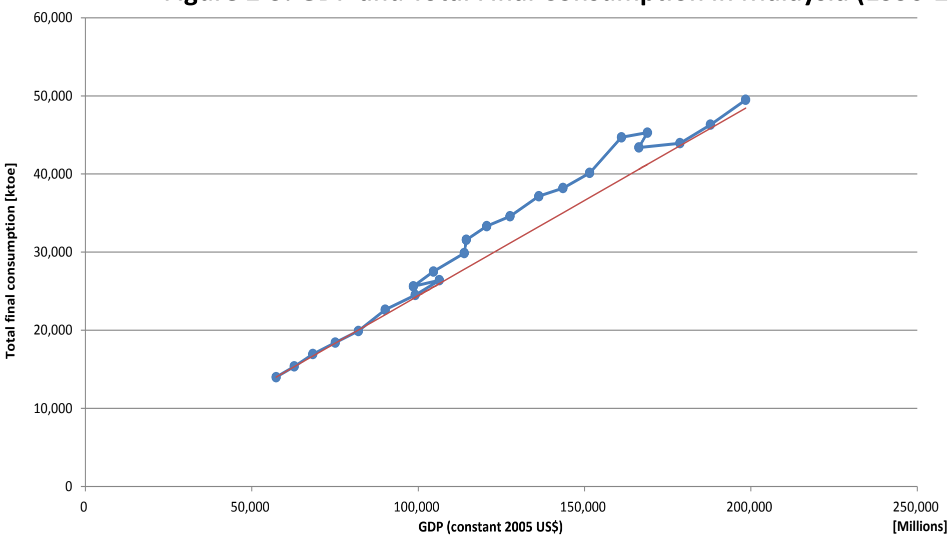
Figure 2-8. Total Final Consumption in Malaysia (1990-2012)



Source: International Energy Agency's Energy Balances.

Figure 2-9, which plots the GDP and total final consumption in Malaysia from 1990 to 2012, clearly shows that the energy-GDP elasticity has been almost 1. This means that the growth rate of energy consumption has been almost the same as the growth rate of GDP during that period (the red line in this figure indicates that elasticity=1). The higher energy-GDP elasticity in Malaysia than in Indonesia implies that the former's national economy is more developed, and its economic activities are more dependent on energy consumption.

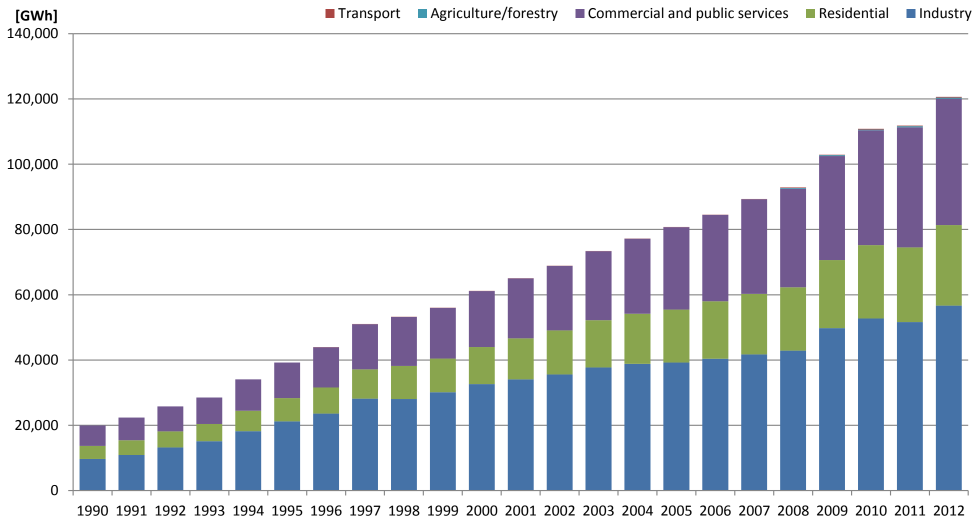
Figure 2-9. GDP and Total Final Consumption in Malaysia (1990-2012)



Source: World Bank 'World Development Indicators' (data.worldbank.org), International Energy Agency's Energy Balances.

Figure **2-10** shows the electricity consumption in Malaysia from 1990 to 2012. During this period, the electricity consumption has grown by six times (8.5 percent per year): from 20 TWh to 121 TWh. Similar to Indonesia, Malaysia's electricity consumption growth is far higher than that of the total energy consumption and that of GDP.

Figure 2-10. Electricity Consumption in Malaysia (1990-2012)



Source: International Energy Agency's Energy Balances.

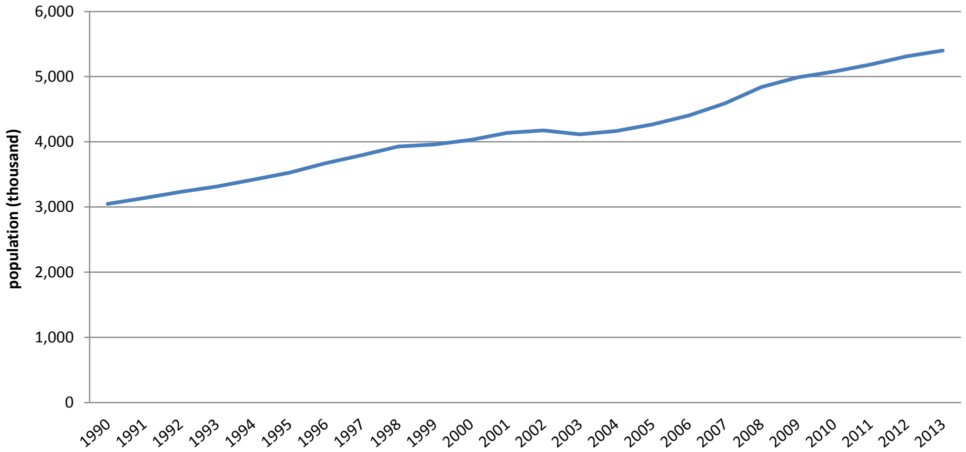
Assuming that the progress of electrification (e.g. shifts of energy consumption from traditional modes of energy usage, such as firewood and kerosene, to electricity usage), contributes to lowering energy-GDP elasticity, etc., the elasticity may become higher when the electrification reaches a certain level—that is, when the growth of electricity consumption becomes as low as that of total energy consumption.

(3) Singapore

i. Population and GDP

In 2013, Singapore had a population of 5.4 million (Figure 2-11). Since 1990, the population has grown by 1.77 times (2.5 percent per year), which is the highest among the five countries in this study. Note that the population in Singapore is strongly affected by its immigration policy. This explains why the population growth in Singapore, unlike in Indonesia and Malaysia, has not been constant, even experiencing negative growth in 2003.

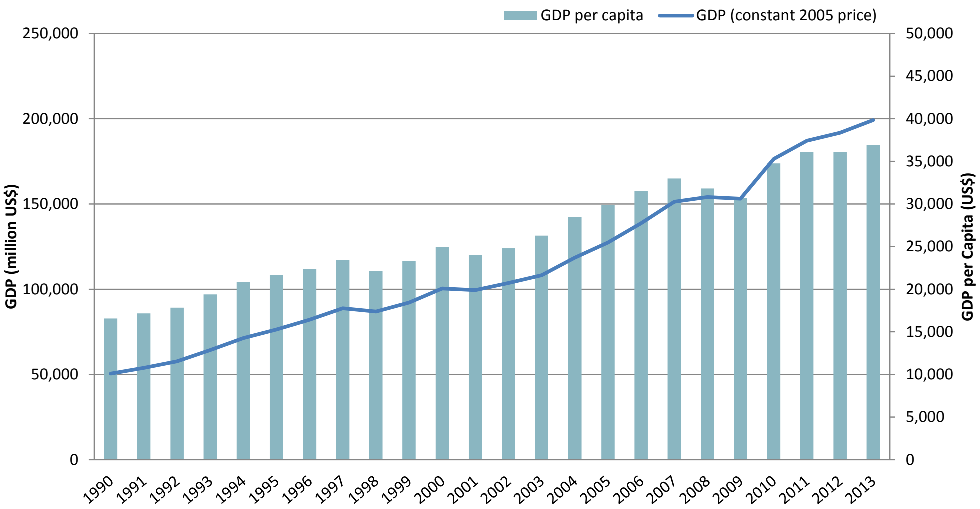
Figure 2-11. Population of Singapore (1990-2013)



Source: World Bank 'World Development Indicators' (data.worldbank.org).

The Asian Financial Crisis in the late 1990s had a lesser effect on Singapore's economy than it did on Indonesia and Malaysia. On the other hand, the Global Financial Crisis in the late 2000s had a greater influence on Singapore's economy, although Singapore was able to recover in the 2010s. From 1990 to 2013, the nation's GDP (constant at 2005 price) increased by 3.9 times (6.2 percent per year), while GDP per capita grew by 2.2 times (3.5 percent per year). Figure 2-12 shows Singapore's GDP and GDP per capita in US dollars.

Figure2-12. GDP and GDP per Capita of Singapore (1990–2013, constant at 2005 price)

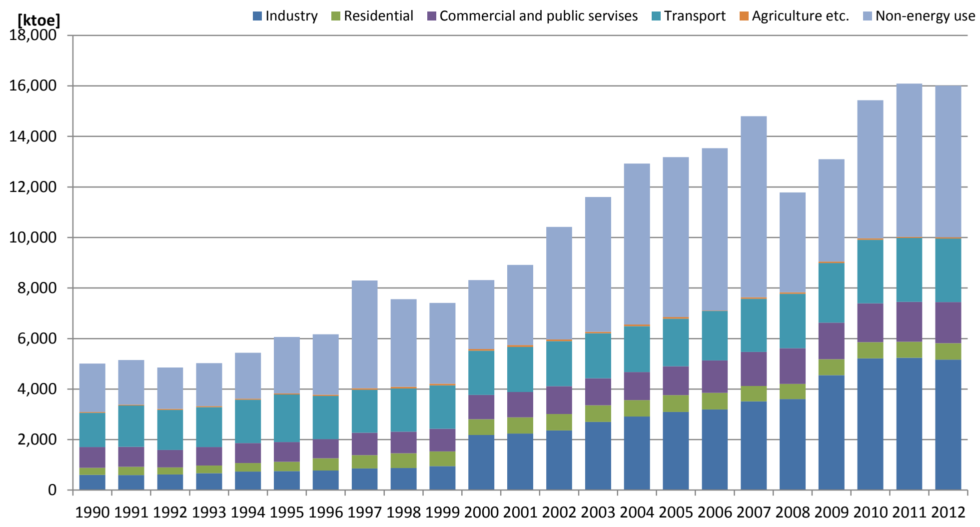


Source: World Bank 'World Development Indicators' (data.worldbank.org).

ii. Energy Balances

The growth in Singapore's national energy consumption has almost the same trend as the GDP growth. The energy consumption has been growing except in the late 1990s and late 2000s, when financial crises caused an economic slump. The total final consumption of energy increased by 3.2 times in 22 years (5.4 percent per year)—i.e. from 5,007 ktoe in 1990 to 16,009 ktoe in 2012 (Figure 2-13).

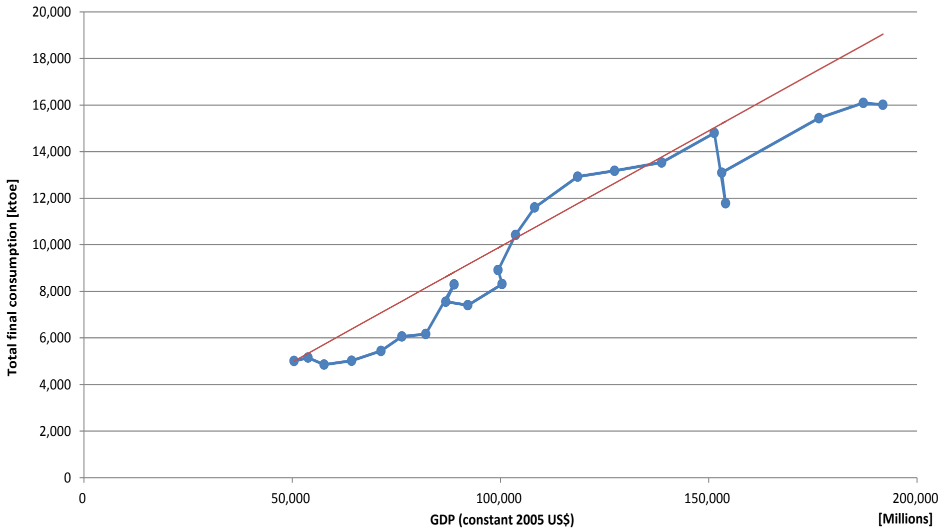
Figure 2-13. Total Final Consumption in Singapore (1990-2012)



Source: International Energy Agency's Energy Balances.

Figure 2-14 presents the GDP and total final consumption in Singapore from 1990 to 2012. The energy-GDP elasticity has been 0.78 during that period (the red line indicates that elasticity=1). Compared to the other four countries, Singapore's trend curve has more propensity to fluctuate (i.e. the curve is less linear). Commercial sectors, which consume less energy than manufacturers, account for a large share in Singapore's national economy whereas a limited number of manufacturers such as petrochemical consume a large volume of energy; such industrial structure likely accounts for Singapore's trend curve.

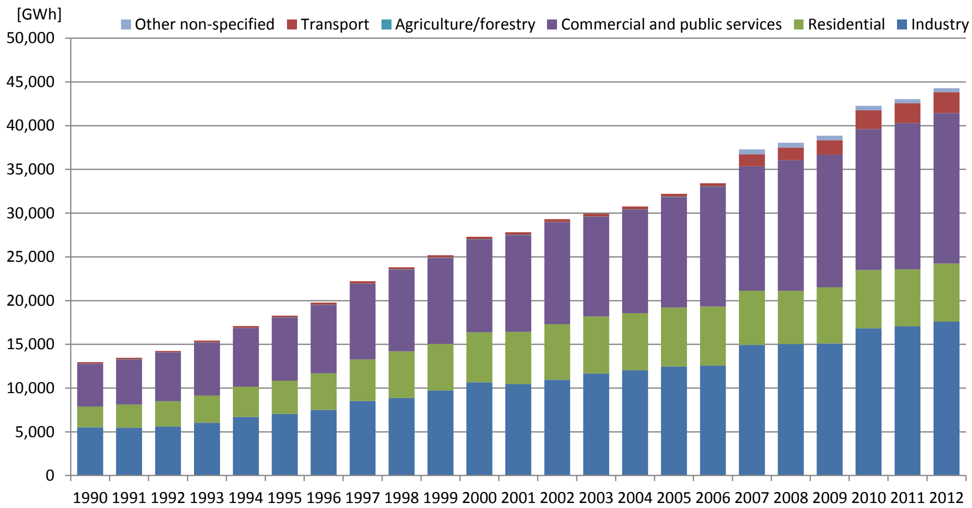
Figure 2-14. GDP and Total Final Consumption in Singapore (1990-2012)



Source: World Bank 'World Development Indicators' (data.worldbank.org); International Energy Agency's Energy Balances.

Meanwhile, Figure 2-15 shows the electricity consumption in Singapore from 1990 to 2012. During this period, the electricity consumption has grown by 3.4 times (5.7 percent per year). The growth rate of Singapore's electricity consumption is not much different from that of its total energy consumption, implying that its electrification of energy consumption (e.g. shifts of energy consumption from traditional modes of energy usage, such as firewood and kerosene, to electricity usage) has advanced more than in Indonesia and Malaysia.

Figure 2-15. Electricity Consumption in Singapore (1990–2012)



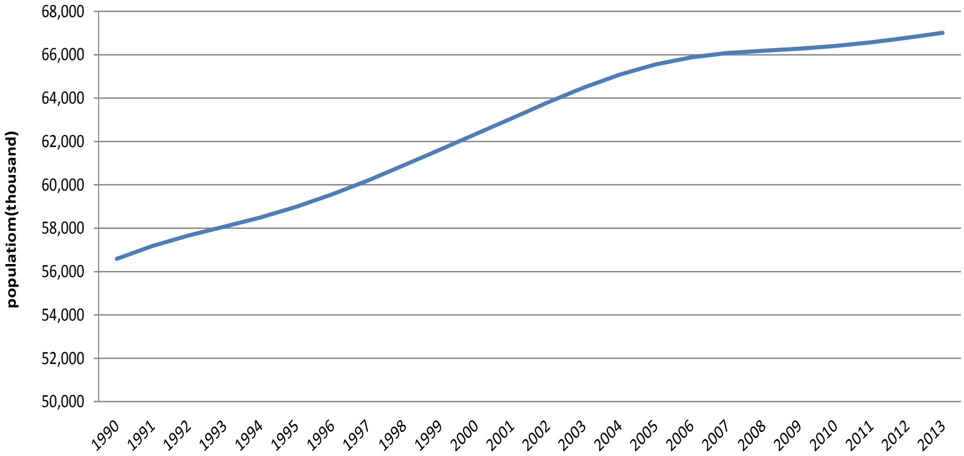
Source: International Energy Agency's Energy Balances.

(4) Thailand

i. Population and GDP

Thailand's population in 2013 stood at 67 million (Figure 2-16). Since 1990, the population grew by 1.2 times (0.7 percent per year)—the lowest among the five countries. After the mid-2000s, its growth fell below 0.5 percent per year, which is attributed to a declining birth rate that comes with social maturation.

Figure 2-16. Population of Thailand (1990-2013)

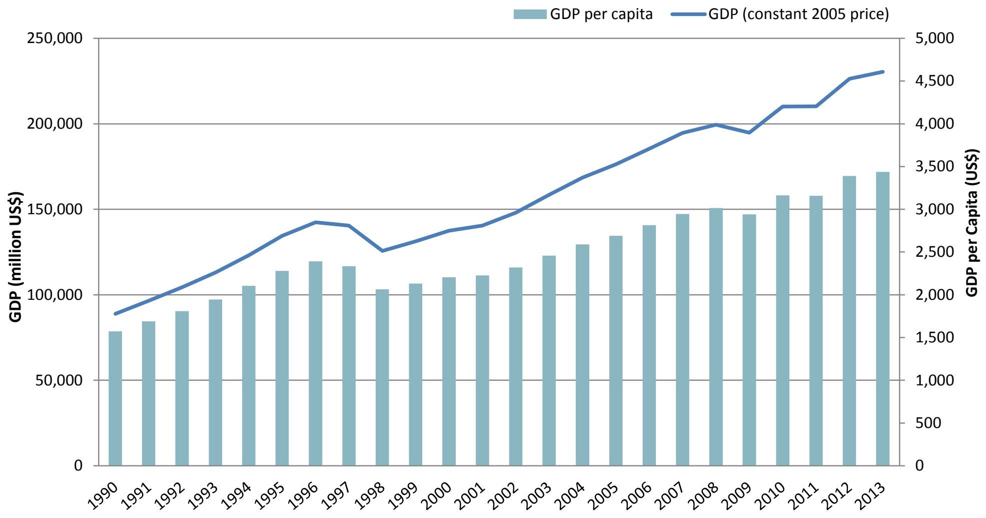


Source: World Bank, 'World Development Indicators' (data.worldbank.org).

Thailand was significantly affected by the Asian Financial Crisis in the late 1990s (Figure 2-17). Another two dips in GDP can be seen (1) when Thailand' exports were severely affected by the Global Financial Crisis in 2009 and (2) when the heavy flooding in 2011 interrupted its recovery. Otherwise, the rest of the years showed an upward trend.

From 1990 to 2013, the GDP (constant at 2005 price) increased by 2.6 times (4.2 percent per year) and GDP per capita rose by 2.2 times (3.5 percent per year).

Figure 2-17. GDP and GDP per Capita of Thailand (1990-2013, constant at 2005 price)

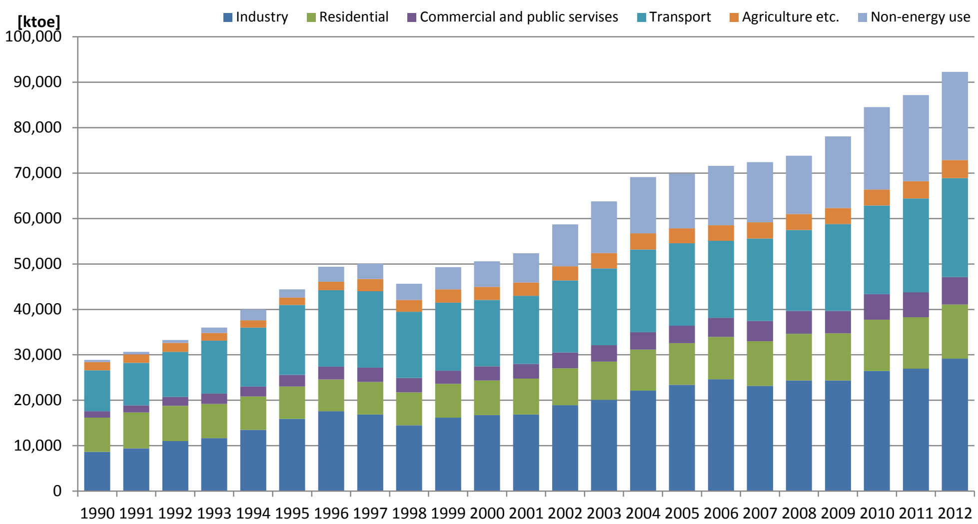


Source: World Bank, 'World Development Indicators' (data.worldbank.org).

ii. Energy Balances

The total final energy consumption of Thailand rose from 28,873 ktoe in 1990 to 92,281 ktoe by 2012 (Figure 2-18). In the past 22 years, therefore, energy consumption increased by 3.2 times (5.4 percent per year).

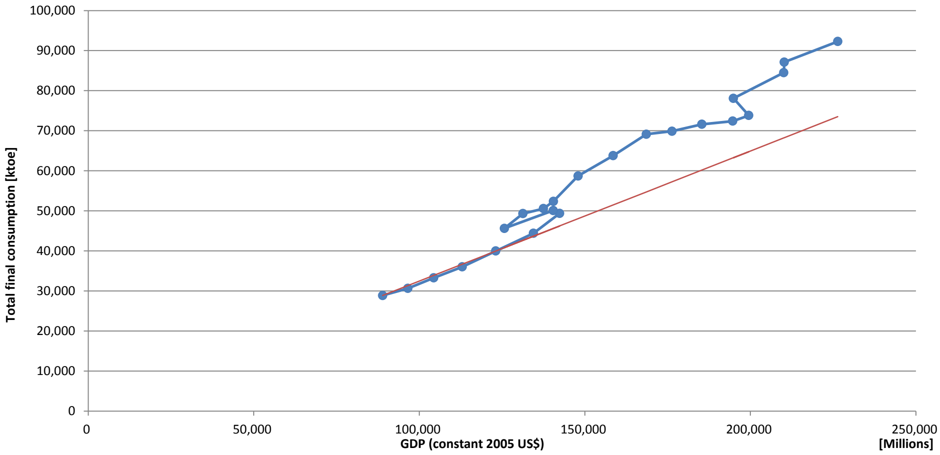
Figure 2-18. Total Final Consumption in Thailand (1990-2012)



Source: International Energy Agency's Energy Balances.

Figure 2-19 shows the GDP and total final consumption in Thailand from 1990 to 2012. Its energy-GDP elasticity was 1.4 (where the red line indicates that elasticity=1), which is the highest among the five countries under study. The energy–GDP elasticity was almost 1 during the early 1990s. Then, from the late 1990s to early 2000s, its slope became steeper before finally settling at roughly 1 since the late 2000s. This implies that the national economy underwent a restructuring such that economic activities became more dependent on energy consumption from the late 1990s to early 2000s.

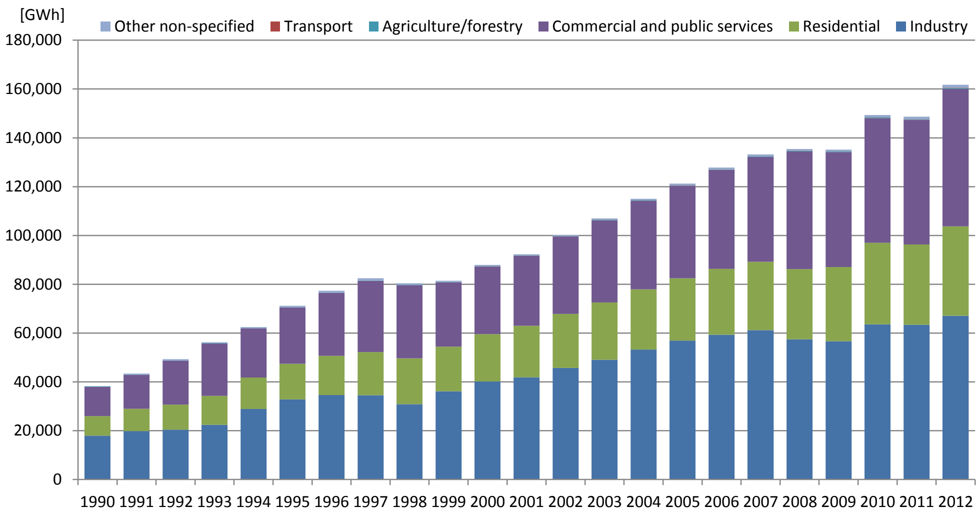
Figure 2-19. GDP and Total Final Consumption in Thailand (1990–2012)



Source: World Bank 'World Development Indicators' (data.worldbank.org); International Energy Agency's Energy Balances.

Figure 2-20 shows the electricity consumption in Thailand from 1990 to 2012. During this period, the electricity consumption rose from 38 TWh to 162 TWh, or an increase by 4.2 times (6.8 percent per year). Its growth in electricity consumption is higher than the growth of its total energy consumption (although the difference is not as conspicuous as, say, in Indonesia and Viet Nam), suggesting that the electrification of energy consumption (e.g. shifts of energy consumption from traditional modes of energy usage, such as firewood and kerosene, to electricity usage) is still ongoing.

Figure 2-20. Electricity Consumption in Thailand (1990-2012)



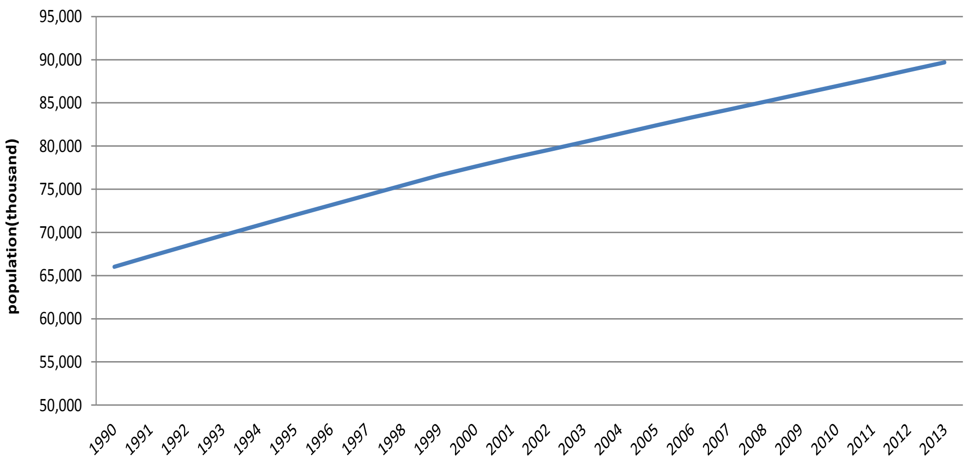
Source: International Energy Agency's Energy Balances.

(5) Viet Nam

i. Population and GDP

In 2013, Viet Nam had 90 million people (Figure 2-21). Its population has grown by 1.4 times (1.3 percent per year) since 1990, which is almost the same trend as that of Indonesia. Like Indonesia and Malaysia, Viet Nam's population growth has been almost constant since 1990.

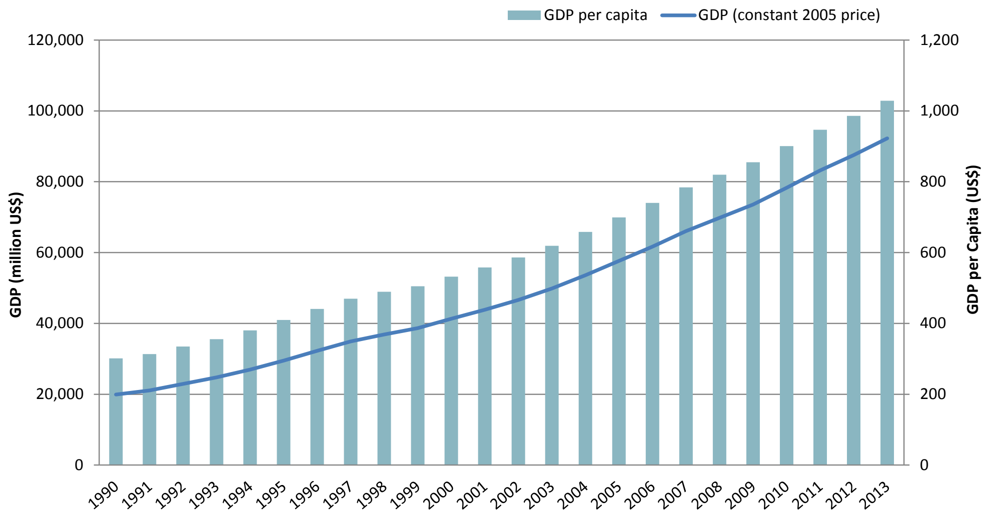
Figure2-21. Population of Viet Nam (1990–2013)



Source: World Bank, 'World Development Indicators' (data.worldbank.org).

Unlike in the other four countries, Viet Nam's economy was not significantly affected by the Asian Financial Crisis in the late 1990s nor by the Global Financial Crisis in the late 2000s. In fact, its economy has been growing steadily. From 1990 to 2013, GDP (constant at 2005 price) increased by 4.6 times (6.9 percent per year) while GDP per capita grew by 3.4 times (5.5 percent per year) (Figure 2-22). Viet Nam shows the highest GDP growth among the five countries.

Figure 2-22. GDP and GDP per Capita of Viet Nam (1990-2013, constant at 2005 price)

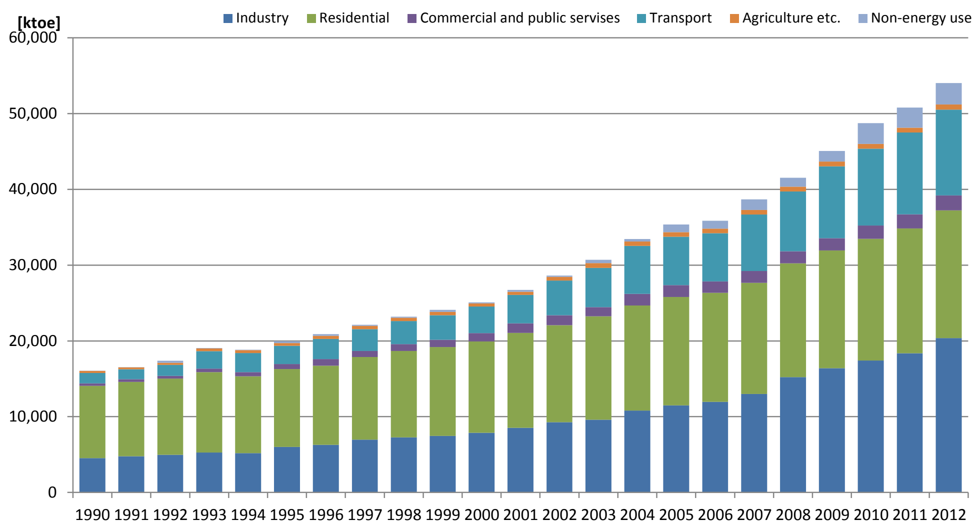


Source: World Bank, 'World Development Indicators' (data.worldbank.org).

ii. Energy Balances

In Viet Nam, the growth in national energy consumption features almost the same trend as its GDP growth. Its total final consumption of energy climbed from 16,056 ktoe in 1990 to 54,028 ktoe in 2012 (Figure 2-23). This represents a 3.43.4 times in 22 years (5.7% p.a.) from 16,056 ktoe in 1990 to 54,028 ktoe in 2012.

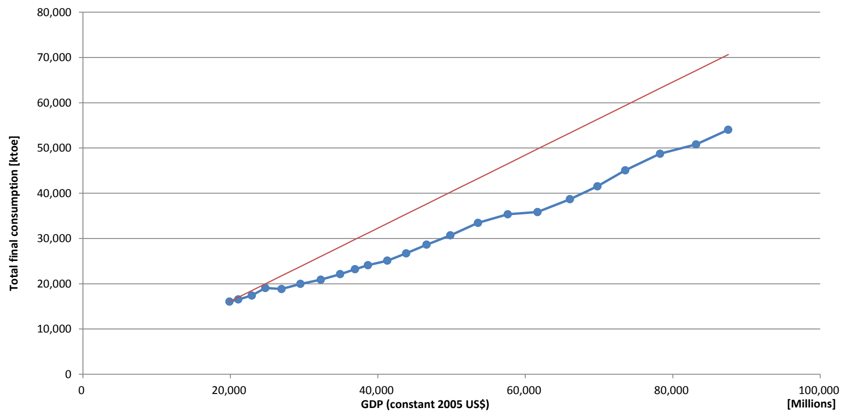
Figure 2-23. Total Final Consumption in Viet Nam (1990-2012)



Source: International Energy Agency's Energy Balances.

Figure 2-24 plots the GDP and total final consumption in Viet Nam from 1990 to 2012. The energy-GDP elasticity has been 0.7 during that period (the red line in this figure indicates that elasticity=1), which is the second lowest among the five countries. The fact that the slope has been close to 1 since the late 2000s implies that the national economy has been gradually depending on energy consumption.

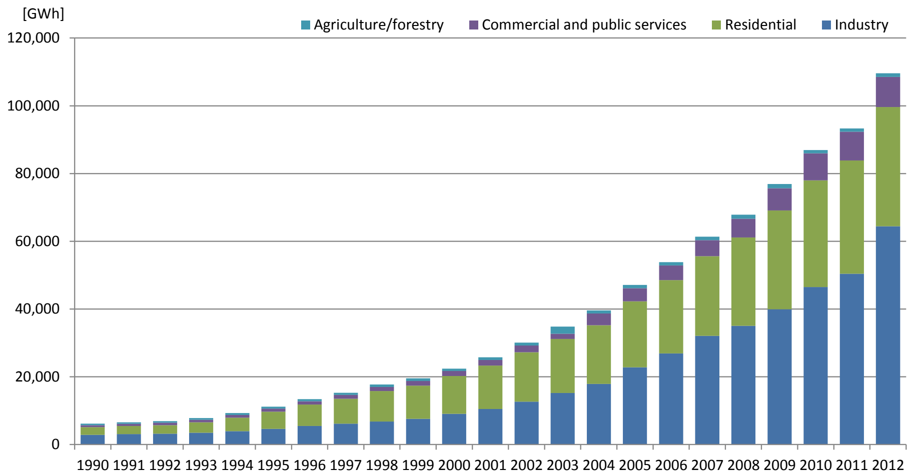
Figure 2-24. GDP and Total Final Consumption in Viet Nam (1990-2012)



Source: World Bank, 'World Development Indicators' (data.worldbank.org), International Energy Agency's Energy Balances.

Figure 2-25 shows that the electricity consumption in Viet Nam climbed from 6 TWh in 1990 to 110 TWh in 2012. This is a growth of 17.7 times (14.0 percent per year), the highest among the five countries. The exponential trend shows that the electrification of energy consumption (e.g. shifts of energy consumption from traditional modes of energy usage, such as firewood and kerosene, to electricity usage) has been moving rapidly.

Figure 2-25. Electricity Consumption in Viet Nam (1990-2012)

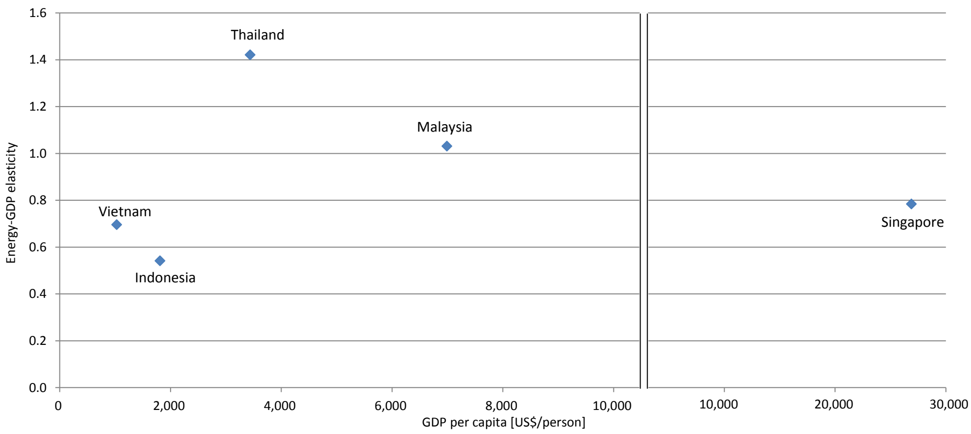


Source: International Energy Agency's Energy Balances.

(6) Summary

Figure 2-26 plots the five countries' GDP per capita as of 2012 (constant at 2005 price) and energy-GDP elasticity (from 1990 to 2012) at the horizontal and vertical axes, respectively.

Figure 2-26. GDP per Capita (2012) and Energy-GDP Elasticity of Five Countries



Source: World Bank, 'World Development Indicators' (data.worldbank.org); International Energy Agency's Energy Balances.

The figure roughly shows a reverse U-shape, which may give an indication on the correlation between the stage of economic development and energy consumption, although one cannot discount the different economic conditions existing in each country.

- In countries that are still in their early stage of economic development such as Viet Nam and Indonesia, the energy-GDP elasticity is lower than 1, indicating that the country's economic activities are not yet heavily dependent on energy consumption.
- When the country's economic development has reached a certain level, such as in the case of Thailand, the energy consumption increases rapidly. At this stage, the energy–GDP elasticity can be higher than 1.
- As a country's economic development advances, a drive toward energy efficiency may be more evident, thus lowering the energy-GDP elasticity. This may be demonstrated by changes in the economic environment (e.g. shift from heavy industries to less energy-consuming industries) and implementation of policy measures for energy efficiency.

Following such assumptions, this study recommends that countries such as Viet Nam and Indonesia should prioritise relatively basic energy efficiency measures over highly advanced but costly measures.

On the other hand, nations such as Malaysia and Singapore, where certain measures for energy efficiency are already in place, would be ready to implement highly advanced technologies for energy efficiency with certain initial costs where economically feasible.

Thailand, which falls between the above-mentioned development stages, may have to look for areas where it makes sense to implement basic measures for energy efficiency considering that it still has a high energy-GDP elasticity. Having said that, it should also start discussions on the applicability of more advanced measures.

1.2. Institutional framework related to energy efficiency

This section provides an overview of five countries' institutional framework on energy efficiency, based largely on materials provided by this study's Working Group members.

(1) Indonesia

i. Organisations on energy efficiency and conservation policy

The Ministry of Energy and Mineral Resources (MEMR) is Indonesia's administrative body for general policies on the promotion of energy conservation in collaboration with the government-owned electric utility, PT PLN.

a. Ministry of Energy and Mineral Resources

The MEMR oversees the resource and energy sectors. The Directorate General of new Renewable Energy and Energy Conservation, which was established as a unit under MEMR in 2010, is in charge of developing energy conservation-related policies and technology standards.

b. PT PLN (Persero)

PT PLN is a stock company that is 100 percent-owned by the Government of Indonesia. Indonesia's power generation sector has PLN, its subsidiary, and Independent Power Producers as key players, while the transmission and distribution sectors are exclusively under the purview of PLN. The company plans to complete its PLN Smart Grids

Road Map in 2015.

c. Others

Several government agencies are involved in the promotion of Indonesia's energy conservation. Among these agencies are the National Energy Council (Dewan Energi Nasional)—responsible for the development of general policies on energy development and utilisation—and the Ministry of Industry (MOI), which looks after the industry sector.

ii. Laws and regulations related to energy conservation

a. Government Regulation No. 70/2009 on Energy Conservation

On 16 November 2009, the government issued Governmental Regulation No. 70/2009 on Energy Conservation. This regulation mandates large energy users to implement energy management by engaging in the following activities:

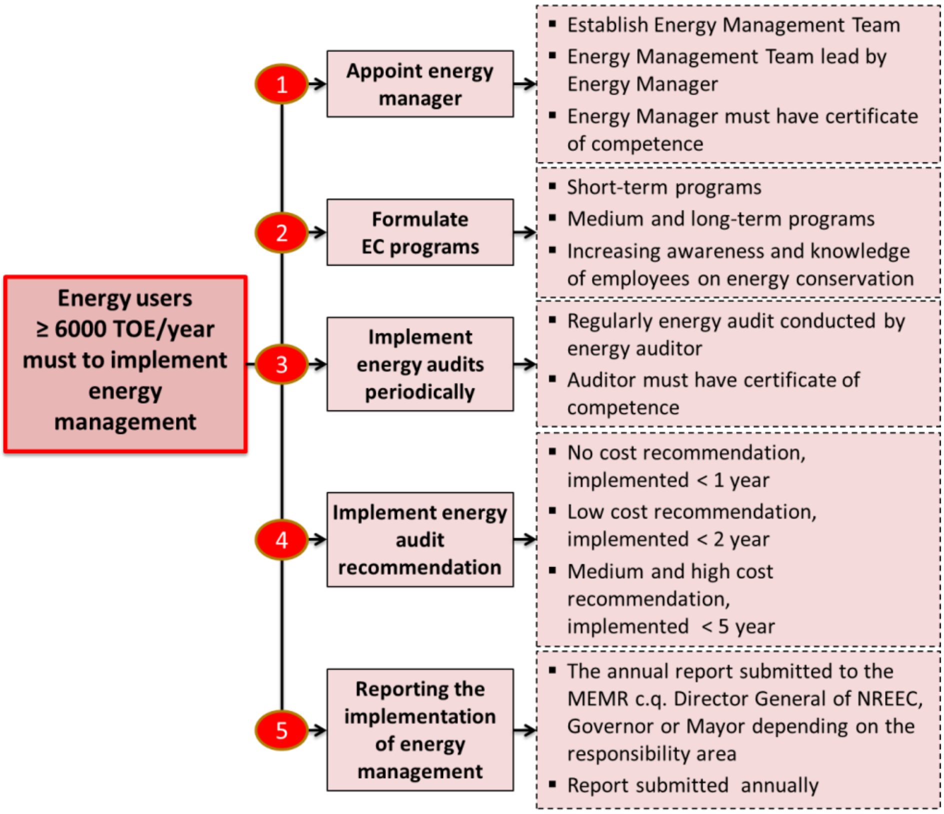
1. to nominate an energy manager,
2. to formulate energy conservation programmes,
3. to implement energy audits periodically,
4. to implement energy audit recommendations, and
5. to report on its energy conservation measures to the government.

Large energy users are users of 6,000 toe, which is equivalent to 251,400 GJ or 69,780 MWh, per year or more. Indonesia has a limited number of these large energy users, but their total energy consumption accounts for about 60 percent of the total energy use in the industrial sector.

b. MEMR Regulation No.14/2012 on Energy Management

The MEMR Regulation No. 14/2012 provides more details on the energy management implementation than the earlier governmental regulation. Figure 2-27 summarises these provisions.

Figure 2-27. MEMR Regulation No. 14/2012 on Energy Management



Source: 'Policy and Program on Energy Management System in Indonesia', Ministry of Energy and Mineral Resources, (6 March 2015).

iii. Energy conservation programme and target

a. Energy conservation programme

a) Energy management: ISO 50001 implementation in industrial sector

Indonesia's MEMR cooperates with United Nations Industrial Development Organization (UNIDO) in promoting the Energy Management Standard (ISO 50001). The objective here is to integrate energy efficiency into the corporate management system within the industrial sector through the energy optimisation and management standard, ISO 50001. The main targeted industries are textile and garments, food and beverages, paper, and chemical industries.

So far, 23 people have been certified as national experts on Energy Management Systems ISO 50001 whereas 21 candidates are awaiting certification. Eleven pilot companies have solicited help from these national experts.

b) Partnership Programme of Energy Conservation

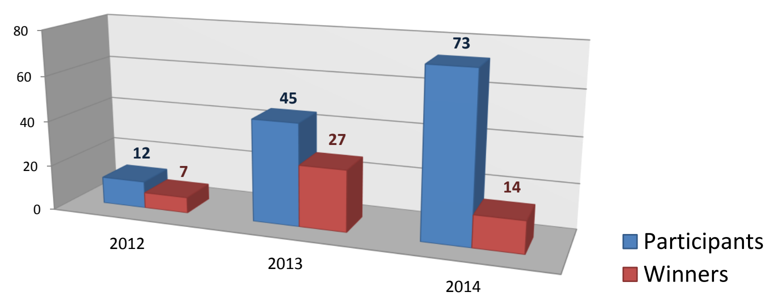
The Partnership Programme on Energy Conservation is a government-funded energy audit service conducted by MEMR on industries and commercial buildings. From 2003 to 2014, MEMR had audited 805 industries and 469 buildings.

According to MEMR, the total potential savings as of 2012 was 1,532 GWh, whereas the total energy savings achieved was only 46 GWh because only energy saving measures with no cost or low cost have been preferred by the industries audited. The programme thus hopes to develop more medium- and high-cost alternatives to achieving greater energy savings with the support of the government. At present, some of the measures recommended in this programme have not been implemented due to limited financial resources.

c) Increasing public awareness

To promote best practices, a National Energy Efficiency Award is given to government institutions and stakeholders in industrial and building sectors that succeed to apply energy efficiency and conservation measures. The award intends to share good practices.

Figure 2-28. Participants and Winners of National Energy Efficiency Award



Source: 'Policy and Program on Energy Management System in Indonesia', Ministry of Energy and Mineral Resources (6 March 2015).

d) Energy management online report (POME)

To facilitate the mandatory reporting of large energy consumers, MEMR developed a Web-based energy management reporting system that goes by the acronym, POME (http://aplikasi.ebtke.esdm.go.id/pome).

e) Minimum energy performance standards and labelling

The Standard and Labelling programme was launched for compact florescent lamps in 2011. Meanwhile, the Minimum Energy Performance Standards for electric household appliances such as air conditioning systems, refrigerators, electric motors, rice cookers, electric irons, etc. were also introduced.

f) Development of smart street lighting

The MEMR develops standards for street lighting systems and guidelines for implementing energy-efficient technology in street lighting. The smart street lighting was implemented in Makasar, Solo, Semarang, Batang, Tulung Agung, and Magetan.

g) Human resource development

Through government-led programmes, 131 energy managers and 76 energy auditors were certified.

b. Target of energy conservation

The objectives of Indonesia's National Energy Conservation Master Plan in 2025 are:

- ✓ To reduce energy intensity by 1 percent per year in all sectors
- ✓ To attain an energy elasticity of less than 1 in year 2025
- ✓ To reduce the final energy consumption by 17 percent

Meanwhile, Table 2-1 lists the energy-saving potentials and sectorial targets in 2025.

Table 2-1. Potential Energy Savings, Indonesia*

Sector	Energy Consumption per Sector Year 2013 (million BOE)	Potential of Energy Conservation, %	Target of Energy Conservation Sectorial (2025), %
Industry	353 (42.4%)	10–30	17
Transportation	323 (38.8%)	15–35	20
Household	99 (11.9%)	15–30	15
Commercial	35 (4.2%)	10–30	15
Others (Agriculture, Construction, and Mining)	23 (2.8%)	25	-

*Note: Based on Handbook of Energy & Economic Statistics of Indonesia 2013. Excludes biomass and non-energy used.

Source: 'Policy and Program on Energy Management System in Indonesia', Ministry of Energy and Mineral Resources (6 March 2015). (Original source: Draft National Energy Conservation Master Plan (RIKEN) 2011).

iv. Status of deploying EMS

According to PLN, projects that promote the application of the energy management system have been carried out in its regional offices such as in Jakarta, Suralaya-Banten, and

Malang-East Java. In addition, PLN cooperates with the New Energy and Industrial Technology Development Organization (NEDO) a unit of the Ministry of Economy, Trade and Industry of Japan, to implement energy efficiency programmes, including the deployment of the BEMS and Factory Energy Management System.

(2) Malaysia

i.Organisations on energy efficiency and conservation policy

In Malaysia, the main government agency responsible for energy efficiency policies is the Ministry of Energy, Green Technology and Water (MEGTW). The Energy Commission and the energy sub-unit of the Economic Planning Unit under the Prime Minister’s Office also support the country’s energy efficiency programmes.

a. *Ministry of Energy, Green Technology and Water*

The MEGTW, also known as KeTTHA (Kementerian Tenaga, Teknologi Hijau dan Air) in Malay, was established in 2009 as a result of the reshuffle and restructuring of ministries. It succeeded the former Ministry of Energy, Water and Communications (MEWC). The ministry acknowledges that there are now new functions and responsibilities for planning as well as policies and programme formulation to address evolving global issues such as environmental pollution, ozone depletion, and global warming. The MEGTW is responsible for defining efficiency standards, and setting and implementing efficiency requirements.

b. Energy Commission

According to Malaysia’s Energy Commission Act 2001, the Energy Commission was established to replace the Department of Electricity and Gas Supply. It is the entity that issues the certificate of approval on standards and labelling schemes.

ii.Laws and regulations related to energy conservation

The legal framework for Malaysia’s energy efficiency is summarised as follows:

a. Electricity Supply (Amendment) 2001 - Act A1116

This act empowers the Minister to promote the efficient use of electricity, such as by determining efficiency standards and installing equipment to meet efficiency requirements.

b. Efficient Management of Electrical Energy Regulations 2008

Under this regulation, users consuming 3 million kWh or more over a six-month period must commission a registered energy manager to analyse their total consumption of electrical energy, advise them on how to efficiently manage their electrical energy and monitor the effectiveness of the implemented measures.

c. Amendment of Electrical Supply Regulations 1994 (Gazetted in May 2013)

On 3 May 2013, the MEGTW gazetted the amendment of the 1994 Electricity Regulations. Such amendment enabled the enforcement of the MEPS on electrical appliances and lighting equipment (incandescent, compact florescent lamps, and light emitting diodes or LEDs).

MS1525: Code of Practice for Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings

Under this code, the energy efficiency requirements were incorporated in the Uniform Building By-laws (UBBL). According to the UBBL's, all non-residential buildings must comply with the UBBL's energy efficiency requirements, which allows for integration of renewable energy systems and energy saving features in buildings. This was introduced in 2001 and updated in 2008.

iii. Energy conservation programme and target

a.Energy conservation programme

a) SAVE Programme

The SAVE programme was launched on July 2011, with two main objectives:

- to increase the total number of energy-efficient electrical equipment, five-star and energy efficient appliances on the market; and
- to increase public awareness on the need to choose energy-efficient equipment to reduce the use of electricity.

Through this programme, purchase of refrigerators, air conditioning systems, and energy efficient chillers is entitled to a cash rebate of MYR100–200 per refrigeration tonne. The programme has successfully reduced domestic electricity consumption by 158.1 GWh per year—or equal to the electricity bill savings of MYR34.4 million. Overall, the reduction in the emission of carbon dioxide (CO2) through this programme is approximately 167,568,689 tonnes.

Figure 2-29. Rebate in SAVE Programme

Source: 'Energy Efficiency in Malaysia' Ministry of Energy, Green Technology and Water, (6 March 2015).

b) Standards and labelling

Under the Electricity (Amendment) Regulations 2013, the Minimum Energy Performance Standards (MEPS) was introduced. The programme sets MEPS for energy-consuming equipment sold in the market. In March 2015, it was introduced for five appliances, namely, refrigerators, air-conditioners, television sets, fans, and lightings (fluorescent, compact florescent lamps, LED, and incandescent). Based on energy efficiency of each appliance, a star rating from one to five is given (the rating is given so that three-star rating would be the average). MEPS requires a minimum rating of two stars. It also mandates that the four out of the five appliances covered (i.e. except for lighting) be affixed with an energy-rating label known as star ratings label. For the lighting products, the efficiency value is required to be shown on the product's package or box. The Energy Commission issues a Certificate of Approval for these products.

c) Energy efficiency in government buildings

To drive energy efficiency practices, MEGTW has identified 105 government buildings exceeding 3,000,000 kWh and conducted energy efficiency programmes over a period of six consecutive months. As a result, 12 buildings in Putrajaya achieved a 10 percent reduction, and 93 buildings achieved a 1.5 percent reduction.

The MEGTW was also tasked to monitor the electricity usage in 25 government buildings in Putrajaya and outside Putrajaya. Until Dec 2014, these 25 government buildings managed to save 5.6 percent of their total electricity consumption as compared to their usage in 2013.

In 2014, energy audit was done for three government buildings, and retrofitting was done in two audited government buildings.

The Energy Performance Contracting initiative was started in January 2013 to promote energy efficiency in government buildings. It is an initiative to overcome capital cost barriers in implementing energy efficiency measures. The cost of investments in energy efficiency improvements would be covered by the Energy Service Company (ESCO), while the owner of government buildings would be required to reimburse ESCOs for the cost of investments from the savings made.

d) Incentives for energy efficiency

Owners of buildings with Green Building Index (GBI) Certificate are eligible for a tax exemption equivalent to 100 percent of the additional capital spent to be GBI certified. Also, those who purchase the GBI-certified buildings and residential properties from developers are eligible for stamp duty exemption on instruments for the transfer of ownership of such buildings. The amount of the stamp duty exemption is on the additional cost incurred to obtain a GBI certificate. This exemption is given only once to the first owner of the building.

b.Target of energy conservation

The target value on energy conservation is not yet set.

iv. Status of deploying EMS

Government buildings in Putrajaya have been installed with a Building Control System (BCS) and BEMS. These systems allow buildings' energy consumption from cooling systems, lighting equipment and others to be monitored and controlled. Continuous monitoring and optimisation of energy performance vis-a-vis human comfort parameters resulted in a significant energy reduction.

HEMS is relatively new and focused only on high-end urban residences. A few pilot projects on smart metering and smart grid were commenced in selected areas in March 2015.

(3) Singapore

i.Organizations on energy efficiency and conservation policy

In Singapore, a multi-agency committee called the Energy Efficiency Programme

Office was formed to promote energy conservation. The office is jointly managed by the National Environmental Agency, an affiliate of the Ministry of the Environment and Water Resources, as the lead manager, and the Energy Market Authority, an unit of the Ministry of Trade and Industry, as co-manager.

To promote energy saving among industry, residential and transportation sectors, the Energy Efficiency Programme Office is engaged in raising consciousness in energy-saving, training of experts, promotion of technological development, management of regional bases, etc.

Government agencies responsible for energy saving programmes are shown in Figure 2-30.

Figure 2-30. Holistic Approach to Implementing Mitigation Measures, Singapore

Source: 'Energy Efficiency in Singapore', National Environmental Agency, (6 March 2015).

ii. Laws and regulations related to energy conservation

a.Energy Conservation Act

Singapore's Energy Conservation Act, which took effect in April 2013, requires large energy users in the industry sector to implement mandatory energy management practices. Large energy users are those corporations that meet the following qualifications:

- Annual energy consumption ≥ 54 TJ /year
- The business activity is attributable to one of the following sectors:
- Manufacturing and manufacturing-related services
- Supply of electricity, gas, steam, compressed air, and chilled water
- Water supply, and sewage and waste management

These large energy users must appoint an energy manager to monitor and report energy use and greenhouse gas emissions, and to submit energy efficiency improvement plans annually.

b. Building Control (Environmental Sustainability) Regulations 2008

The Building Control (Environmental Sustainability) Regulations 2008 sets out a minimum environmental sustainability standard equivalent to the Building and Construction Authority's Green Mark certification for new buildings and existing ones that undergo major retrofitting.

c. Building Control Regulations 2013 (Environmental Sustainability Measure for Existing Buildings)

Under the Building Control Regulations 2013, building owners are required to submit building information and energy consumption data as well as periodic energy efficiency audits of building cooling systems, and to comply with the minimum environmental sustainability standard (Green Mark Standard) for existing buildings.

iii.Energy conservation programme and target

a.Energy conservation programme

a) Green Mark Certification

The Green Mark Scheme of the Building and Construction Authority was launched in 2005. It is a benchmarking scheme that incorporates internationally recognised best practices in environmental design and performance.

The minimum environmental sustainability standard (Green Mark-Certified Level) is required for new buildings with an area of at least 2,000 m2, and existing buildings consisting of hotels, retail businesses, or offices with an area of 15,000 m2 or more when the building cooling system is installed or replaced.

b) Green Mark Incentive Schemes

Once higher-tier Green Mark levels are achieved, developers can build an additional floor area. If significant improvement in energy efficiency is achieved by retrofits, owners of existing buildings are eligible for grants to undertake retrofits. The government provides building owners and tenants with grants to undertake energy improvement works that involve the installation of energy-efficient equipment.

As to design prototypes, the government provides developers and building owners with grants to focus their effort on the design stage to attain higher energy efficiency levels beyond Green Mark Platinum standards.

The scheme called the Building Retrofit Energy Efficiency Financing provides loans to building owners and energy services companies wanting to carry out energy retrofits.

c) Minimum Energy Performance Standards

Minimum energy-efficiency standards improve the average efficiency of household appliances such as air conditioners, refrigerators, and clothes dryers.

d) Mandatory Energy Labelling Scheme

The Mandatory Energy Labelling Scheme allows consumers to compare energy efficiency performance and lifecycle costs of different appliance models for the consumers to make informed purchasing decisions. It covers air conditioners, refrigerators, clothes dryers, and television sets.

b.Target of energy conservation

The greenhouse gas emission in BAU (business-as-usual) level is expected to reach 77.2 MT in 2020. Thus, the target is to reduce emissions by 7 percent to 11 percent below 2020 BAU levels. Key mitigation measures are energy efficiency and fuel switching.

iv.Status of deploying EMS

a.Industry sector

Most industrial companies are not equipped with any Energy Management Information System[3]. Costs and benefits are not yet clear. Such is the case because advanced modules require software and consultancy, which doubles the cost of implementation. This can be addressed by a variety of policy tools such as legislative acts, incentives, demonstration projects, activities that raise awareness, and training.

b.Buildings sector

The Energy Innovation Research Programme, administered by the Building and Construction Authority, invests SG$15 million to support research in two areas, namely, Building Management and Information Systems, and air conditioning and mechanical ventilation.

[3] Based on National Environmental Agency's industry consultations from March to June 2012 with companies under Energy Conservation Act.

Eight projects were awarded in June 2014. Examples of Building Management and Information Systems are ‘Intelligent Information Management System for Smart Buildings Using MultiAgent-enabled Wireless Sensor-Actuator Networks’ and ‘Optimized Energy Measurement and Verification Protocol for Existing Buildings’.

Some BEMSs have been implemented in public-sector buildings. For example, JTC (Jurong Town Corporation) Summit piloted the Integrated Estate Management System in 2014. Fusionopolis (120,000 m2) has 18,000 data points on its 2,500 pieces of equipment. The electricity savings by 15 percent were achieved within six months of implementation. The Fault Detection-and-Diagnosis algorithm was used. Inefficient equipment or systems were identified and resolutions were explored.

c.Households sector

The HEMS can help households manage energy use, but its deployment is still at a pilot stage. Singaporean authorities opt to test the effectiveness of HEMS through trials under local conditions before they proceed to deploy. How the population interacts with HEMS, its ability to nudgeusers’ energy-efficient behaviour, and the cost of HEMS vis-a-vis electricity savings are some factors to consider when planning to introduce HEMS. As one objective of HEMS is to visualize energy consumption and induce behaviour changes, its features such as display, automation, and feedback shall be also considered.

(4) Thailand

i.Organisations on energy efficiency and conservation policy

The principal organisation in charge of energy saving policies in Thailand is the Department of Alternative Energy Development and Efficiency (DEDE), a unit of the Ministry of Energy (MOE). The Energy Policy and Planning Office, another affiliate agency of the MOE, supports the energy efficiency programmes as part of the country’s energy policies. In addition, the Thailand Industrial Standard Institute serves as the regulator of the Minimum Energy Performance Standards, while the Electricity Generating Authority of Thailand shares responsibility with DEDE for the labelling scheme of the High-Energy Performance Standards.

a.Department of Alternative Energy Development and Efficiency

Formerly called the National Energy Authority, DEDE was established in 1953 under the National Energy Authority Act, and acquired its current name by virtue of the Ministry of Energy's Government Administrative Act B.E. 2545 (2002).

Under the Act on Administrative Organisation of State Affairs, DEDE is responsible for energy efficiency promotion, energy conservation regulation, energy sources provision, alternative development of integrated energy uses, and energy technology dissemination.

b. Energy Policy and Planning Office

Thailand's Energy Policy and Planning Office is in charge of energy policies and planning and engaged in the promotion of energy savings and use of alternative energy; preparation of short- and long-term measures to solve oil shortage; supervision and assessment of the effectiveness of national energy policy and energy management plans, etc.

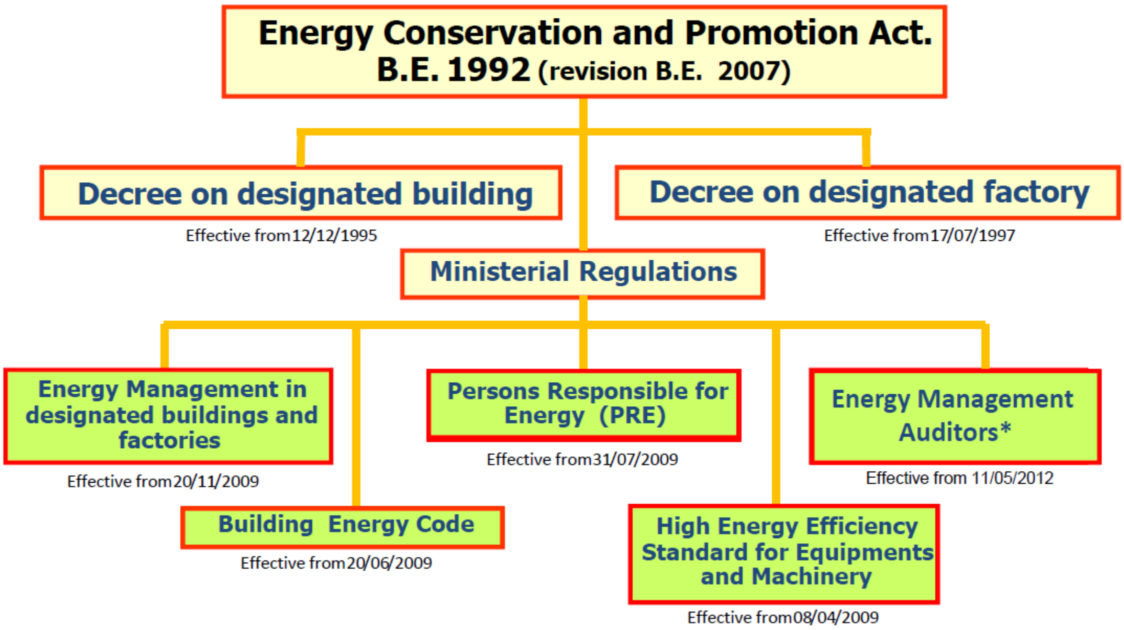
ii.Laws and regulations related to energy conservation

a.Energy Conservation and Promotion Act. (B.E. 1992 (Revision B.E. 2007))

The Energy Conservation and Promotion Act came into effect on 2 April 1992. That year, the act focused on engineering solutions and paid little attention on the value of people. In 2007, the act was revised to introduce EMS and systematic approach of energy conservation.

Figure 2-31 presents the energy efficiency laws and regulations in Thailand.

Figure 2-31. Energy Efficiency Law and Regulations in Thailand



Source: 'Energy Policy and Energy Efficiency in Thailand', Department of Alternative Energy Development and Efficiency, (6 March 2015).

iii. Energy conservation programme and target

a.Energy conservation programme

a) Designated building and factory

Large energy users are designated to implement energy management programmes and appoint a 'person responsible for energy'. The designated facilities (factory/building) are those with electricity demand of 1,000 kW or more, or transformers of 1,175 kVA or more, or energy consumption of 20 million MJ/year or more. In March 2015, 8,700 factories and buildings were identified. The number of persons responsible for energy (i.e. energy managers) to be appointed is shown in Table 2-2.

Table 2-2. Number of Energy Managers

Type	Designated Factory/Building	
Electricity demand	1,000 kW - 3,000 kW	≥ 3,000 kW
Transformer size	1,175 KVA - 3,530 KVA	≥ 3,530 KVA
Energy used	20 million - 60 million MJ/year	≥ 60 million MJ/year
Number of Energy Manager	1	2 Where at least one is senior

Source: 'Energy Policy and Energy Efficiency in Thailand', Department of Alternative Energy Development and Efficiency, (6 March 2015).

Capacity building programmes, such as trainings and seminars, were completed in 200 factories/buildings. Compliance with ISO 50001 is recommended as a voluntary programme for designated facilities. Selected for the actual implementation of ISO 50001 were 50 pilot facilities.

b) Building Energy Code

New or retrofitted buildings with total area of 2,000 m2 or more must be designed to comply with the Building Energy Code. The Building Code has stipulations on the building envelope, lighting system, air-conditioning system, hot water generating system, renewable energy utilisation, and whole building performance.

c) Standard and labelling

The energy standards and labelling framework consists of the MEPS and the High-Energy Performance Standards (HEPS). The MEPS covers both voluntary and mandatory programmes. It is jointly managed by DEDE and Thailand Industrial Standard Institute. Standards are set up by DEDE but regulated by Thailand Industrial Standard Institute. HEPS is a voluntary programme. Its standards are set up by DEDE, whereas labelling programmes are the responsibility of both DEDE and Electricity Generating Authority of Thailand.

d) Financial incentives

When implementing energy efficiency measures, 20 percent of capital investments for highly efficient equipment/machineries valued from THB50,000 up to THB3 million is through direct subsidy. Subsidies support the installation of machineries under the 11

DEDE standard measures (such as those covering LED, voltage regulators, etc.) and the installation of 12 advanced technologies (such as absorption chillers and other approved technologies). Besides subsidies support, ESCO fund, tax incentive, and soft loan are provided. Subsidies support the installation of machineries under the 11 DEDE Standard Measures (such as those covering LED, voltage regulators, etc.) and the installation of 12 advanced technologies (such as absorption chiller and other approved technologies). Besides subsidies support, ESCO fund, tax incentive, and soft loan are provided.

e) Social / awareness raising

Some recognition programmes such as the Thailand Energy Awards, ASEAN Energy Awards, and School Energy Conservation Competitions have been implemented. Mass media—TV, radio, internet, newspaper, magazines, etc.—are utilised to effectively promote the awareness programmes.

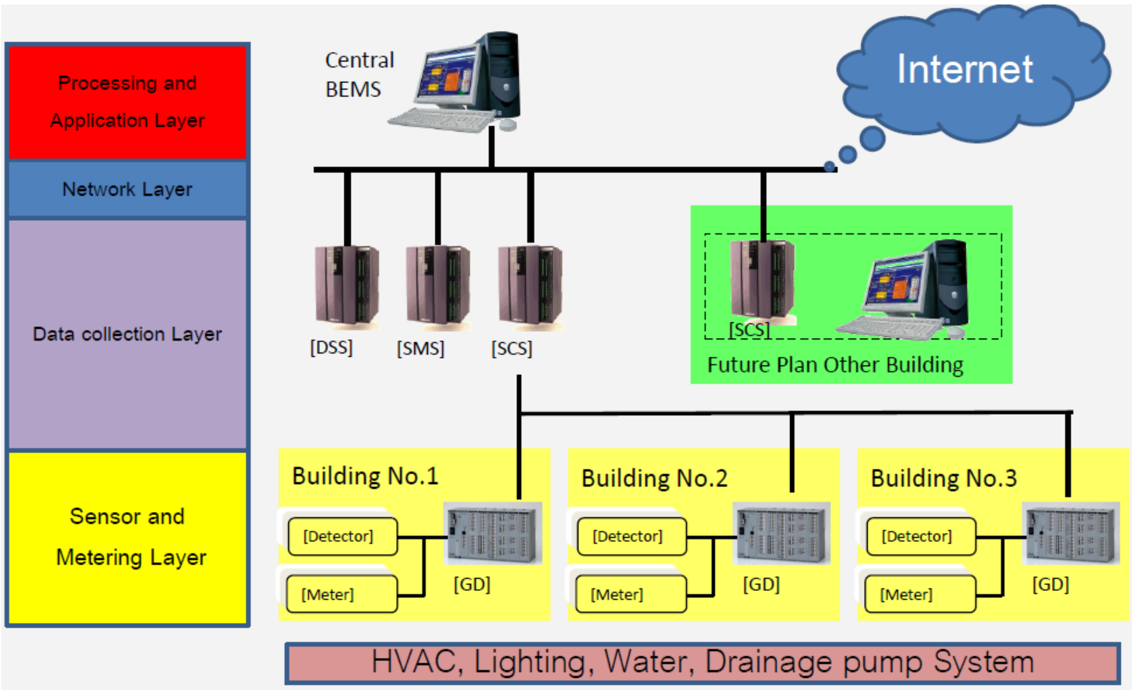
b.Target of energy conservation

As of 23 August 2011, the government policy aimed to reduce Thailand's energy intensity by 25 percent within 20 years. The final energy consumption in 2030 was expected to be reduced by at least 38,200 ktoe. In the draft version of the new Energy Efficiency Plan (2015-2036), the final energy consumption in 2036 is expected to be reduced by at least 57,400 ktoe, while a 30 percent reduction in energy intensity is targeted.

iv. Status of deploying EMS

Electric power utilities have initiated several projects to promote EMS. Metropolitan Electricity Authority (MEA), the power distribution utility covering Metropolitan Bangkok, completed the pilot phase of a smart energy building project in 2010. Its aim here is to implement a BEMS in MEA offices and later, to expand the system to offices of business customers. The project was deployed from 2012 to 2016. In addition, a telecommunication networking among district offices has been established as an energy management network.

Figure2-32. BEMS System Structure in Metropolitan Electricity Authority



Source: 'MEA's EE Promotion and EMS system', Metropolitan Electricity Authority (6 March 2015).

(5) Viet Nam

i.Organisations on energy efficiency and conservation policy

Viet Nam's Ministry of Industry and Trade (MOIT) organises the energy saving policies and supervises the implementation of the Viet Nam National Energy Efficiency Program (VNEEP). The Institute of Energy—a unit of MOIT—and the Electricity Regulatory Authority of Viet Nam (ERAV) are also engaged in energy conservation.

a.Ministry of Industry and Trade (MOIT)

The MOIT was established in 2007 to integrate overlapping authorities and promote Viet Nam's development as an industrial nation thereby strengthening the response to rapid economic growth and internationalization. Toward this end, MOIT took over the responsibilities from its predecessor, the Ministry of Industry, and is now in charge of the management of the electric power and energy sector. According to the Government's Decree No. 36/2012/NĐ-CP, MOIT's responsibilities over electricity, new energy, renewable energy, and energy saving and efficiency are:

a) to approve and manage the execution of provincial/municipal electricity development plans; to publicise lists of electricity works in development plans and to call for investments;

b) to approve cascade hydropower, new energy and renewable energy plans;

c) to perform tasks related to nuclear power, new energy, and renewable energy in accordance with existing laws;

d) to perform tasks related to electricity regulation in accordance with laws;

e) to manage energy saving and efficiency efforts in fields under its purview.

In 2011, the General Department of Energy was formed within MOIT, and the Energy Conservation Office was established.

b. Institute of Energy

Institute of Energy, which is under the jurisdiction and management by MOIT, is responsible for drafting the plan on energy policies, formulating an electric power development plan on the national and regional levels as well as the researching on power equipment, energy savings and new energy, etc.

ii.Laws and regulations related to energy conservation

Law No. 50/2010/QH12 (dated 17 June 2010) is a fundamental law on energy efficiency and conservation. Viet Nam’s legal framework for energy efficiency is summarised in Table 2-3.

Table 2-3. Legal Framework on Energy Conservation in Viet Nam

Name	Date	Issuer	Outline
Law No. 50/2010/QH12 (EE&C Law)	17 June 2010	The National Assembly	On Energy Efficiency and Conservation
Decree No. 21/2011/ND-CP	29 March 2011	The Government	Stipulates detailed requirements and measures to execute the EE&C* Law
Decree No. 134/2013/ND-CP	17 October 2013	The Government	Stipulates the sanctioning of administrative violations in the power sector, dam security, and EE&C
Decision No. 79/2006/QĐ-TTg	14 April 2006	The Prime Minister	National Target Programme on EE&C
Decision No. 1427/QĐ-TTg	2 October 2012	The Prime Minister	National Target Programme on EE&C in year 2012-2015
Decision No. 51/2011/QD-TTg	12 September 2011	The Prime Minister	List of devices and equipment that must have energy labels
Decision No. 03/2013/QD-TTg	14 January 2013	The Prime Minister	Amendment and supplementation of some articles of Decision 51/2011/QD-TTg
Decision No. 68/2011/QD-TTg	12 December 2011	The Prime Minister	List of energy-saving devices that may be purchased by agencies funded by the state
Circular No. 39/2011/TT-BCT	18 October 2011	MOIT	Training, awarding certificates on energy management and energy auditor
Circular No. 07/2012/TT-BCT	04 April 2012	MOIT	Energy labelling for energy consuming devices and equipment
Circular No. 09/2012/TT-BCT	20 April 2012	MOIT	Planning for EE&C and implementation of energy audits
Circular No. 02/2014/TT-BCT	16 January 2014	MOIT	Stipulates EE&C measures in industrial sector

* Note: EE&C – Energy Efficiency and Conservation.
Source: Compiled from 'Energy Efficiency & Conservation in Viet Nam', Viet Nam Electricity, (6 March 2015).

iii. Energy conservation programme and target

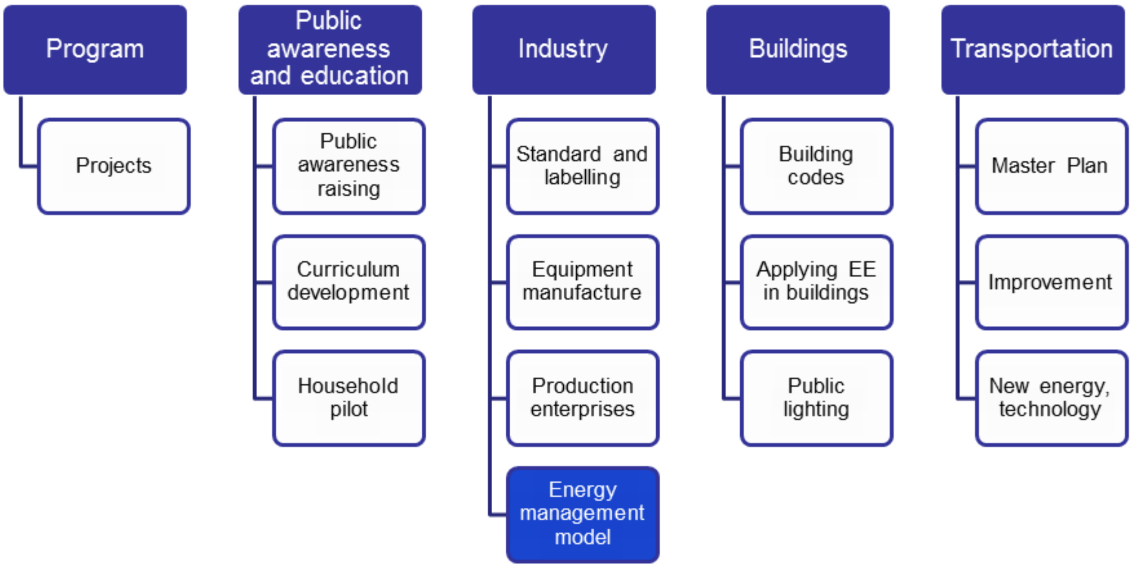
a.Energy conservation programme

a) Vietnam Energy Efficiency Program

The VNEEP is a 10-year programme approved in April 2006. It aims to achieve energy savings of 3 percent to 5 percent of the total energy consumption during the period 2006–2010 and 5 percent to 8 percent during the period 2011-2015 compared with the forecasted base case of energy demand as of 2006. The VNEEP identified 6 components and 11 projects to achieve these targets.

The VNEEP is now in its second five-year phase (2011–2015). It consists of 4 program groups and 13 projects (Figure 2-33).

Figure 2-33. VNEEP Programme Groups and Projects (Phase II)



Source: 'Current Energy Situation in Viet Nam' Institute of Energy, (6 March 2015). (Original Source: Decision No. 1427/QD-TTg)

b.Energy conservation target

The energy savings targets of 3 percent to 5 percent for 2006–2010 and 5 percent to 8 percent for 2011-2015 compared with the total energy consumption forecasted in 2006 are set in VNEEP's National Program on Energy Efficiency and Conservation (EE&C).

iv. Status of deploying EMS

No pilot project on EMS deployment has been made.

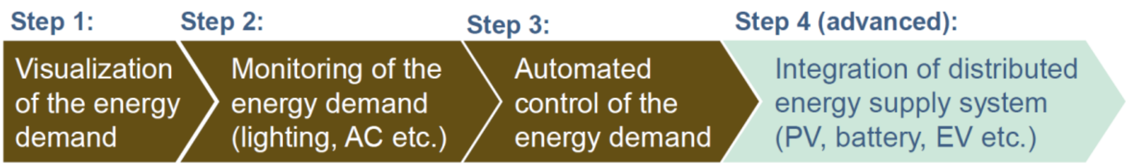
2. Basic Functions and Benefits of xEMS Technologies

2.1. Overview of xEMS technologies

Basic and common functions of xEMS technologies are described in four development steps.

The first step is to visualise the energy demand by using meters or monitors. Based on previous research, a reduction of 8 percent to 10 percent can be expected when the attitude of consumers regarding energy use, especially towards lighting and power outlets[4], changes. The second step is to monitor the energy demand by using information and communication technologies. Here, 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. Third step is to control the energy demand automatically by communication. Conceptually, both consumers' 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'. The final step is to integrate the distributed energy supply systems (e.g. photovoltaics, energy storage, electric vehicles, etc.).

Figure 2-34. Development Stages of xEMS



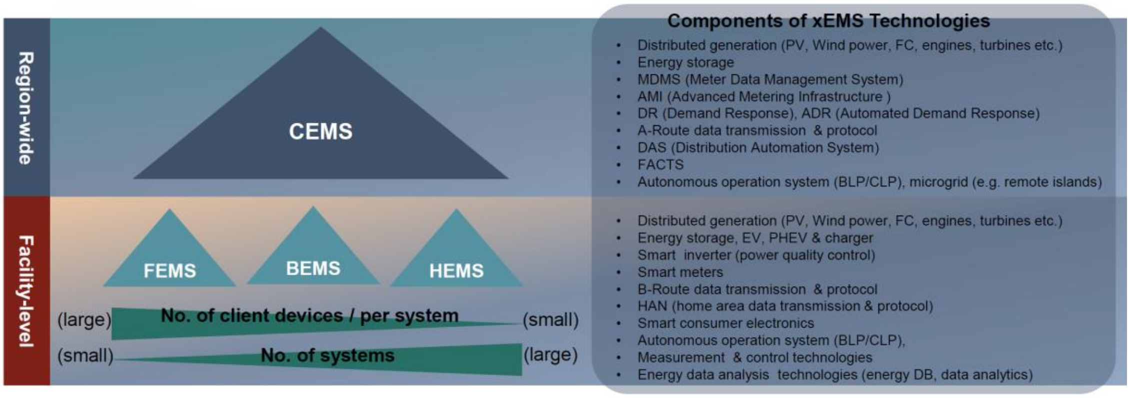
Source: Authors.

The development of xEMS technologies started with large energy consumers. Interests over the benefits emanating from energy management systems in factories and buildings are easy to coordinate due to the small number of stakeholders. Recently, xEMS for residential use (i.e. HEMS) has become available, driven by the development of smart consumer electronics. Furthermore, the concept of CEMS, which integrates the facility-level

[4] Evaluation and Relation Program, 'Visualization of Emission Gas – Effect of Electricity Consumption Reduction by Visualization in the Office – Case of Okamura Corporation' by Ministry of Environment, Japan (2011). From http://www.env.go.jp/council/37ghg-mieruka/r372-01/mat01.pdf [As of August 2015].

EMS into the community-level energy management, has been studied.

Figure 2-35. Components of xEMS Technologies



Source: Authors.

2.2. Overview of energy efficiency measures for office buildings

As discussed earlier, there are several modes of implementing xEMS technologies in EAS countries. Following the Working Group's meeting in March 2015 in Jakarta, members agreed that the first year of the study shall focus on the viability of implementing EMS for office buildings (i.e. BEMS) in EAS countries. Energy efficiency in office buildings is a common challenge in all five countries.

Building owners generally aim to maximise their economic benefit against the cost of investments. However, the internal rate-of-return (IRR) for any BEMS deployment in EAS countries and the related energy-efficiency numbers are apt to be lower than the required hurdle rate for investment; hence, most owners are reluctant to decide on the costly investment.

It is, therefore, important to identify the cost and benefit as quantitatively as possible through case studies to get a realistic picture of the impact of such activities on energy efficiency.

There are many ways to attain energy efficiency, ranging from simple change of attitudes towards energy use, to adoption of state-of-the-art technologies. Therefore, this study first made a long list of these energy-efficiency measures, and then discussed how the list was trimmed down to the choice measures based on the suggestion of the Working Group members, technical experts, manufacturers, building owners, etc.

In this section, the discussed energy efficiency measures are classified into three types: (1) Manner and attitude; (2) Optimisation of existing facilities operation; and (3)

Investment in highly efficient technologies. Those categorised in (1) are the simplest measures with low cost of implementation. Those categorised in (2) are also relatively low-cost measures compared to (3) but some technical experiences are needed compared to those in type (1). Those categorised in (3) are generally the most advanced but require a certain initial amount of investment.

(1) Manner and attitude

i. Adjusting room temperature settings

Energy is saved by adjusting room temperature settings appropriately. In Japan, the government recommends the temperature setting at 28°C in the summer, 20°C during winter. Raising the temperature setting of air conditioners helps to reduce electricity consumption.

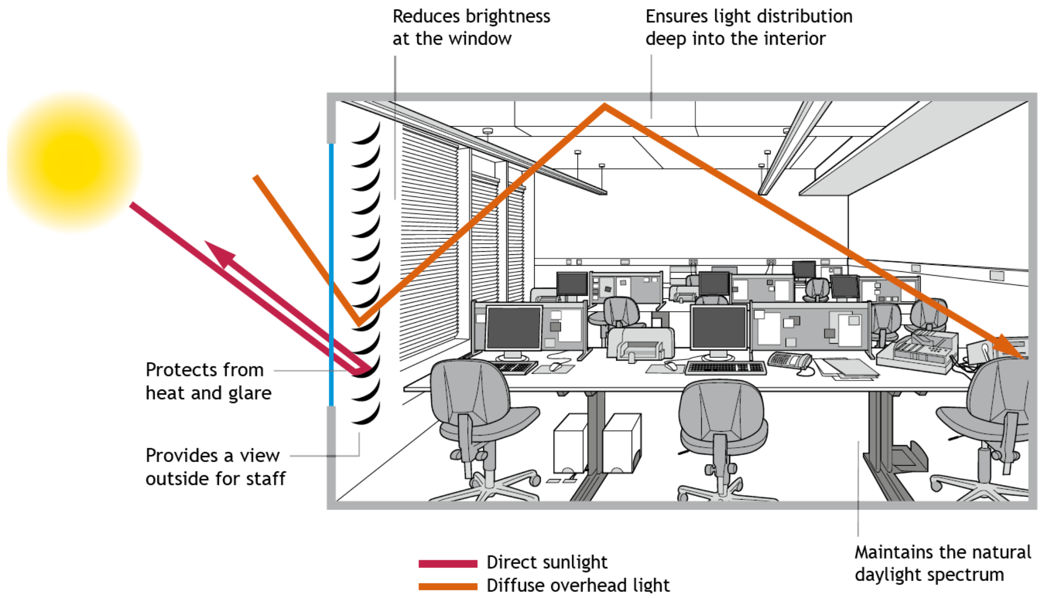
ii. Switching off lights during lunch break

Lighting accounts for a significant part of the energy used in office buildings. Accordingly, a lot of energy can be saved also by improving employees' energy conservation awareness. One of the ways to save is to turn off lightings in offices during lunch break.

iii. Using window shades to reduce solar radiation load

Covering office windows with blinds/curtains or screens can reduce solar radiation. Awnings to shade windows also help. In addition, window blinds on the east side of the building are closed at the end of business hours to reduce solar load in the next morning.

Figure 2-36. Using Window Shades to Reduce Solar Radiation Load



Source: 'Office-based Companies', The Carbon Trust (2010).

iv. Controlling lighting block-by-block

To reduce energy waste, lighting fixtures in unused areas are turned off. When rendering overtime work, employees should turn on those lightings only in the space where they continue to work.

v. Controlling air conditioning system block-by-block

A person sitting near the window may feel warm during the summer, while those far from the window may feel cold. To improve occupants' comfort and save on energy, the air conditioning system in offices must be one that can be controlled in blocks so that rooms or spaces are heated or cooled independent of each other.

vi. Switching off air conditioners in unused rooms/off-working hours

Air conditioners should be switched off in rooms where there are no workers (i.e. vacant room, at night, during weekends and holidays).

(2) Optimisation of existing facilities' operation

i. Adjusting the heat source and auxiliary equipment

Depending on the difference in the load by season, the operational parameters of equipment such as air conditioning/heat source equipment and auxiliary machines are adjusted to optimise the costs. Figure 2-37 illustrates the main components of the heat source controlling system. A good example is the Marunouchi Heat Supply (to be discussed in Section 3.5), where the operation of turbo chillers and absorption chillers are changed across seasons.

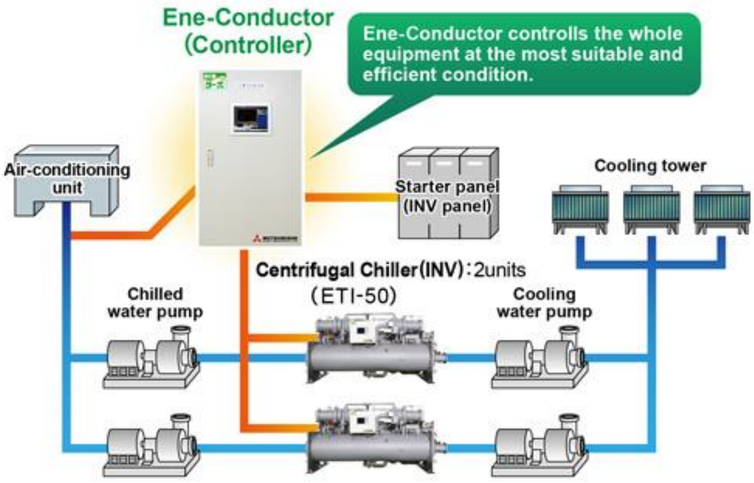
Figure 2-37. Adjustment of Heat Source and Auxiliary Equipment

Source: Mitsubishi Heavy Industries, Ltd. From http://www.mhi-global.com/products/detail/centrifugal_chiller_enecon.html [As of August 2015].

ii. Controlling the number of machines in operation (units/pumps /cooling towers)

Varying the number of units in operation depending on the load level at any given point in time helps to make facilities' operation more efficient.

Figure 2-38. Machine-numbers Control

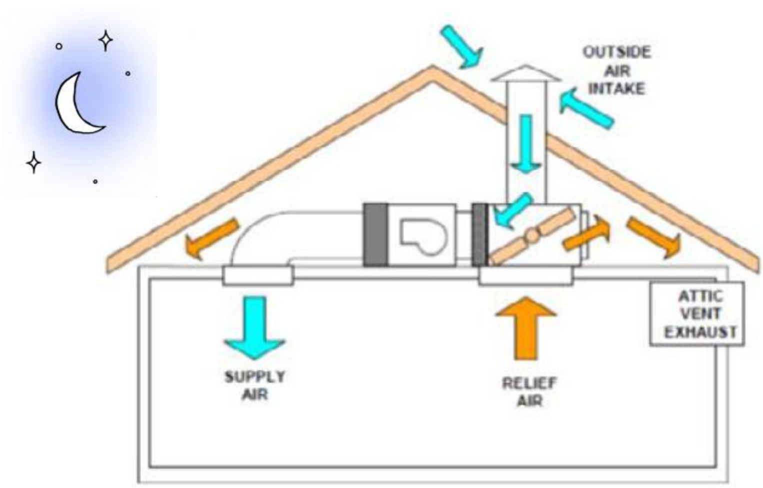


Source: Mitsubishi Heavy Industries, Ltd. From https://www.mhi-global.com/products/detail/distributed_power_case_turbo.html [As of August 2015].

iii. Scheduling the ventilation (air intake at night)

When the outside air temperature is lower than the indoor temperature at night, outside cool air intake is preferred to mitigate air conditioning load.

Figure 2-39. Scheduling of Ventilation (Air-Intake During Night)

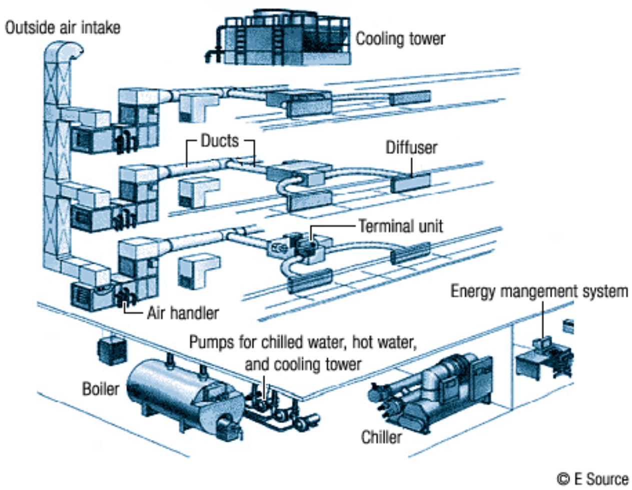


Source: 'Building America Top Innovations Hall of Fame Profile', United States Department of Energy, (2013).

iv. Using residual heat and chilled water before stopping heat source

In this method, the heat source equipment is turned off even before it totally cools off to maximise the use of the heat and chilled water in the water recirculating system. Afterwards, only the pumps are operated to use the residual heat/chilled water.

Figure2-40. Residual Heat/Chilled Water Recirculating System



Source: E Source Companies LLC. Accessed from
http://fpl.bizenergyadvisor.com/BEA1/PA/PA_Cooling/PA-14 [As of August 2015]

v. Setting partial operation of elevators

The number of elevators in operation is reduced during nonpeak hours (night-time, holidays, etc.).

vi. Partial lighting in public area

To save on electricity, only a portion of the lights in public areas (corridors, stairs, entrances, lobbies, etc.) is turned on.

Figure 2-41. Partial Lighting in Public Areas

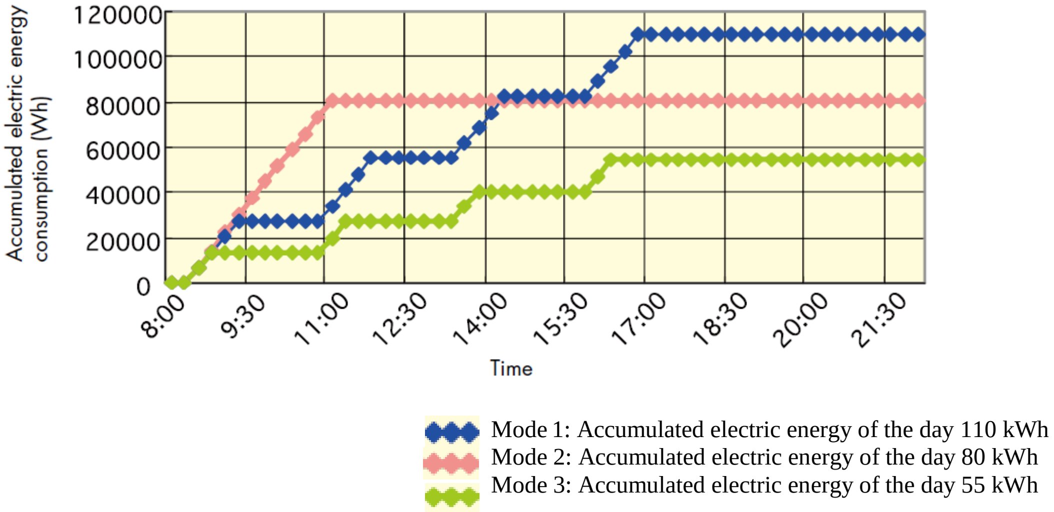
Source: WASEDA University. From http://www.waseda.jp/student/weekly/contents/2010a/1217/217a.html [as of August 2015.

vii. Setting intermittent operation of ventilation fan

The ventilation fan is allowed to operate intermittently while taking into account the acceptable air quality. As a result, energy consumption is reduced.

The difference in intermittent operation methods is shown in Figure 2-42. Mode 3 has a 50 percent difference in electric energy consumption when compared with Mode 1.

Figure 2-42. Difference in Intermittent Operation Methods of Ventilation Fan



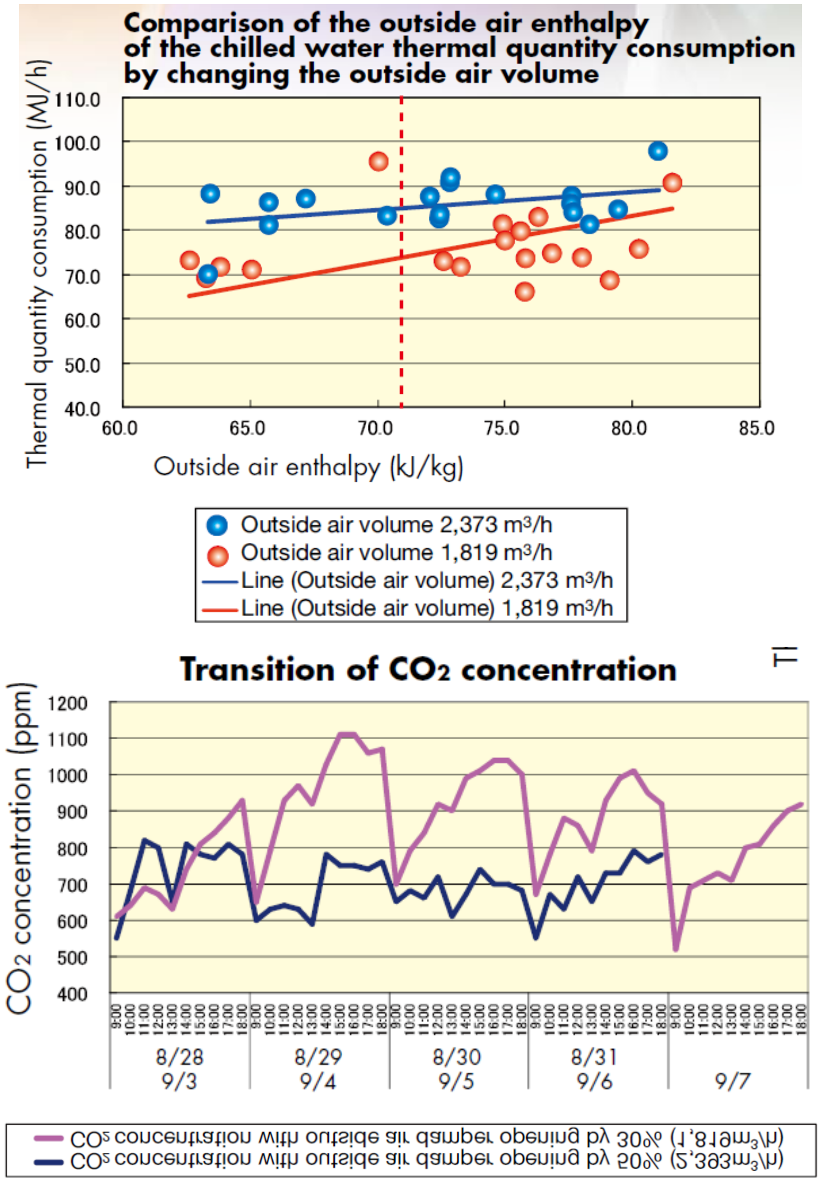
Source: 'Energy Conservation for Office Buildings', The Energy Conservation Center, Japan (2010).

(3) Invest in highly efficient technologies

i. Ventilation control by CO_2 sensors

Room capacity, as prescribed in its design, determines outdoor air intake for ventilation. However, in reality, not many cases have the prescribed number of persons present in a room at any given point in time. As shown in Figure 2-43, by reducing the outside air volume from 2,373 m3/h to 1,819 m3/h, the chilled water thermal quantity consumption drops whereas CO_2 concentration increases. Therefore, it should be controlled by using CO_2 sensors.

Figure 2-43. Ventilation Control by CO_2 Sensors



Source: 'Energy Conservation for Office Buildings', The Energy Conservation Center, Japan (2010).

ii. Replacement with high COP heat source

Coefficient of Performance (COP) is a performance indicator that shows cooling/heating capacity (kW) per 1 kW of electricity consumption. The higher the COP heat source, the more efficient the unit. Therefore, a replacement with a higher COP heat source results in a reduction in energy consumption.

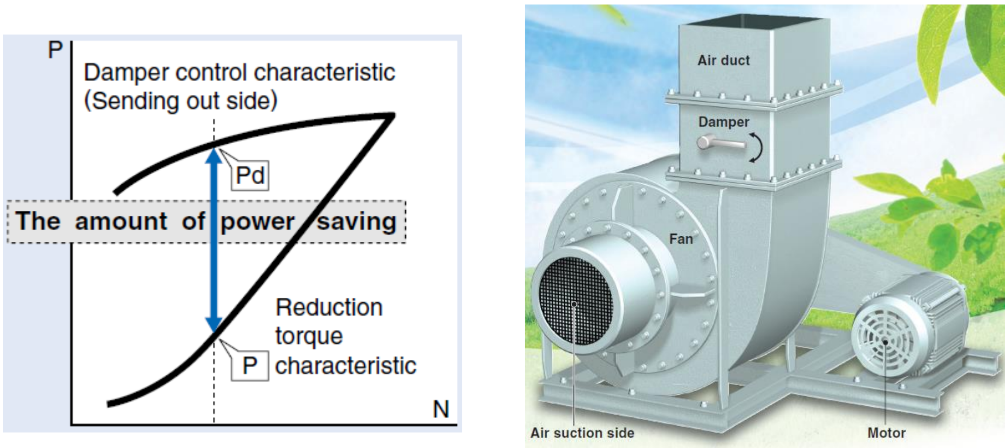
Figure 2-44. High COP Heat Source

Source: Mitsubishi Heavy Industries, Ltd. From https://www.mhi.co.jp/aircon/catalogue/index.php?mode=browse&contentsNumber=290 [As of August 2015].

iii. Replacement with inverter-driven motors (for pump and fan)

For non-inverter pumps and fans where the motor's speed is fixed, the damper or valve can be used to adjust the volume of air/water flow. However, even if this system lowers the flow volume, the loss in the damper or valve occurs and the axis power of motor (*Pd* in Figure 2-45) is not reduced significantly. If an inverter-driven motor that can control the motor speed is installed, the motor output will be reduced according to a cube of revolving speed, and energy savings (*Pd* – *P* in Figure 2-45) can be expected.

Figure2-45. Replacement into Inverter-driven Motors

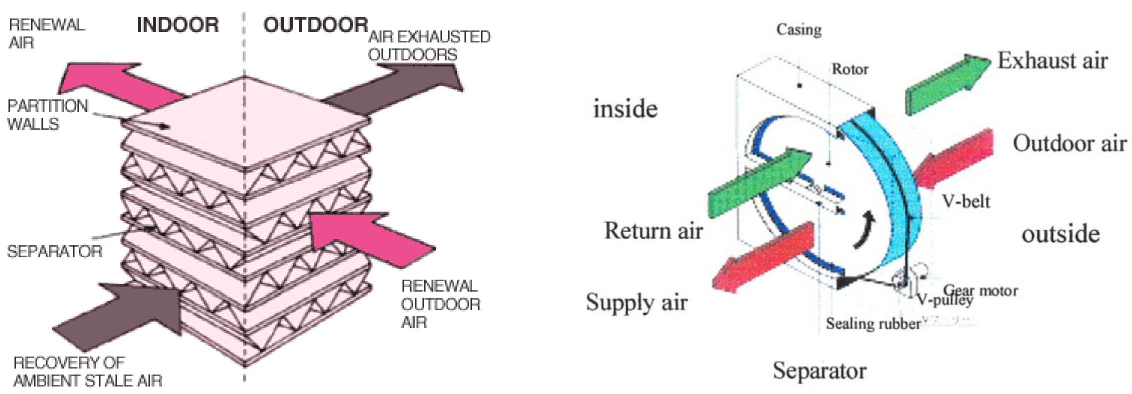


Source: 'Proposal-Using the inverter for energy-saving Mitsubishi Inverter FR-F/D/E 700', SETSUYO ASTEC Corp. (2009).

iv. Installation of total heat exchanger in ventilation system

Total heat exchangers can transfer sensible heat and latent heat simultaneously without mixing the air. Since the loss of heat by outdoor air intake for ventilation is reduced, this is useful for energy savings. Figure 2-46 shows the two types of total heat exchangers. Total heat exchangers are made of specially processed paper or aluminium foil that is absorbent and designed to fully exchange temperatures and moisture of exhaust air and outside air.

Figure 2-46. Total Heat Exchangers



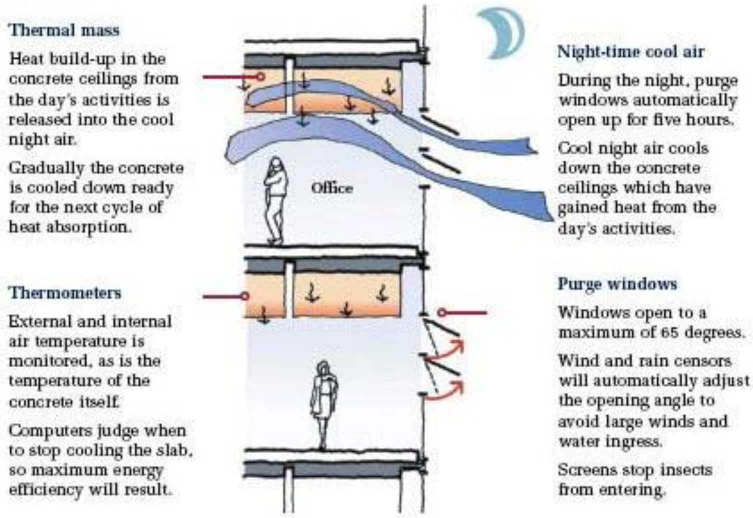
(Stationary type) (Rotary type)

Source: Stationary type: Mitsubishi Electric Corp. From
https://climatizzazione.mitsubishielectric.it/en/informazioni-utili/lossnay.php [As of August 2015]
Rotary type: 'Research on Energy Saving Effect and No Cross Contamination Characteristic for the Rotary Type Total Heat Exchanger' Seibu Giken Co., Ltd. (2008).

v. Night-purge ventilation (automatic)

Automatic night-purge ventilation (i.e. intake of cool air from outdoors during summer nights) is efficient to reduce the stored heat in the building frame and to mitigate the air conditioning load in the room at night.

Figure 2-47. Night-purge Ventilation (Automatic)



Source: Architecture Media Pty Ltd. From http://architectureau.com/articles/practice-15/ [as of August 2015].

vi. Lighting control by human sensors

A human sensor (occupancy sensor) is a lighting control device that detects presence of people and turns the lights on or off automatically. Sensors are used in the toilets, staircases, meeting rooms, and other office areas.

Figure 2-48. Lighting Control by Human Sensors

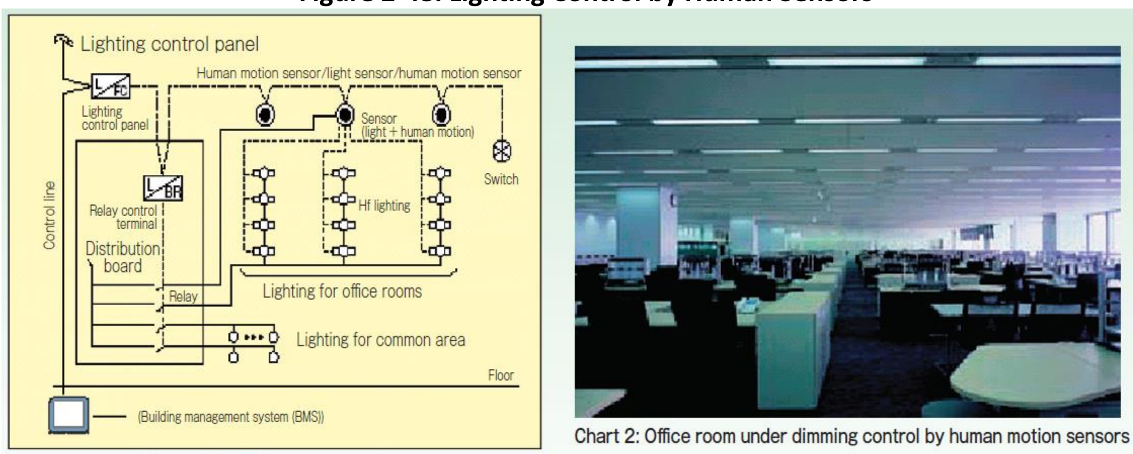


Chart 1: Lighting system diagram

Chart 2: Office room under dimming control by human motion sensors

Source: The Energy Conservation Center (2011), *Guidebook on Energy Conservation for Buildings*, Japan.

vii. Spraying of mist on compressor units (vapour effect)

By spraying mist on compressor units, the inlet air temperature decreases when mist water evaporates. As a result, the cooling capacity increases and the compressor's power consumption decreases.

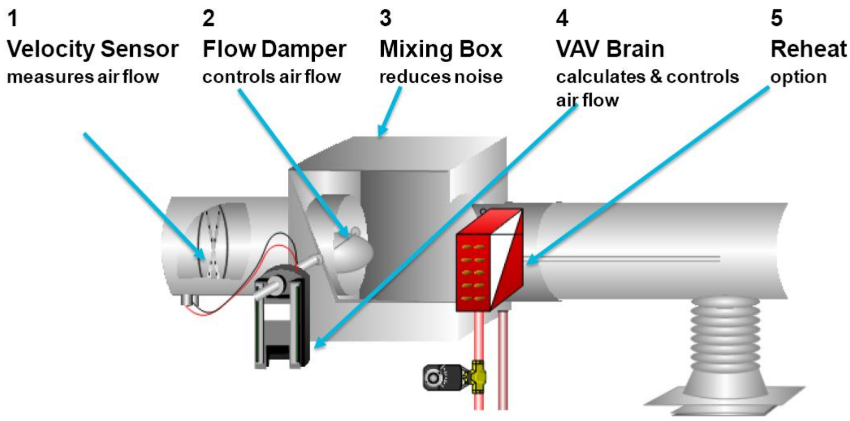
Figure 2-49. Spraying Mist on Compressor Units

Source: Osaka City Website. From http://www.city.osaka.lg.jp/suido/page/0000162694.html [as of August 2015].

viii. Installation of variable air volume system

The variable air volume (VAV) system changes the volume of airflow at a constant temperature (Figure 2-50). Compared with the constant air volume system, the VAV system consumes less energy for fans.

Figure 2-50. The Variable Air Volume (VAV) System

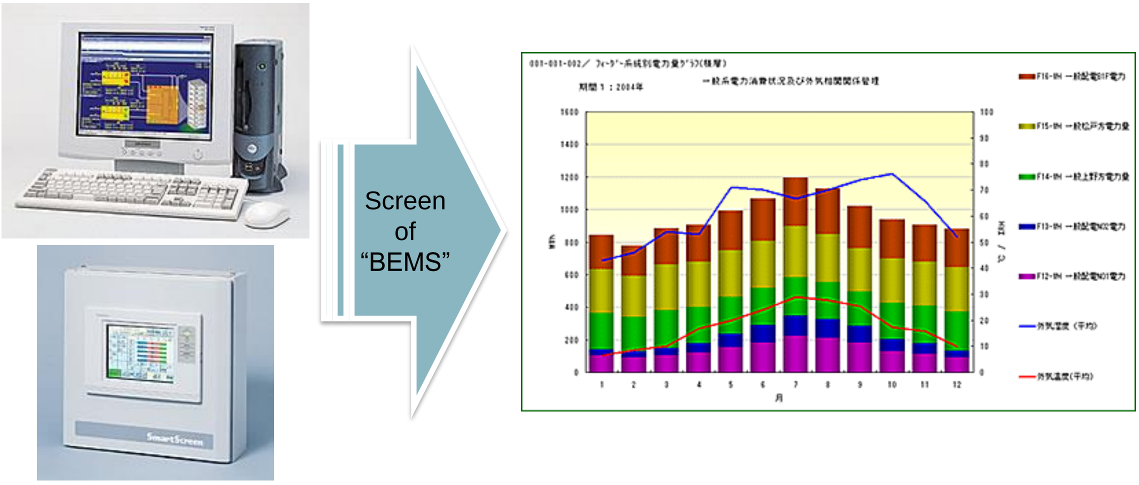


Source: 'Variable Air Volume (VAV) Air Handling System: What Makes VAV Box Performance Better', Johnson Controls Inc.

ix. Deployment of BEMS to visualise the real-time energy demand

A BEMS is based on a network of controllers and offers closer control and monitoring of building services performance, including heating, ventilation, and air conditioning. This is shown on a computer screen in real time and allows settings to be changed quickly and easily (Figure 2-51).

Figure 2-51. Building Energy Management System



Source: Azbil Corp. From http://www.azbil.com/products/bi/ba/tems/bems/index.html [as of August 2015].

3. xEMS Implementation and Energy Efficiency Measures in Office Buildings

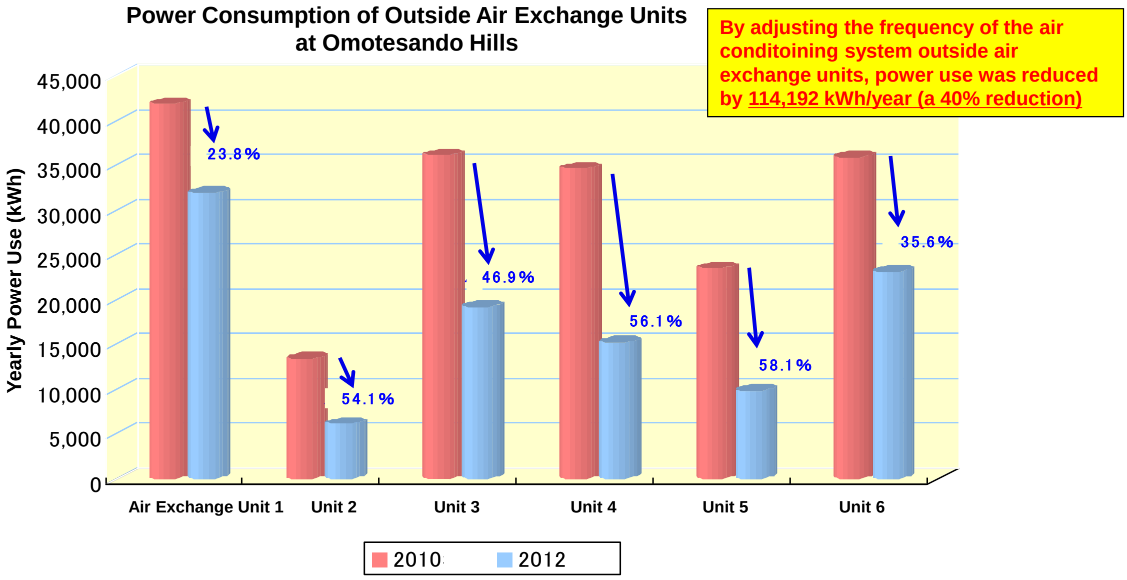
3.1. Omotesando Hills (Tokyo, Japan)

(1) Summary

Omotesando Hills is a shopping mall located in the Shibuya district of Tokyo. Its total floor area is approximately 34,000 m^2. It was built by Mori Building using conventional technologies and equipment but contains a number of unique EMS. Mori Building has a number of company divisions involved in building management, technical designs and so on, and they use data obtained from the BEMS of their properties to come up with new ideas.

Omotesando Hills has a large volume of exhaust air since it holds both restaurants and retail stores. In retail stores, air conditioning output is adjusted automatically by measuring the CO_2 density of the return air being drawn out of the space. In restaurants, the outside air exchange units were originally operated at a constant, unchanging rate. Eventually it was determined that the system could be cut back to save energy, and the special inverters originally installed in the air conditioning system came into use. As shown in the graph below, Omotesando Hills was able to save about 40 percent of its outside air exchange unit's energy use by adjusting the system output using these inverters (Figure 2-52). The building recouped its investment in inverters in about three years.

Figure 2-52. Power Consumption of Outside Air Exchange Units at Omotesando Hills



Source: Presentations by Mori Buildings, 3 July 2015.

(2) Notable uses of BEMS

The operators of Omotesando Hills 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, as shown in Table 2-4:

Table 2-4. Air Conditioning Schedule and Store Open Hours, Omotesando Hills

Store Open Hours

Type of Store	Mon.- Sat.		Sun.	
Shops	11:00 – 21:00	10h	11:00 – 20:00	9h
Restaurants	11:00 – 23:30	12.5h	11:00 – 22:30	11.5h
Cafes	11:00 – 22:30	11.5h	11:00 - 21:30	10.5h

Air Conditioning Operating Hours

Type of Store	AC Operating Hours		Total Operating Time	
	Before April 2012	After April 2012	Before April 2012	After April 2012
Restaurants/cafes	7:30 – 26:00	7:30 – 25:30	18.5h	18h
Shops	10:00 – 23:00	10:30 - 23:00	16.5h	16h

Source: Mori Buildings.

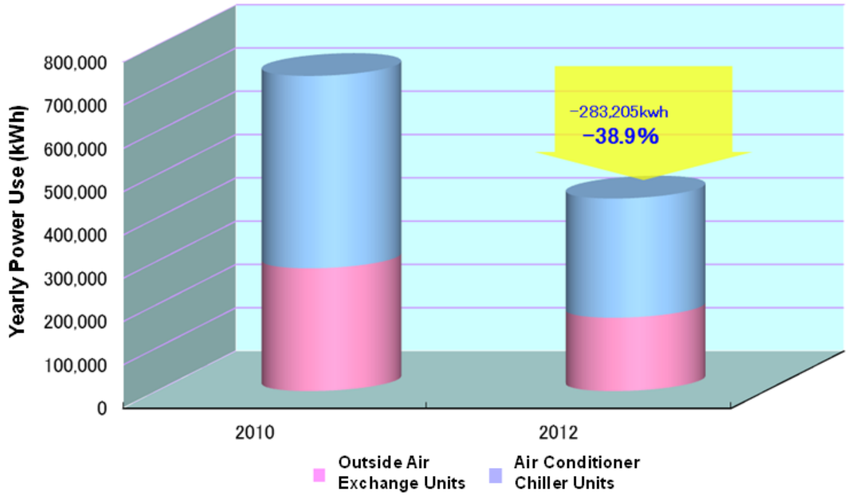
In addition to cutting back the operational hours of the air conditioning, the frequency of the air-conditioning units was adjusted to harmonise with that of the ventilation unit in the kitchens, because the amount of intake of external air was found to be excessive. Adjusting the system frequency makes a substantial contribution to energy conservation because the amount of electric power demanded is proportional to the cube of the electrical frequency. Aside from that of the air-conditioning units, the frequency of other machines such as turbo refrigerators and cooling towers were also adjusted. Because of this adjustment, the entire energy used in 2012 saw a 38.9 percent reduction compared to 2010 figures.

(3) Effect

Figure 2-53 shows the reduction in total energy use through frequency and operational hour adjustment on the outside air exchange units and chiller units. Compared to 2010, the building achieved a decrease in total air conditioning energy use of 38.9 percent in 2012. This is equivalent to saving 283,205 kWh of electric power, which is worth about JPY 4.7 million (about US$40,900).

While this is an effective method for energy saving, it is still necessary to conduct preliminary surveys and environmental assessments before doing the frequency adjustment.

Figure 2-53. Total Reduction in Air Conditioning System Power Use, Omotesando Hills



Source: Mori Buildings.

3.2. Intelligent Energy System Project (Singapore)

(1) Summary

The Intelligent Energy System (IES) Project is a pilot smart grid that tests new technologies' capability to enhance Singapore's power grid infrastructure. The key collaborators in this project are Energy Market Authority, Singapore Power, and Nanyang Technological University.

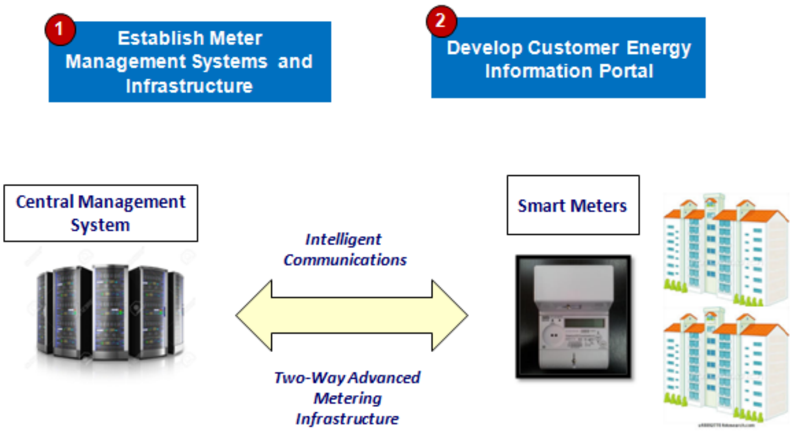
The project objectives are to establish advanced metering infrastructure architecture scalable for a nationwide rollout, to develop the framework for integration of IES customer applications (e.g. EMS for homes and buildings), and to investigate the potential for residents' behavioural change if provided with real-time electricity consumption information.

(2) Notable activities of xEMS

The project has two phases. Phase 1 is a technical trial on the development of end-to-end system infrastructure, including advanced metering infrastructure ('smart meters') as well as the supporting backend IT systems.

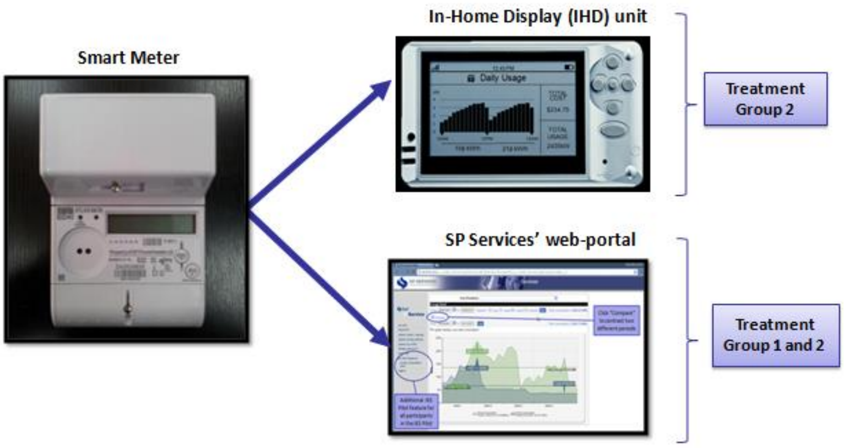
Phase 2 is an IES Residential Pilot. It is a study of how residential energy usage patterns are affected if consumers are provided with consumption information through the use of smart meters. Smart meters were rolled out to 1,900 households in about 30 residential blocks in the Punggol district, and each household was provided with an in-home display, a portable device with a rechargeable battery that displays real-time and historical data on electricity usage. The system estimates and shows electricity cost patterns. Through smart meters, data are collected and sent to the customer's in-home display and to Singapore Power Service's web-portal. Participants can access Singapore Power Services' web-portal to obtain data about their electricity consumption and compare their daily electricity consumption over time.

Figure 2-54. Intelligent Communications Infrastructure, IES Project



Source: Presentation by Singapore Power 'Intelligent Energy System (IES) Project', 2 July 2015.

Figure 2-55. Energy Consumption Information, IES Project



Source: Singapore Power.

(3) Key findings

The IES project proponents concluded that providing consumption information to customers could lead the latter to take an energy efficiency-driven behaviour.

Customers who only had access to the web-portal did not change their energy consumption. In fact, only 9.8 percent even looked at the web-portal. On the other hand, customers who received the in-home displays reduced their energy consumption by 3.8 percent. This shows the potential to further influence consumption behaviour by providing information, but the information needs to be accessible (i.e. displayed on a physical unit that can be seen right away, as opposed to an internet website).

The researchers also found that load profiles were similar across households, even when consumption levels differed. Also, majority of the residential consumption load occurs at night, when wholesale prices are lower.

(4) Status of IES project

Smart meters have already been rolled out to large factories and office buildings, but not to residential customers yet. Singapore Power is currently trying to determine the best way to integrate smart meters across all market segments, and to install demand response and automatic control along with the meters. It is also investigating how existing and future smart meters will integrate into the electric grid, as having a common communication protocol is necessary (Note: Most communication is currently done using Radio Frequency mesh).

One of the main reasons behind the interest in using smart meters is the future deregulation of the residential power sector. Currently, large consumers can negotiate rates with power generating companies, including time-of-use rates. In the future, smaller consumers will have the same choice.

(5) Post-project research

The research of this project will be continued in Nanyang Technological University's Eco-Campus project. The project will focus on smart grid technologies, including electric vehicles, battery management systems, smart home systems, and renewable generation.

In the long term, Singapore Power aims to greatly diffuse smart meters throughout the country. Singapore's government aims for a 100 percent diffusion by 2018. At present, only 40,000 meters are installed.

3.3. Sengokuyama Mori Tower (Tokyo, Japan)

(1) Summary

Sengokuyama Mori Tower is a multi-purpose complex located in the Minato district of Tokyo. It has a total floor space of 143,426.23 m^2 with a leasable area of 2,000 m^2 per floor. The complex uses BEMS technology to monitor the energy systems and collect data.

(2) Notable uses of BEMS

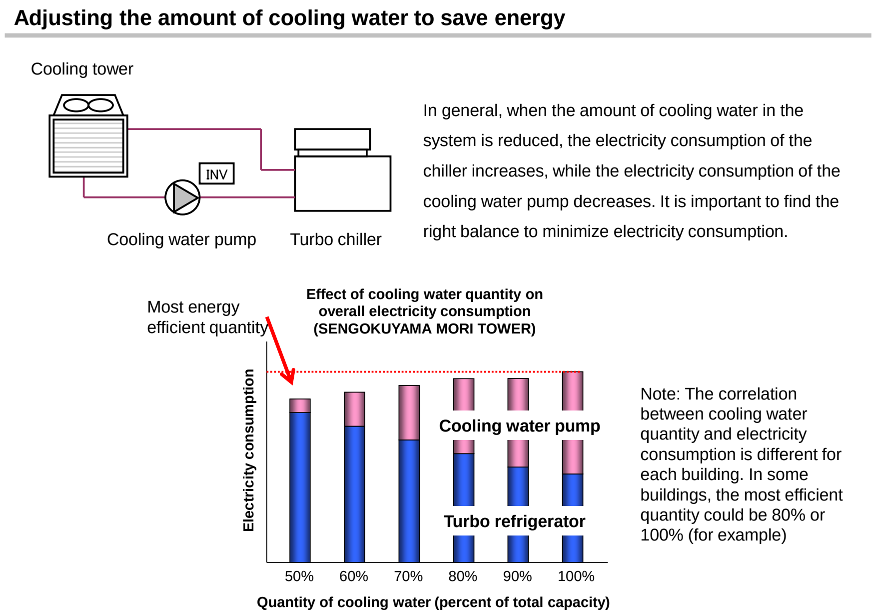
The heating and air conditioning system of the building consists of turbo chillers, absorption chillers, thermal storage, AHUs (air handling units) and fan coil units (FCUs). The turbo chillers are operated at night to store heat in the thermal storage. This heat is used in the daytime for peak shaving to take advantage of the time-of-use tariff.

One energy efficiency measure being used is the careful regulation of the water flow through the chilled water system. By modifying the flow, the building saves energy without having to adjust room temperature.

Mori Building uses a unique energy efficiency indicator called the Water Transportation Factor, which is defined as the energy needed to convey 1 MJ of heat. For example, Holland Hills Mori Tower, another Mori building, achieved a factor target of 35. The Roppongi Hills Mori Tower has an even higher factor.

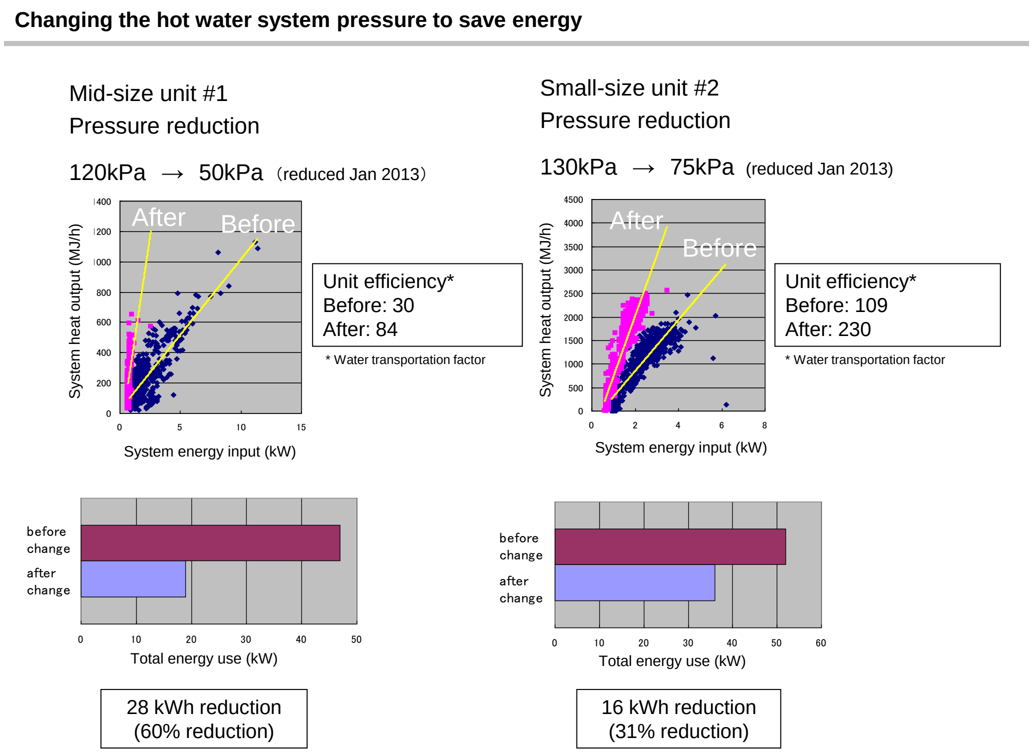
Two of the major factors affecting system efficiency are the amount of chilled water being sent through the system, and the pumping power of the hot water being sent. The Water Transportation Factor was improved in the Sengokuyama Mori Tower by adjusting both factors (Figures 2-56 to 2-57).

Figure 2-56. Applied Technologies in Sengokuyama Mori Tower



Source: Mori Buildings.

Figure2-57. Changing Hot Water System Pressure To Save Energy, Sengokuyama Mori Tower



Source: Mori Buildings.

Energy was also saved by using high-quality LED lighting fixtures equipped with light sensors. Figure 2-58 provides more details on this.

Figure 2-58. Luminaires for Quality Lighting, Sengokuyama Mori Tower

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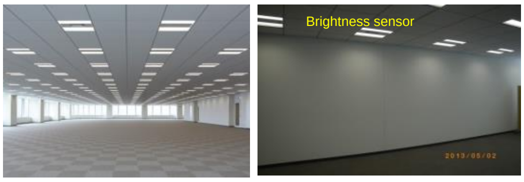


Typical fluorescent lighting fixture

LEDs with light sensors used in Sengokuyama Mori Tower

- Bluish-white (Color temperature is high)
- Color rendering is low (Red is illegible)
- Radiant-feeling

- More pleasant light
- Color rendering is high
- Saves significant energy
  - **600,000 kWh saved each year**
  - **14.4 million yen saved each year for tenants**
  - **Annualized cost of installing the higher quality fixtures: 5.4 million yen/year**

Source: Mori Buildings.

(3) Effect

By adjusting the amount of cooling water in the system and the pressure of the hot water system, and by installing efficient LED lighting fixtures, the building was able to save a considerable amount of energy. Adjusting the amount of cooling water saved about 10 percent of the energy formerly used for the system. Adjusting the pressure of the hot water system saved 30 percent to 60 percent, depending on the specific unit. The efficient lighting fixtures, while requiring a higher upfront cost, saved tenants a significant amount as well.

3.4. ECOZZERIA, Shin-Marunouchi Building (Tokyo, Japan)

(1) Summary

The Shin-Marunouchi Building was completed in 2007 by Mitsubishi Estate, a major Japanese real estate company. Mitsubishi Estate operates a number of different businesses, including an office building business mainly in the Marunouchi district of Tokyo, a retail property business, and a hotel business.

Many companies in this district are members of ECOZZERIA, a space that showcases the diverse environmental efforts made during the urban design of Tokyo's Marunouchi area, and provoke communal ideas for new environmental countermeasures. Its interior design was based on the concept of the 3 Rs (Reuse, Reduce, Recycle). It has the communication zone and the salon zone. The communication zone is a place where one can get information about green action in the Marunouchi area as well as real-time environmental data. The pine pilings and plate glass were recycled from the old and new Marunouchi Buildings. The salon zone is available for seminars, events, and meetings related to the environment. New ideas and systems have been created by people who gather here and seek to realise sustainable urban development.

The company uses the ECOZZERIA space as a focal point to build partnerships among the industry sector, government, academia and community in spreading the idea of cities where ecology and the economy coexist. Various educational activities were created to involve the local community.

Mitsubishi Estate conducts studies on new environmental technologies and systems, especially new lighting systems and air conditioning. However, it does not believe that installing new technologies is enough, and is therefore trying to get all companies to show these technologies to the public and promote an environmental mindset in the city.

The partnership of the industry, government, academia, and local community are enthusiastically engaged in initiatives whose prime concept is the building of a city where ecology and the economy are symbiotic. They have generated initiatives in the neighbourhood. One event is the *Uchimizu* during the summer. Here, people wear traditional Japanese clothing called *Yukata* and pour water on the streets to cool down the city. Other projects aim to educate the local community. The Eco-Kids programme, for one, invites children to the area during summer to educate them towards an environmental mindset and attitude.

Figure 2-59. Concept of ECOZZERIA Facilities

Source: Introduction of '3x3 Lab Future' Facility, ECOZZERIA website. From http://www.ecozzeria.jp/about/facility.html [as of August 2015]

(2) Notable activities for BEMS

ECOZZERIA has a LED lighting system. Each member-company has LED lighting on desks with a switch and a lux meter that can change the strength of the lighting. As for overhead light intensity, while other offices set the intensity of illumination at 700 lux, the ECOZZERIA space sets its lighting at 300 to 500 lux because its own data showed that this lower lux level enables workers to look at their screens for a long time without discomfort. The colour temperature of the lighting can be changed from 3000K to 6000K. Changing the colour temperature influences the mood of the workplace.

The amount of energy used for lighting is 70 percent compared to that of ordinary offices. Light emitting diodes (LEDs) are common in many Japanese offices as studies do not show LED to have any negative impact on health. While the initial investment cost is about three times more expensive than the cost of usual lighting systems, the running cost is cheaper. Nonetheless, lowering the initial investment cost would be necessary, too, as it means a shorter payback period.

For the area's air conditioning system, temperature can be adjusted easily by sending cool water through an innovative tubing system integrated into the ceiling. Tubes for air conditioning spread around the entire ceiling, except where the lighting exists. While a room with a regular air conditioning system has a lot of cool spots (meaning, some places in the room are overcooled), a room with *radiation air conditioning* doesn't have cool spots. A regular cooling system needs very cold water. In contrast, a radiation air conditioning uses 10°C to 15°C water, which decreases energy consumption of regular air conditioning systems by 25 percent. Specifically, radiation air conditioning sets a temperature of around 8°C, but after getting through heat exchangers on the roof, it settles at around 10°C to 15°C. Note, however, that the investment cost of radiation air conditioning is about 1.5 times more expensive than regular air conditioning.

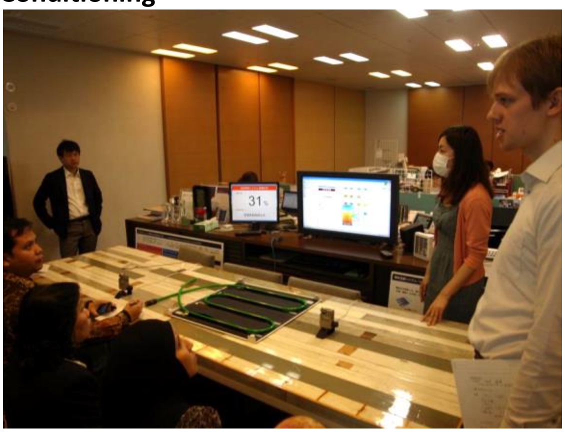
This radiant air conditioning system installed in ECOZZERIA is only a demonstration project, but the company has also installed this equipment in an entire building in the Kayaba-cho area. They plan to expand the system to other buildings in the future.

Outlets on the ceiling are for ventilation, recently introduced for ventilation of the room. By using heat exchangers, the temperature of the fresh air from the outside is almost the same as the room temperature, and then controlled by CO_2 sensors.

(3) Effect

ECOZZERIA succeeded in saving energy by using LEDs and switch off system, among other measures. Its energy usage for lighting is only 70 percent of that in ordinary offices. In addition, as mentioned earlier, radiation air conditioning helped decrease energy consumption by 25 percent when compared to regular air-conditioning systems.

Figure 2-60. ECOZZERIA's Tubes for Ceiling Air Conditioning



Source: Authors.

Figure 2-61. Laboratory of ECOZZERIA

Source: Authors

3.5. Marunouchi Heat Supply (Tokyo, Japan)

(1) Summary

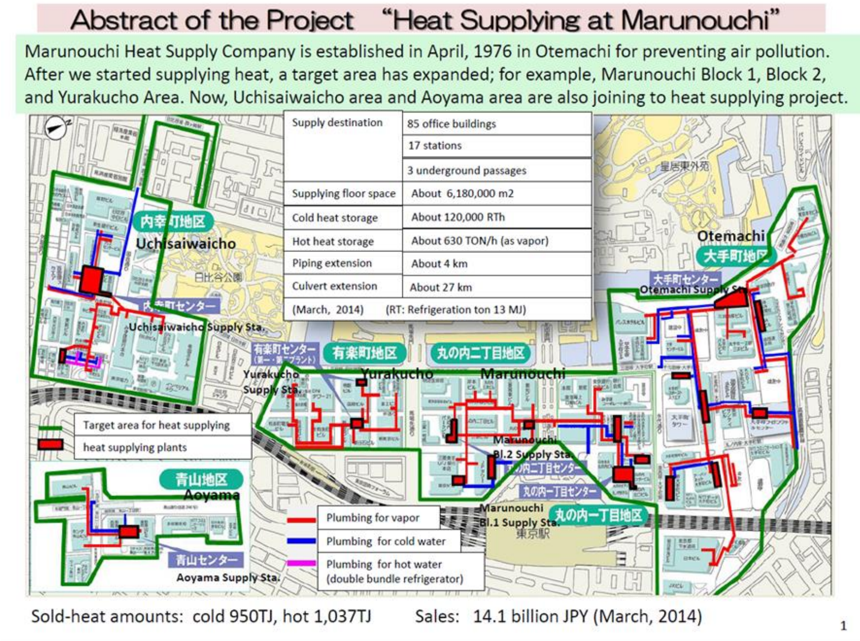
Marunouchi Heat Supply is a central heating supply business established in 1972 and features one of the advanced cases of district heating and cooling system in Japan. It earns about JPY14 billion (about US$120 million) of sales per year and employs about 127 people. It operates 90 facilities in six districts, providing a steady supply of heat and air conditioning to customers occupying a total floor area of more than 6 million m^2. Its system is mainly comprised of boilers, chillers, and district piping systems. The boilers produce clean steam at around 175°C as well as chilled water for customers in each district area.

This is one of the advanced cases of district heating and cooling system (DHC) in Japan. DHC has both environmental and economic benefits.

The DHC system controls boilers and chillers and reduces CO_2 emissions significantly. One of its major advantages is its efficient operation due to a centralised boiler-and-chiller system. It reduces primary energy consumption by 20 percent to 25 percent compared to standalone heating and cooling systems.

Also, the DHC reduces the initial investment cost significantly for owners of new buildings (customers for DHC supplier) because they do not need to install boilers, chillers, and other equipment. In addition, the system can lower the cost of operation, monitoring, and maintenance.

Figure 2-62. Project Outline of Marunouchi Heat Supply



Source: 'Our business', Marunouchi Heat Supply website. From http://www.marunetu.co.jp/business.html [as of August 2015].

(2) Notable activities for EMS

The company uses environment-friendly pumps and chillers. Chillers are used to cool water down to 5°C to 7°C. Marunouchi Heat Supply installs both turbo chillers and absorption chillers to realise the best mix of electricity and gas consumption.

Turbo chillers are used mainly for making cold water except during peak hours, when the company reduces the electricity demand by using absorption chillers that do not consume electricity. The COP of absorption chillers is about 1.5, while that of turbo chillers is between 5 and 6. The COP of turbo chillers increases to about 25 when it is combined with inverters; hence, this type of chillers is often preferred at the plant.

The company supplies customers with steam and chilled water through conduits and a district piping system. Each building's intake facilities process the steam and water through heat exchange equipment, sending them to air-conditioning units, kitchens, and other facilities.

The DHC's plants and district piping systems are built deep underground, making them highly resistant to earthquakes. Even during the major earthquakes of recent years, plants and affected areas suffered no damage. The company has various measures to ensure dependability, such as multi-piping system and emergency power generators.

Figure 2-63. Turbo Chillers

Source: Authors.

Figure 2-64. District Piping System

Source: Authors

(3) Effect

Companies and building-owners in this area are not just following regulations but are also implementing various independent initiatives to achieve CO_2 reductions. In 2009, CO_2 emissions from buildings were around 710,000 t-CO_2, a decrease of approximately 2.7 percent from 2008. This result indicates that 58 (about 90 percent) of the 65 large commercial buildings that are required to report to the Tokyo Metropolitan Government had successfully reduced their CO_2 emissions.

Initially, building owners found difficulties in installing solar panels in the area because of the effects of high winds on the rooftops of high-rise buildings. However, these obstacles have now been overcome, and the number of solar panel installations has increased steadily. In 2010, 453 kW of capacity was installed above the Tokaido Line platforms at Tokyo Station and 150 kW on the roof of Mitsui & Co., Ltd.'s head office building. The total installed capacity in this area is now 820 kW.

Table 2-5. Solar Power Production by Marunouchi Heat Supply

Location	Capacity	Installed
Tokyo Station, above *Shinkansen* platforms	30kW	1993
Tokyo International Forum	67kW	1997
Marunouchi Bldg.	10kW	2002
Mitsubishi UFJ Trust & Banking Bldg.	30kW	2003
Shin-Marunouchi Bldg.	20kW	2007
Marunouchi Park Bldg.	60kW	2009
Tokyo Station, above Tokaido Line platforms	453kW	2010
Mitsui Bussan Head Office Building	150kW	2011

Source: 'The OMY CSR Report 2011: A Community for 1,000 Year'. From http://www.ecozzeria.jp/images/english/index/pdf/csr2011en.pdf [as of August 2015].

3.6. Azbil BEMS

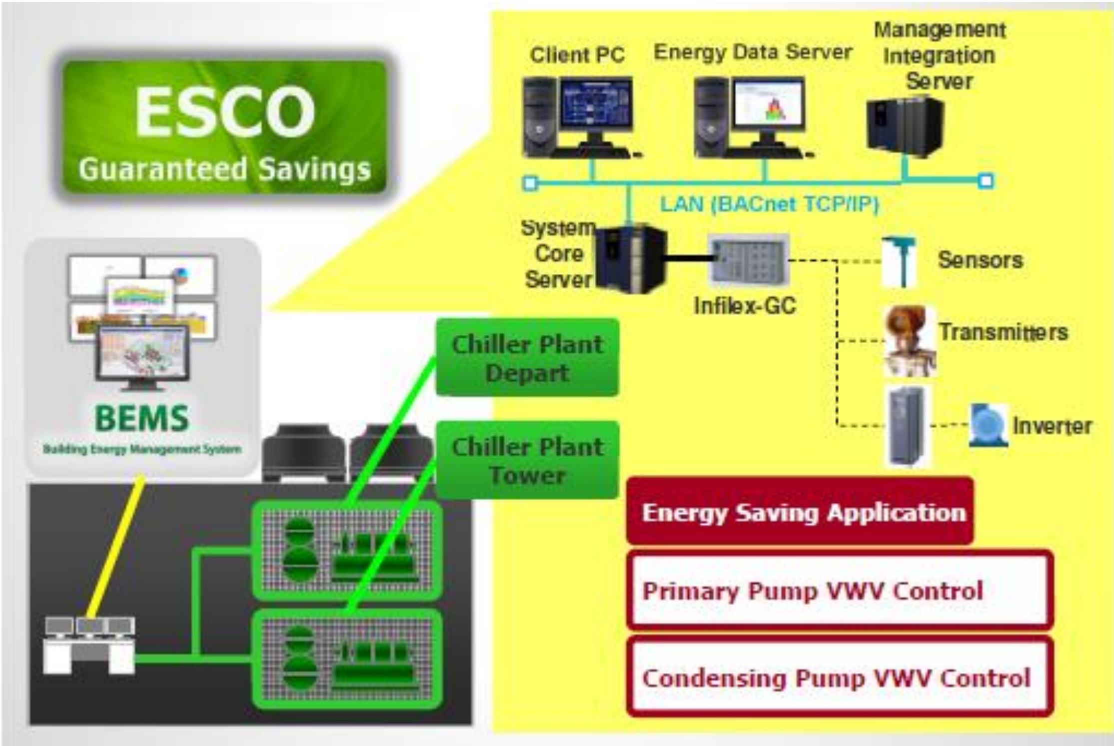
(1) Summary

Azbil is an energy solution provider, originally founded in 1906 as a trading company. It has about 200 locations in Japan and overseas. It has three core businesses: advanced automation on factories, building automation, and life-line automation on public infrastructure.

Recent ESCO pilot projects in Thailand are the Amari Water Gate Bangkok and Amarin Plaza, where 663,483 kWh/year of energy and THB 3,498,347/year are saved. For Amari Water Gate Bangkok alone, around 15 percent of energy was saved.

BEMS, variable water volume control for both combined heat and power system, and combined desalination and power generation system as well as cooling tower fan variable speed drive control are applied at Amarin Plaza. During the first year of application, data on the usage were checked monthly. On the second year, monitoring was done quarterly, mainly on BEMS data from Japan. When the targets were not hit, the company would search for and mitigate the causes.

Figure 2-65. Azbil's Energy Saving System



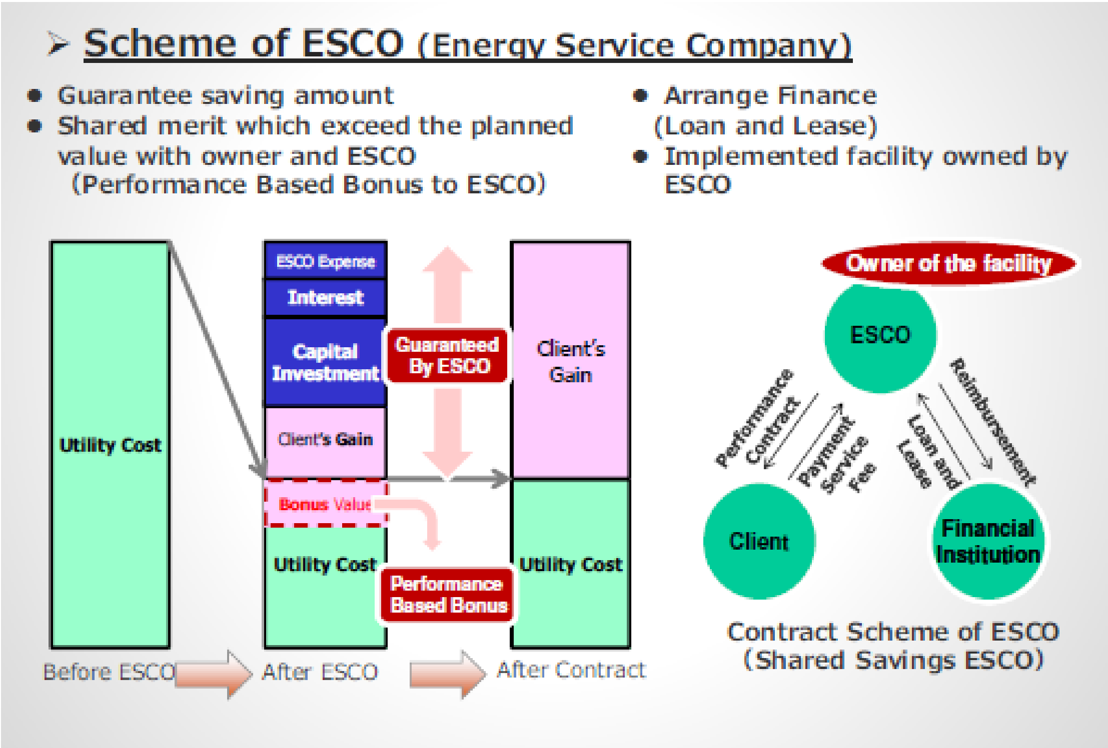
Source: 'Energy Saving Activities with BEMS', Azbil Corporation.

(2) Business model

There are two types of ESCO contract. One is guaranteed savings (left side of Figure 2-66). In this contract, ESCO guarantees the savings amount, and both the owner and ESCO share the benefits in excess of the planned value. The Amarin Plaza ESCO contract entered is the guaranteed-savings type.

The other contract is the shared savings type (right side of Figure 2-66). In this case, Azbil (an ESCO) arranges the finance (loan and lease), and retains the ownership of installed facilities.

Figure 2-66. ESCO Schemes (Guaranteed Savings and Shared Savings)



Source: Presentation by Azbil, 3 July 2015.

Before starting the services, ESCO goes into a contract with customers, which includes the following parameters: the baseline demand, the expected reduction in energy consumption that they guarantee, the operation schedule, and the specification of existing facilities. The ESCO project's payback period is, in general, three years.

In Japan, the contract is very complicated and usually includes many conditions for various cases. On the other hand, the projects in Thailand tried to simplify the contract. However, it needs to be noted that when more complicated energy-saving solutions are integrated into the scheme, more conditions, which may influence the performance of these solutions, will need to be added as part of the contract.

As a pilot project, there was no profit gained from the project in Bangkok. In Japan, building owners invest in energy saving solutions even without any cost incentives to do so. On the other hand, in other countries in Asian, building owners are interested in energy-saving solutions because of their potential to reduce costs. At present, they have little understanding of the purpose of ESCO, and both the companies and government have to step up and cooperate in educating customers about how ESCO contracts work and how energy can be used more efficiently.

Nowadays, Asian countries consume more energy than ever before, with some starting to import oil and gas to supplement their own production. As a business, ESCO is still small, but it has the potential to be viable once such countries need to pay more for energy. The ESCO business contributes not only to energy savings but to improving foreign trade balance, too.

In the future, the ESCO business will be extended to renewable energy integration as well and ESCO will not only provide energy service but also be a kind of energy service provider.

Chapter 3

Case Study: PT PLN (Persero) Head Office in Jakarta, Indonesia

For the first year of study on the potential of BEMS, the head office (Yayasan Building) of PT PLN (Indonesia) and the Nonthaburi Office of Metropolitan Electricity Authority (Thailand) were chosen as the case study among the list of candidate sites proposed by the Working Group members. These two sites were chosen to represent typical office buildings in the EAS region, one relatively old and the other, new. In the second year, the focus of case studies will be from the remaining three countries.

The case study at PLN Head Office and MEA Nonthaburi Office are discussed in Chapters 3 and 4, respectively.

1. Overview: Case Study Site

PT PLN (Persero) is a state-owned electric company in Indonesia with its head office located in the central district of Jakarta. As the office had never conducted an integrated assessment and solution for energy management system, the case study proposed to show the general energy consumption information of PLN head office building complex (Table 3-1).

Table 3-1. Overview of PT PLN Cases

Name	Yayasan Dana Pensiun	Gedung PLN Pusat	Computer PLN Pusat
Year operated	1994	Unknown	Unknown
Total floor area	28,000 m^2	20,000 m^2	2,300 m^2
Air-conditioned floor area	20,000 m^2	16,000 m^2	2,000 m^2
Number of floor	Overground: 16 Underground: 2	Overground: 9 Underground: -	Overground: 4 Underground: 1
Number of daytime workers	700	200	50
Maximum demand	2,600 kW	1,000 kW	600 kW
Supply voltage	20 kV	20 kV	20 kW
Total capacity of electrical facilities	3,000 kW	1,100 kW	630 kW

i. Heat source: AC, etc.	30%	40%	50%
ii. Lighting	30%	25%	20%
iii. Office electronics	30%	30%	20%
iv. Motors	10%	5%	10%

Note: AC – air-conditioning system.
Source: Prepared by the study team using PT PLN (Persero) data.

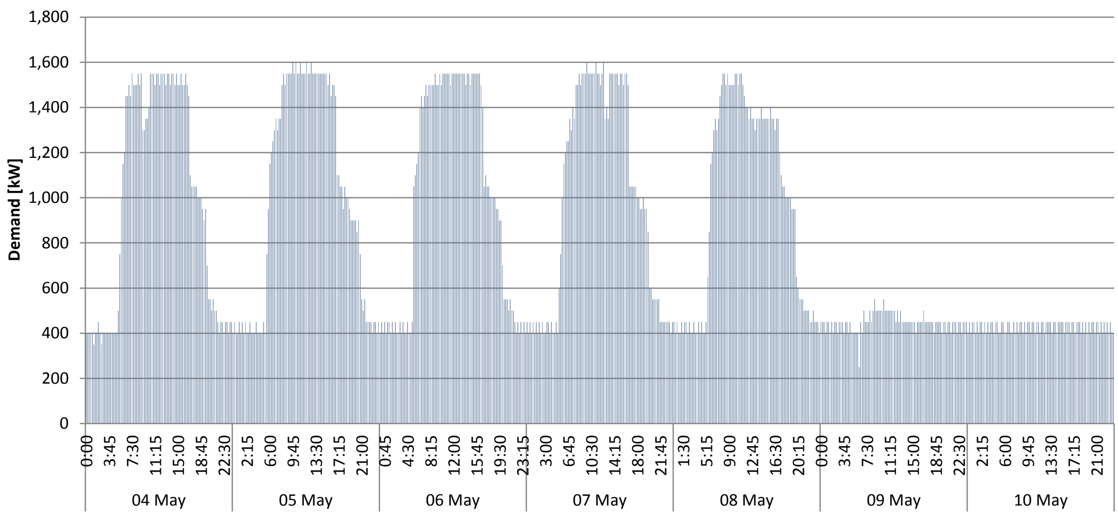
2. Preliminary Study

Before conducting a detailed survey on the fields, the study team analysed the potential of energy efficiency based on the data provided by PLN. Results of this preliminary survey were presented by the study team during the second Working Group meeting in Tokyo on 2 July 2015.

2.1. Energy saving target

This Yayasan Building was considered for the study based on the demand size. At the Yayasan Building, power demand is metered every 15 minutes. The building's actual load profile during a week (4-10 May 2015) is shown in Figure 3-1

Figure 3-1. Weekly Load Profile of Yayasan Building (4-10 May 2015)

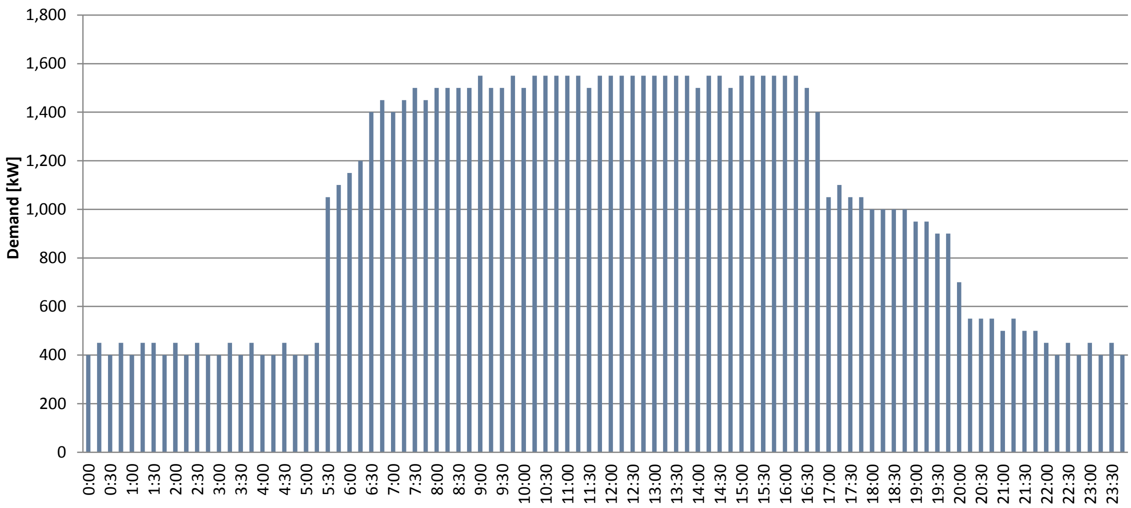


Source: Prepared by the study team using PT PLN (Persero) data.

The table shows a pattern in the building's load profile. On weekdays, the load starts increasing in the morning and after keeping a constant level (about 1,500 kW), it starts dropping in the evening down to the off-peak load (about 400 kW). At night, a constant level (about 400 kW) is kept. The load on weekends is almost flat at about 400 kW.

Figure 3-2 is the daily load profile on 6 May 2015. The load starts increasing at 05:30 and keeps at an almost constant level from 07:00 to 16:00. Then it starts decreasing gradually until it reaches the bottom load at about 22:00.

Figure 3-2. Daily Load Profile of Yayasan Building (6 May 2015)



Source: Prepared by the study team using PT PLN (Persero) data.

According to the information provided by PLN, the annual electricity consumption of the Yayasan Building in 2014 was 6,636,000 kWh. A monthly breakdown is shown in Table 3-2

Table 3-2.Monthly Electricity Consumption at Yayasan Building (kWh), 2014

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
571,300	573,500	495,300	577,950	562,600	550,600	540,800	494,200	535,550	564,100	602,600	567,500

Source: PT PLN (Persero).

Of the 12 months, November had the highest consumption while August had the lowest, followed by March. According to PLN, this is a cyclical factor due to the peak and off seasons of business, and not due to weather conditions. The average annual consumption per floor space was 237 kWh/m^2.

The main electrical equipment installed at the Yayasan Building is listed in Table 3-3.

Table 3-3. Main Electrical Equipment Installed at Yayasan Building

1. Heat-source equipment (AC etc.) 30 % of total power consumption

	Name of the product	No. of units	Capacity (Tons*)	COP	
Chiller system	Carrier	5	450 TR		* Please add more lines if needed
*Centralized cooling					

	Name of the product	No. of units	Capacity (Tons*)	COP	
Packaged AC	DAIKIN	10	2 PK		* Please add more lines if needed
*Individual cooling					

*Note: 1 Ton = capacity of removing the heat to freeze 2000 pounds of water into ice in 24 hours (=3515 W)

		No. of units	Capacity (kW)	Inverter controlled
Auxiliary power	Coolinng water circulation pump	8		~~Yes~~ / No
	Cooling tower			
	Primary water cooling pump	8		~~Yes~~ / No
	Secondary water cooling pump	6		~~Yes~~ / No
	Indoor unit			
	Fan coil unit			

Others (if any, sepcify)

2. Lighting 30 % of total power consumption

Type of lighting (LED, Fluorescent etc)	No. of units	Capacity (kW)	
LED	5000	0.012	* Please add more lines if needed
Energy Saving Lamps	1000	0.018	
Tube Lamps	500	0.05	
Mercury / Halogen	100	0.15	

3. Office electronics (PC etc.) 30 % of total power consumption

Laptop PC	400	units x	0.075	kW/unit
Desktop PC	600	units x	0.1	kW/unit
Others (if any, sepcify) Printers	600	units x	0.15	kW/unit

4. Motors 10 % of total power consumption

Water pump for water supply and drainage	8	units x		kW/unit
Lifts (elevators)	6	units x	50	kW/unit
Escarators	-	units x	-	kW/unit
Others (if any, sepcify)				

5. Others (if any)

Source: PT PLN (Persero).

Based on the obtained information above, the study team estimated the breakdown of the daytime load (average: 1,518 kW) by equipment. This analysis assumed that the cooling demand accounts for about 40 percent of the daytime demand.

Cooling	618 kW (41 percent)
Motor (Lift & Pump)	180 kW (12 percent)
Office electronics	200 kW (13 percent)
Lighting	120 kW (8 percent)
Base load night time	400 kW (26 percent)
Daytime load	1,518 kW (100 percent)

2.2. Desktop analysis of energy saving potential

Based on the information provided by PLN, the study team carried out a rough analysis of the energy savings potential at Yayasan Building.

(1) Energy savings through operational practices

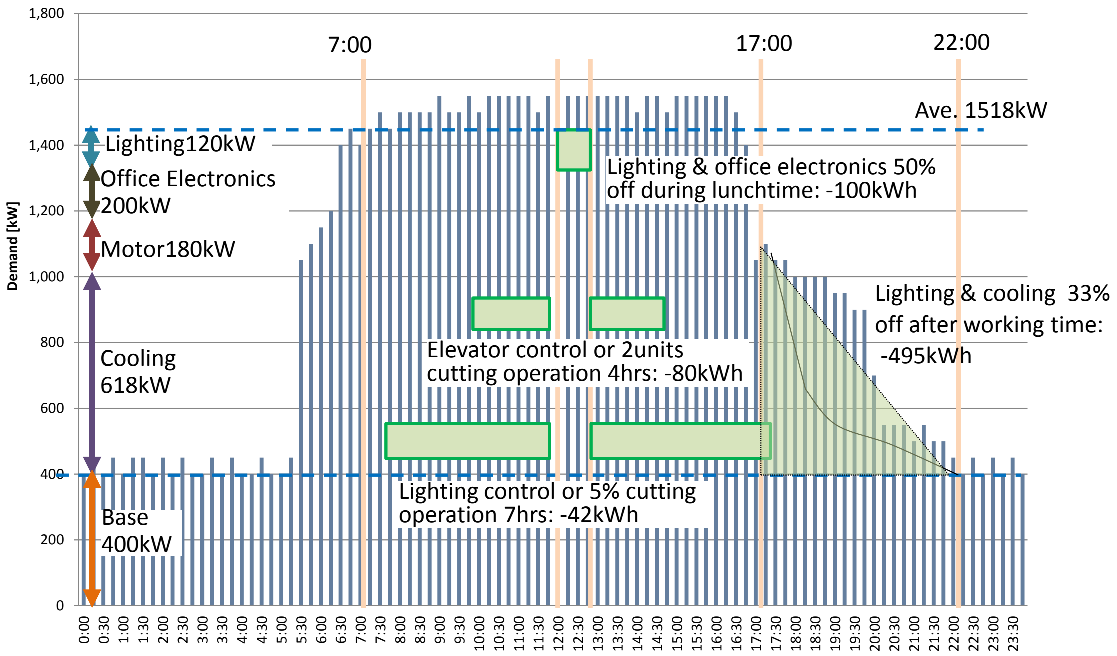
The study team estimated the energy savings by simply changing the operational practices—i.e. without additional investment—to be 717 kWh/day, which is equivalent to 2.8 percent of the daily power consumption on weekdays of 25,523 kWh/day.

The above estimates have factored in the following energy-saving measures:

- ***Turning off the lighting and electronics during lunch break: 100 kWh***
  Data show that the daytime load is almost constant despite the lunch break from 12:00 to 13:00. Practices to turn off unnecessary lighting and electronics during that time may be able to reduce the electricity consumption by 50 percent. [= 200 kW x 1 hour x 50 percent]
- ***Reducing the units of elevators in operation: 80 kWh***
  In general, office buildings' elevators are capable to meet the demand during peak hours (i.e. the time people arrive and leave the office and take their lunch break). Outside of these peak hours, the demand decreases. Thus, the study team assumed that two units of elevators can be stopped for four hours (i.e. 10:00–12:00 and 13:00–15:00).
  [= 50 kW x availability factor 20 percent x 2 units x 4 hours]
- ***Turning off unnecessary lighting: 42 kWh***
  The study team assumed that 5 percent of the lighting demand during business hours pertains to unnecessary usage (i.e. no person was present inside a room). [120 kW x 7 hours x 5 percent]
- ***Turning off lighting and cooling sy*stems strictly after *working hours: 495 kWh***
  The study team observed that the load's decreasing slope after working hours (after 17:00) is rather moderate, probably because there is no strict practice of turning off lights and cooling systems once employees leave the office. The study team assumed that about one-third of the electricity demand beyond the base load (400 kW) can be reduced.
  [(1,000 kW-400 kW) x 5 hours /2 x 33 percent = 495 kWh]

Figure 3-3 shows the estimated energy savings potential.

Figure 3-3. Energy Saving Potential of Yayasan Building (May 2015)



Source: Prepared by the study team using PT PLN (Persero) data.

(2) Further steps for energy saving

The study team believed that there is still more energy savings potential at Yayasan Building. The next steps to take may, however, more or less affect building occupants' comfort or require certain costs for investment. The energy efficiency potential from these measures have not been calculated in detail, but assuming that 10 percent of air-conditioning demand can be reduced, the new measures will contribute to a 488 kWh-reduction per day (= 618 kW x 8 hours x 10 percent), which is equivalent to 1.9 percent of the daily power consumption on weekdays.

- ***Increasing the temperature setting of air conditioners***. Currently, air conditioners at Yayasan Building are set at between 20°C and 22°C. The study team deems that raising the temperature by 3°C (i.e. 23°C–25°C) is possible as long as the working environment is not significantly affected.
- ***Shortening the operation hours of chillers.*** Data show that the power demand for chillers starts increasing from 05:30. This is considered the start of chillers' operation. Because the working time at PLN starts at 07:00, it is still doable to delay the start of

chillers' operation.

- ***Implementing variable cooling control.*** Investment in a variable cooling control system such as inverter control of fans and pumps, variable control of air volume, and multiple cooling control, can help reduce the demand for air conditioners.
- ***Replacing desktop PC with laptop PC.*** According to PLN, there are roughly 400 laptop PCs and 600 desktop PCs in the office. By changing the numbers to '800 laptop and 200 desktop', it will contribute to 10 kW reduction of the power demand. [= (400 units x 0.075 kW + 600 units x 0.10 kW) – (800 x 0.075 kW + 200 x 0.10 kW)]

Furthermore, the study team pointed out that the base load at night-time (i.e. almost constant at 400 kW) is obviously too high for an office building of this size, and argued that this means a possible huge waste of energy.

During the site survey in August 2015, the researchers found that the power supply-to-server computers at Computer PLN Pusat (the data centre) is sourced from Yayasan Building, not from the data centre's own power supply. The load from Yayasan Building to the data centre is a little less than 400 kW, which matches the base load of the Yayasan Building. Because there is limited potential for energy savings at the data centre—at least on a short-term basis—its reduction in energy usage is not considered in this study.

3. Observation from site survey

On 3 August 2015, a site survey consisting of a walk-through and interviews with facility personnel was conducted to ascertain the potential for energy savings. Based on the year the chillers were manufactured (1994), the assessment showed that 20 years had passed since the completion of the facility, and the equipment has deteriorated and become obsolete.

Below are the outline system diagrams of the chilled water supply system, and air conditioning and ventilation system and findings on their operability.

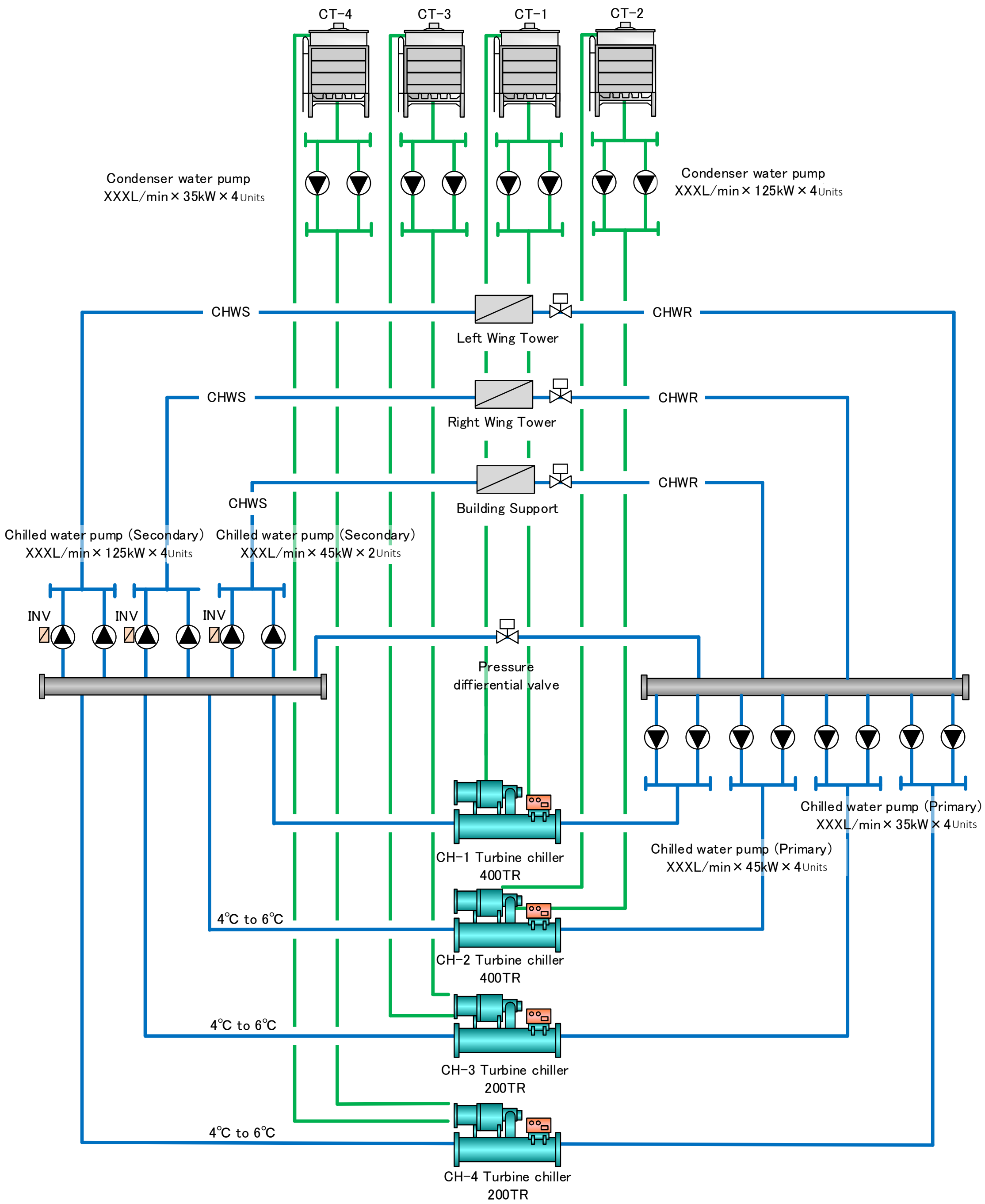
<u>Chilled water system</u>

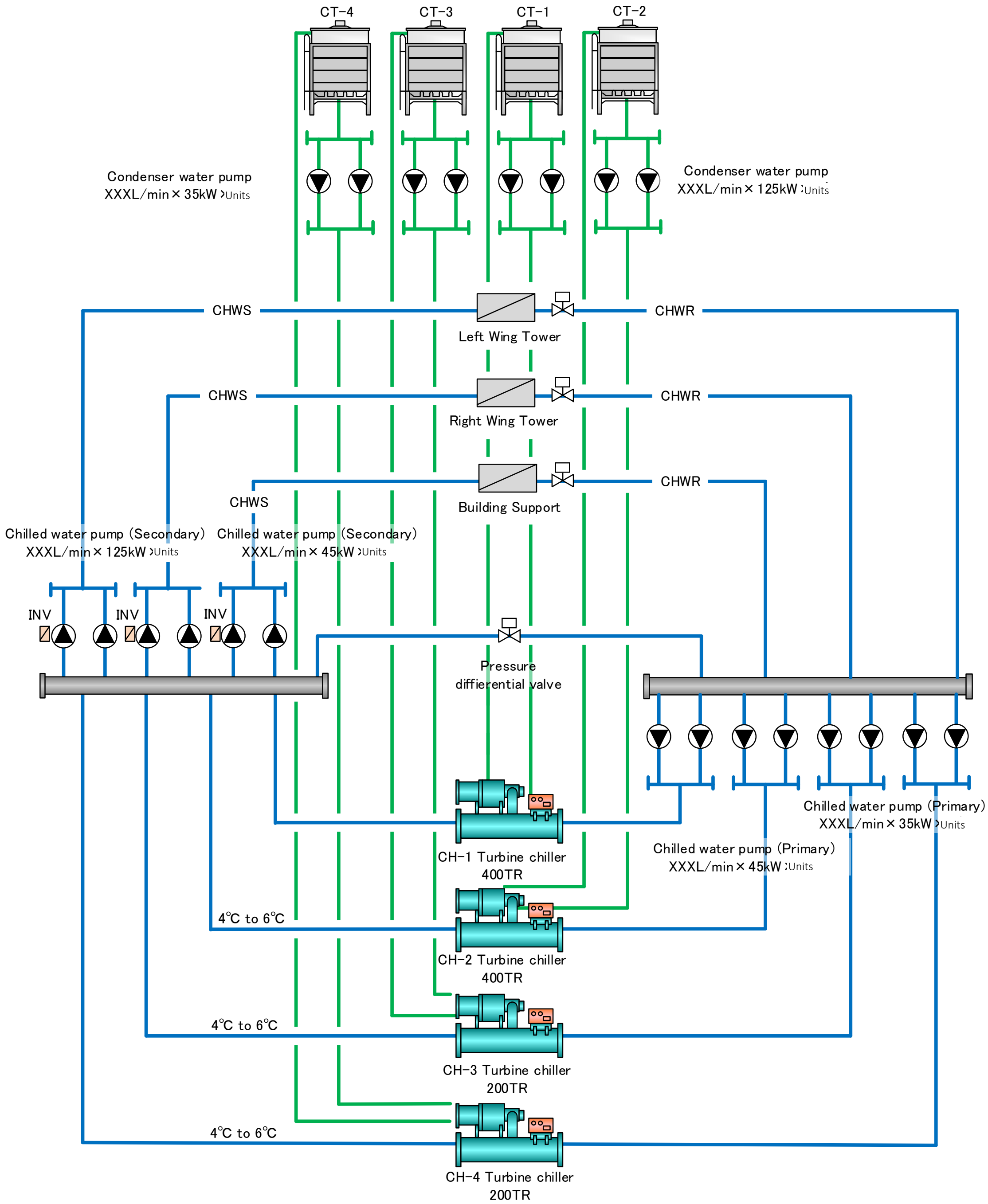
- 10 hours operation per day (06:00 to 16:00)
- Four chiller units installed. Two units (200TR and 400TR) are normally in operation
- Chilled water supply temperature setting is 4°C to 6°C, condenser water supply temperature setting is 22°C to 25°C
- Two chilled water pumps, two condenser water pumps with one unit as backup
- Only chilled water pump (secondary) has built-in inverter control but frequency setting is fixed
- There is no BMS installation and all air-conditioning operation is manual
- Sub-meters are installed to measure chilled water calorific values and chiller electrical energy

<u>Air conditioning and ventilation system</u>

- Distributed installation of FCU in each area with temperature control
- There is substantial air exhaust of toilets on each floor; however, there is fresh air intake via the ductwork connected to fan coils. The toilet system has three exhaust fan units installed on the roof
- Several fan units are installed in the basement car park. At present only one unit is in operation

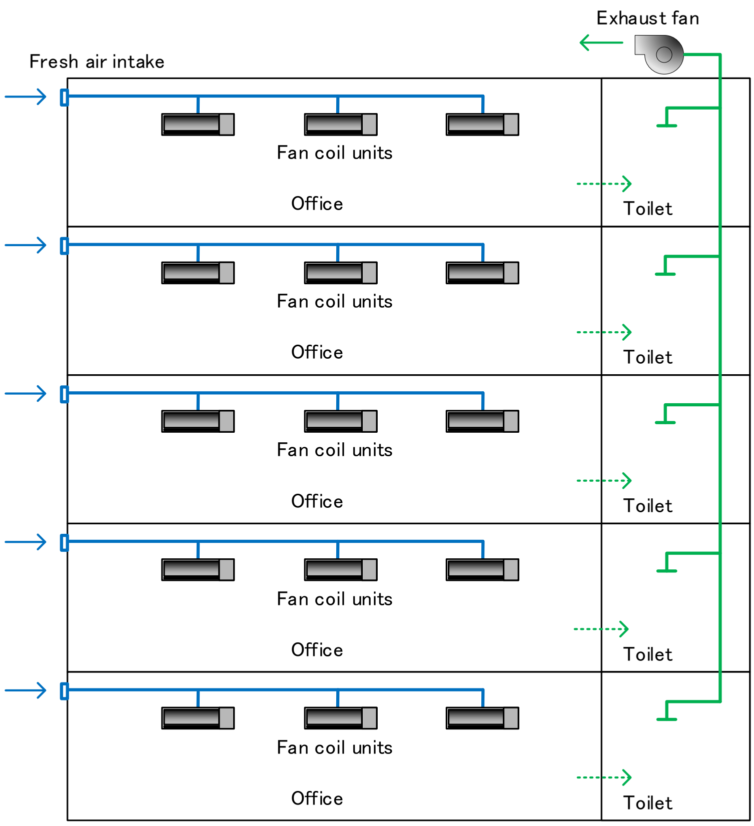
Figure 3-4. Simplified Diagram of Chilled Water Supply System





Source: Authors.

Figure 3-5. Simplified Diagram of Air Conditioning and Ventilation



Source: Authors.

3.1. Energy usage conditions

Particulars on energy consumption at this facility are shown in Table 3-4, using assessed annual energy consumption and calculation conditions for energy-saving proposals. According to the PLN offices responsible for facility management, the electricity consumption of this building includes the electricity supply to the server computers in the computer centre (Computer PLN Pusat) located in a building next to the Yayasan Building. As shown in Table 3-1, electricity is supplied to this computer centre separately, but the server computers in this building are not sourced internally but from the Yayasan Building. Therefore, it might be more appropriate for the calculation of the total energy consumption of the Yayasan Building to exclude the supply to these computers.

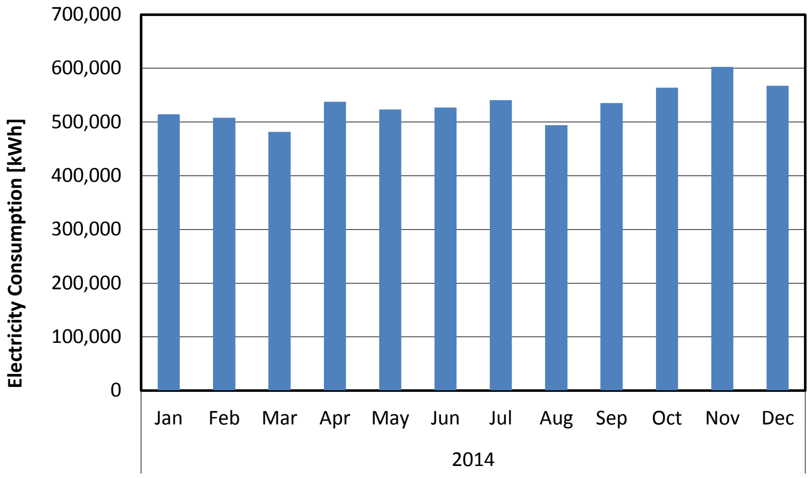
Based on the monthly power consumption for 2014, there were no large variations for each month, and the average monthly value fluctuated slightly around 533,000 kWh. The average value for November showed the largest increase, but this was due to the number of events and seminars held during the said period.

Table 3-4. General Information on Annual Energy Usage, 2014

Items	Conditions	Remarks
Annual electricity consumption (Jan 2014 to Dec 2014)	6,396,300 kWh	Including power consumption by servers in the computer block
Electricity consumption density	228 kWh/m^2/year	Total floor area: 28,000 m^2
Electricity unit price	IDR 1,192/kWh	Unit price for energy reduction calculations

Source: Prepared by the study team using PT PLN (Persero) data.

Figure 3-6. Annual Electricity Consumption, 2014



Source: Prepared by the study team using PT PLN (Persero) data.

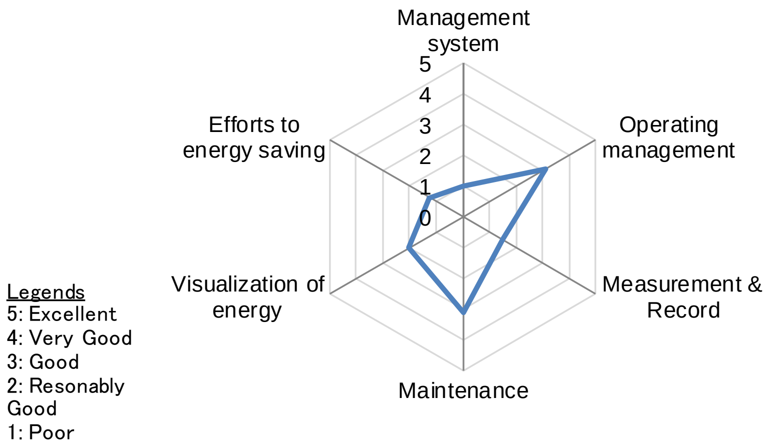
3.2. Energy management status

Based on the results of site walk-through and interviews, the current state of energy management was evaluated based on six criteria, each given a score with five points as the highest (Figure 3-7). Each criterion is further broken down into four or five evaluation items as summarised in Table 3-5.

Scores for 'operating management' and 'maintenance' are relatively good. However, the study team observed that some facilities showed signs of malfunctioning. This can be explained by the poor scores for 'management system'—meaning that there is no system for collecting sufficient data on the installed facilities.

The energy intensity of this building—an important indicator of energy management—was 228 kWh/m^2/year as of 2014. This is a useful indicator for peer comparison with other buildings with a similar load profile.

Figure 3-7. Energy Management Conditions



Source: Authors.

Table 3-5. Evaluation on Energy Management Conditions

	Items	Point to be Checked	Grade	Score	Sum
Management System	Organisation in place?	Is there a designated person or post with responsibility for energy management	In practice	1.00	1
	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?	No action	0.00	
	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?	No action	0.00	
Operating Management	Operating standard	Are there any operating standards for main systems?	Under review	0.63	3.1
	Operation managers	Are there any designated operation managers in accordance with standards?	In practice	1.25	
	Peak power management	Is attention paid to peak power using demand meter etc?	In practice	1.25	
	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	1.5
	System operation period	Are operating times recorded for main combustion, cooling, lighting systems etc.	Under review	0.50	
	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?	No action	0.00	
Maintenance	Maintenance and inspection standards	Are there any standards for maintenance and inspection of main systems?	Under review	0.63	3.1
	Maintenance and inspection log	Are there any records of maintenance and inspection of main systems?	In practice	1.25	
	Drawing maintenance	Are as-builts and system drawings maintained?	In practice	1.25	
	Scheduling of repairs and renewals	Are scheduled repairs or renewals planned based on the inspection records?	No action	0.00	
Visualization of Energy	Energy graph preparation	Are graphs showing energy data prepared?	No action	0.00	2
	Previous year's data comparison	Is there energy data from the previous year?	No action	0.00	
	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?	Under review	0.50	
	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?	Under review	0.63	1.3
	Target review	Is there a review of energy saving targets?	No action	0.00	
	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?	No action	0.00	

Source: Authors.

3.3. Proposals for improvement

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

No.	Energy saving measures	Electricity consumption saving [kWh/year]	Saving cost [IDR 1000]	Initial cost [IDR 1000]	Pay back period [Year]
A No Cost Measures (Improvement in operational practices)					
A-1	Intermittent operation of exhaust fan	34,500 kWh (0.5%)	41,124	—	—
A-2	Adjust invertor set value of secondary pump	254,600 kWh (4.0%)	303,483	—	—
A-3	Chilled water temperature change	6,900 kWh (0.1%)	7,271	—	—
Sum		296,000 kWh (4.6%)	344,607		
B High Cost Measures (Large scale remodeling)					
B-1	Renewal of turbo chillers	639,000 kWh (10.0%)	761,688	16,560,000	21.7
Sum		639,000 kWh (10.0%)	761,688	16,560,000	

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		
Reduced Energy Consumption (Electricity)		
A only	296,000 kWh/year	(4.6%)
A & B together	935,000 kWh/year	(14.6%)

A No Cost Measures (Improvements in operational practices)	
A-1	Intermittent operation of exhaust fan
Target systems	Exhaust fan for parking
Energy saving effect	34,500 kWh/year

Present condition

As the car park is mainly used by commuters to the head office, only a few vehicles are likely to enter or leave the building within the day. The exhaust fan for the car park is in operation during daytime.

Measures

Estimated vehicle traffic is about two hours in the morning and the evening, so the exhaust fan can be shut down outside of these periods. The purpose of running the exhaust fan is to remove exhaust from vehicles to prevent the air environment in the car park to worsen. The car park also has an opening that provides natural ventilation during the day.

Calculation of effectiveness

Exhaust fan capacity 30 kW × 1unit

Electrical load factor 0.8

Operation hour (present) 10 h (6:00 to 16:00) × 240 days

Operation hour (improved) 4 h (6:00 to 8:00 & 14:00 to 16:00) × 240 days

Electricity unit price IDR 1,192 /kWh

Electricity reduction 30 kW × 0.8 × (10 h – 4 h) × 240 days = 34,500 kWh/year

Saved energy cost 41,124,000 IDR/year

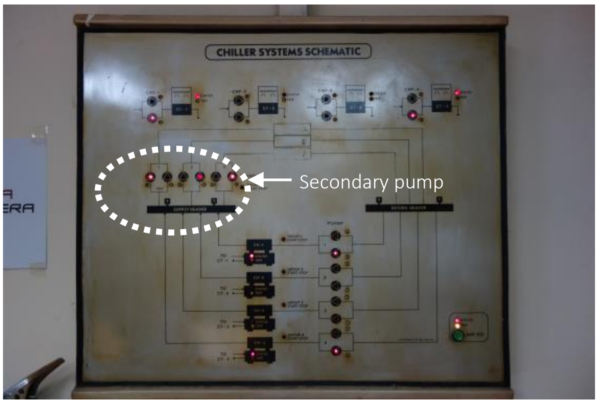
Matters that should be noted

The facility manager can manually shut down the ventilation fan. However, if possible, he could install two operation timers in the motor power board to operate automatically the fan for two hours in the morning and in the evening.

A-2	Adjust inverter set value of secondary pump
Target systems	Chilled water secondary pump
Energy saving effect	254,600 kWh/year

Present condition

The secondary pumps for three systems operate based on inverters, with large capacity pumps (125 kW) operating at fixed frequency of 40 Hz; and small pumps (45 kW), at 50 Hz.



Monitor panel for chilled water system.

Measures

Pump power consumption can be reduced by slightly reducing the inverter frequency while maintaining the lifting height of secondary pumps that can supply chilled water to the end of each system (i.e. the FCUs furthest from the pump).

While it is not possible to measure the differential pressure of the chilled water supply pipe and return pipe at the furthest FCU, the following alternatives can be used to indirectly ascertain the chilled water supply conditions at the end of the supply network:

- Select the roof situated farthest from each pump (3 points)
- Install wall-mounted thermometers/humidity gauges in each room, and take two (morning and evening) measurements one week before the proposed implementation.
- Reduce the inverter frequency value setting by 5 Hz and measure the temperature and humidity for one week, confirming whether there is any change in the indoor environment.
- If there is no change and the inverter frequency has been further reduced by 5 Hz, proceed to aim to reduce frequency by 10 Hz from the present value for the indoor environment.

Calculation of effectiveness

The amount of power reduced by lessening the inverter frequency by 10 Hz is shown below.

Pump capacity	125 kW × 2 units & 45 Hz× 1 unit
Electrical load factor	0.8
Operation hour	10 h (6:00 to 16:00) ×240 days=2,400 h/year
Inverter set value (current)	40 Hz (125 kW pump) & 50 Hz (45 kW pump)
Inverter set value (Improved)	30 Hz (125 kW pump) & 40 Hz (45 kW pump)
Rate of electricity reduction	125 kW: [(40 Hz/50 Hz)^3-(30 Hz/50 Hz)^3]÷0.9÷0.8=0.41 45 kW: [1-(40 Hz/50 Hz)^3]÷0.9÷0.8=0.67 Inverter efficiency: 0.9 Pump efficiency: 0.8
Electricity unit price	IDR 1,192 /kWh
Electricity reduction	125 kW × 0.8 × 2,400 h/year × 0.41 × 2 units= 196,800 kWh/year

$$\frac{45\ \text{kW} \times 0.8 \times 2{,}400\ \text{h/year} \times 0.67 = \quad 57{,}800\ \text{kWh/year}}{254{,}600\ \text{kWh/year}}$$

Saved energy cost IDR 303,483,000 /year

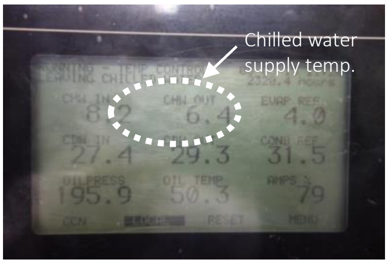
Matters that should be noted

When reducing the inverter frequency setting, the situation must be monitored for some time to ensure that there are no defects in the pump's operation. Once the operation is confirmed to be stable, it is important to measure the temperature and humidity in the most remote rooms.

A-3	Chilled water temperature change
Target systems	Turbo chiller
Energy saving effect	6,900 kWh/year

Present condition

The chiller supply water's temperature is approximately 6°C (to be more exact, 5.9°C and 6.4°C on the actual day it was measured).



Operation panel of chiller.

Measures

The effectiveness of the FCU's cooling and dehumidification are roughly equal. Thus, the power consumption can be reduced by changing the chiller temperature setting from the current 6°C to 7°C.

The chiller power consumption was not measured, but about 40 percent of the annual power consumption was estimated to come from the chiller.

Calculation of effectiveness

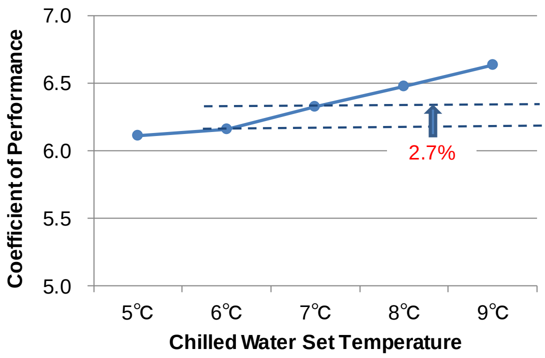
Chiller electricity consumption (assumed) 6,396,300 kWh/year × 40%=2,558,000 kWh/year

Rate of electricity reduction (figure below) 2.7%

Electricity unit price IDR1,192/kWh

Electricity reduction 2,558,000 kWh/year × 2.7% = 6,900 kWh/year

Saved energy cost IDR7,271,000/year



Matters that should be noted

If the chiller temperature setting is not restricted to the proposed 7°C but increased to 8°C, further reductions in power consumption can be achieved. The chiller's water temperature setting and relative humidity of the office are related, and dehumidification is generally carried out up to about 8°C. Any setting higher than that means there is a high risk of raising the relative humidity in all offices.

Ideally, temperature and humidity meters should be installed in some offices, and the progress monitored.

B High cost measures (Large-scale remodelling)	
B-1	Replacement of turbo chillers
Target systems	CH-1 to 4 Turbo chillers
Energy saving effect	639,000 kWh/year

Present conditions

The existing turbo chillers were manufactured in 1994 and are now showing signs of deterioration. The COP has also decreased.

The existing chiller.

Measures

By upgrading units with more recent highly efficient turbo chillers, the COP can be improved to reduce the power consumption. The chiller power consumption (estimated) value is the same as that proposed in Proposal A2.

Calculation of effectiveness

Electricity consumption of chillers (assumed) 6,396,300 kWh/year × 40%= 2,558,000 kWh/year

COP of existing chillers (assumed) 4.5

COP of renewed chillers 6.0

Electricity unit price IDR1,192/kWh

Electricity reduction 2,558,000 kWh/year × (1-4.5/6.0)

= 639,000 kWh/year

Saved energy cost IDR761,688,000/year

Investment cost (estimated roughly) IDR16,560,000,000 (4 chillers only)

Recovery period 21.7 years

Matters that should be noted

As the construction costs for chiller replacement would be high, it might be possible to replace each unit by turns.

Chapter 4

Case Study: MEA Nonthaburi District Area (Bangkok, Thailand)

1. Overview of the Case Study Site

The MEA Nonthaburi District Office is one of the district offices (branch offices) of MEA in northern Bangkok. Its site has 11 buildings. Of these, the newly reconstructed main office building completed in 2012 was chosen here for the case study.

Plans to deploy the BEMS in the main building is ongoing. According to MEA officers, some energy-saving measures are already in practice—e.g. personal switch control, and switching off machines during lunchtime. They understand well that the combination of three elements of energy management—i.e. people's mindset, equipment, and management methods—is important in achieving energy savings, and they need suggestion and advices in this regard.

Table 4-1 is the general overview of the MEA Nonthaburi Office and its energy consumption.

Table 4-1 Overview of MEA Nonthaburi Office Main Office Building, Thailand

Name	Nonthaburi District Office
Year Operated	2012
Total floor area	11 081 m^2
Air-conditioned floor area	6 969 m^2
Number of floor	11
Number of daytime workers	330
Maximum demand	418.4 kW
Supply voltage	24 kV
Total capacity of electrical facilities 1) Heat source: AC, etc. 2) Lighting 3) Office Electronics and Motors	580 kW 60% 12% 28%

Source: Prepared by the study team using Metropolitan Electricity Authority data.

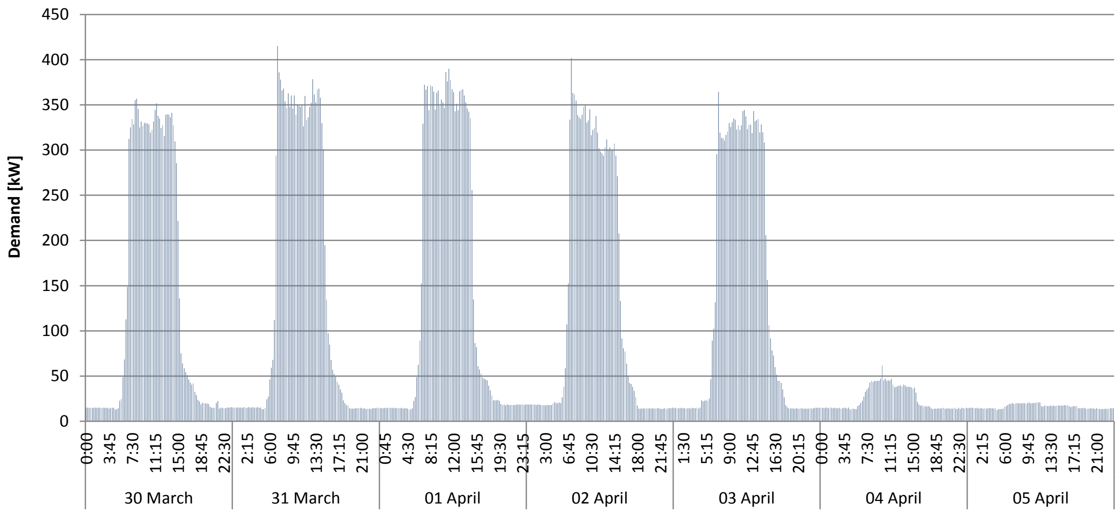
2. Preliminary Study

The study team also analysed the potential energy efficiency based on the data provided by MEA before conducting a detailed field survey. The study team also presented the tentative results of this preliminary survey at the second Working Group meeting in Tokyo on 2 July 2015.

2.1. Energy saving target

At the Main Office building of the MEA Nonthaburi District Office, power demand is metered every 15 minutes. The actual load profile of the building for a week (30 March–5 April 2015) is shown in Figure 4-1.

Figure 4-1. Weekly Load Profile of Nonthaburi Main Office Building (30 March 2015 – 5 April 2015)

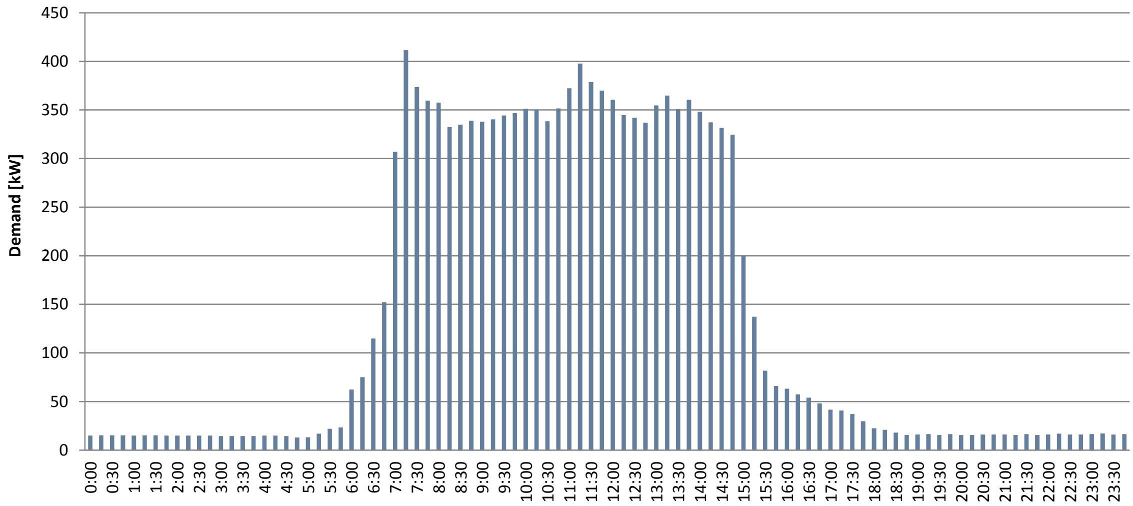


Source: Prepared by the study team using Metropolitan Electricity Authority data.

Like PLN Yayasan Building, the load profile of Nonthaburi Main Office Building follows a pattern. On weekdays, the load increases at the start of the working hours. After maintaining a constant level (300-400 kW), it starts decreasing to the off-peak load in the evening (about 20 kW). The load at night is almost constant at about 20 kW. On Saturdays, it increases during the daytime although not as much as that on weekdays, because some employees work in the office even on weekends.

Figure 4-2 shows the daily load profile on 9 April 2015. The load starts increasing rapidly at 05:30 and, after hitting the daily peak at 07:00, slightly decreases, before settling at around 350 kW until 15:00. Then, the load starts dropping rapidly, although not as fast as the increase in the morning, and almost reaches the bottom load at around 18:30.

Figure 4-2. Daily Load Profile of Nonthaburi Main Office Building (9 April 2015)



Source: Prepared by the study team using Metropolitan Electricity Authority data.

According to the MEA, the annual electricity consumption of the Nonthaburi Main Office Building in 2014 was 1,492,055 kWh. The monthly breakdown is shown in Table 4-2.

Table 4-2. Monthly Electricity Consumption at Nonthaburi Main Office Building (kWh), 2014

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
93,045	95,599	119,679	123,988	138,066	140,282	135,740	134,356	132,512	130,613	144,606	103,569

Source: Metropolitan Electricity Authority.

In Thailand, the hottest days in the year usually comes in April and May, and the annual peak load on the national grid of the Electricity Generating Company of Thailand is usually recorded during these two months. The monthly electricity consumption of this building in April and May, however, is smaller than that in June probably because of the many national holidays in April and May. The electricity consumption in November, which is a relatively cool month, is the largest among twelve months. Such is presumed to be because this is a peak season for business.

The main electrical equipment installed at Nonthaburi Main Office Building is listed in Table 4-3.

Table 4-3. Main Electrical Equipment Installed at Nonthaburi Main Office Building

1. Heat-source equipment (AC etc.) 59.76 % of total power consumption

	Name of the product	No. of units	Capacity (Tons*)	COP	
Chiller system	Trane water cooled chiller	3	221	4.753	
*Centralized cooling	YORK Air cooled chiller**	1	56.5	Unidentifiled	** design for day off

	Name of the product	No. of units	Capacity (Tons*)	COP	Remark
Packaged AC	AC split type(trane) (1.64 kW)*	1	18000 Btu/hr	3.22	minimum efficiency from ministerial regulations
*Individual cooling	AC split type(trane) (2.73 kW)*	2	30000 Btu/hr	3.22	
	AC split type(trane) (3.27 kW)*	4	36000 Btu/hr	3.22	
	AC split type (LG)** (1.61 kW)*	6	18831 Btu/hr	3.43	from name plate
	AC split type (LG)** (2.28 kW)*	3	24000 Btu/hr	3.09	
	AC split type (LG)** (2.67 kW))*	2	30176 Btu/hr	3.31	
	AC split type (LG)** (11.05 kW)*	1	100000 Btu/h	2.65	
	AC split type (LG)** (12.19 kW)*	1	125000 Btu/h	3.01	
	Multi V VRF (LG)** ((55.14 kW)*	1 curcuit / 9 Fc	630700 Btu/hr	3.35	

*Note: 1 Ton = capacity of removing the heat to freeze 2000 pounds of water into ice in 24 hours (=3515 W)

* Power supply ** design for day off

		No. of units	Capacity (kW)	Inverter controlled	
Auxiliary power	Cooling water circulation pump	3	22	Yes / No	Under Construction
	Cooling tower	3	5.5		
	Primary water cooling pump	3	22	Yes / No	Under Construction
	Secondary water cooling pump	-	-	Yes / No	
	Indoor unit	6			
	Fan coil unit	53			

Others (if any, sepcify)

2. Lighting 11.84 % of total power consumption

Type of lighting (LED, Fluorescent etc)	No. of units	Capacity (kW)
1x120 w PAR38	160	19.84
1x18 w Compact Fluorescent	430	9.46
1x18 w Fluorescent	34	0.75
2x18 w Fluorescent	8	0.35
1x26 w Compact Fluorescent	176	5.28
1x36 w Fluorescent	464	18.56
2x36 w Fluorescent	1,204	96.32
1x300 w Halogen	4	1.22
Total	2,480	151.78

* Please add more lines if needed

3. Office electronics (PC etc.) 28.40* % of total power consumption *included 4. motors

Laptop PC	8	units x		kW/unit
Desktop PC	110	units x		kW/unit
Laser printer	103	units x		kW/unit
Scaner&Barcode scaner	20	units x		kW/unit
Display or LCD TV	18	units x		kW/unit
Others (if any, sepcify)		units x		kW/unit

4. Motors Unidentifiled % of total power consumption

Water pump for water supply	2	units x	4	kW/unit
Water pump for water supply	2	units x	11	kW/unit
Lifts (elevators)	2	units x	18.5	kW/unit
Fireman lift	1	units x	15	kW/unit
Escarators	-	units x		kW/unit
Others (if any, sepcify)				

5. Others (if any) -

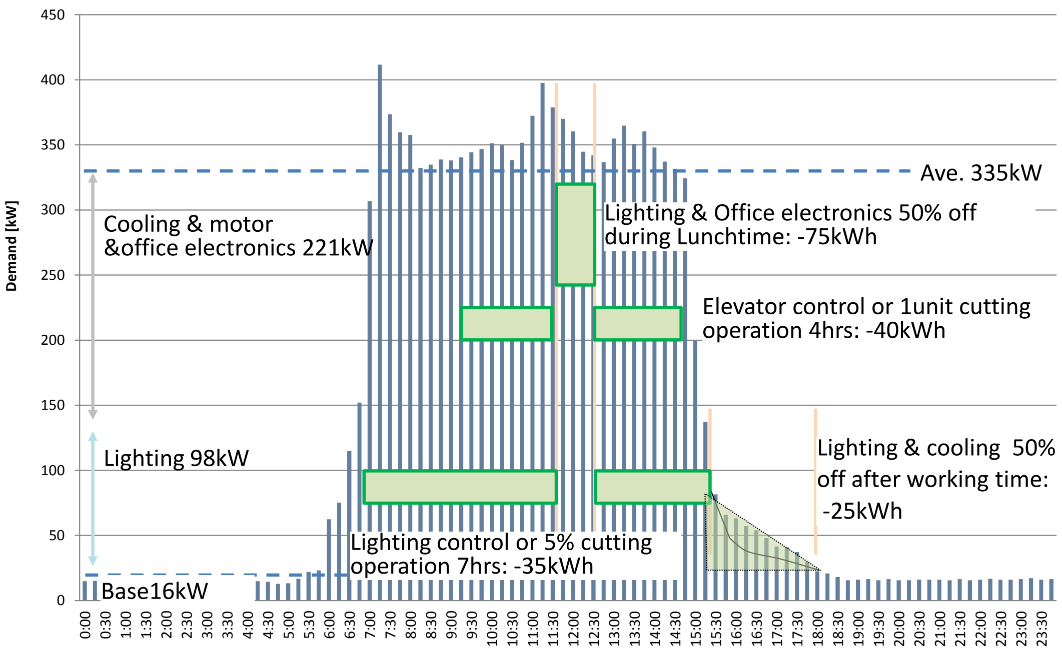
Source: Metropolitan Electricity Authority.

Based on the above information, the study team estimated the breakdown of the daytime load (averaging 1,518 kW) by equipment. This load estimate assumes that the cooling demand accounts for about 40 percent of the daytime demand.

Cooling & Motor	221 kW	(66%)
(including office electronics)		
Lighting	98 kW	(29%)
Base load night time	16 kW	(5%)
Daytime load	335 kW	(100%)

2.2. Measures for achieving the target

Figure 4-3. Energy Saving Potential of Nonthaburi Main Office Building, April 2015



Source: Prepared by the study team using Metropolitan Electricity Authority data.

3. Observation from Site Survey

A site survey with walkthrough and interviews with personnel were conducted on 5 August 2015 to gain an understanding of the energy-saving performance. The building that was completed in 2012, along with all its equipment, was identified as the newest infrastructure.

The following descriptions on the chilled water supply system, and cooling and ventilation system relate to the diagrams below.

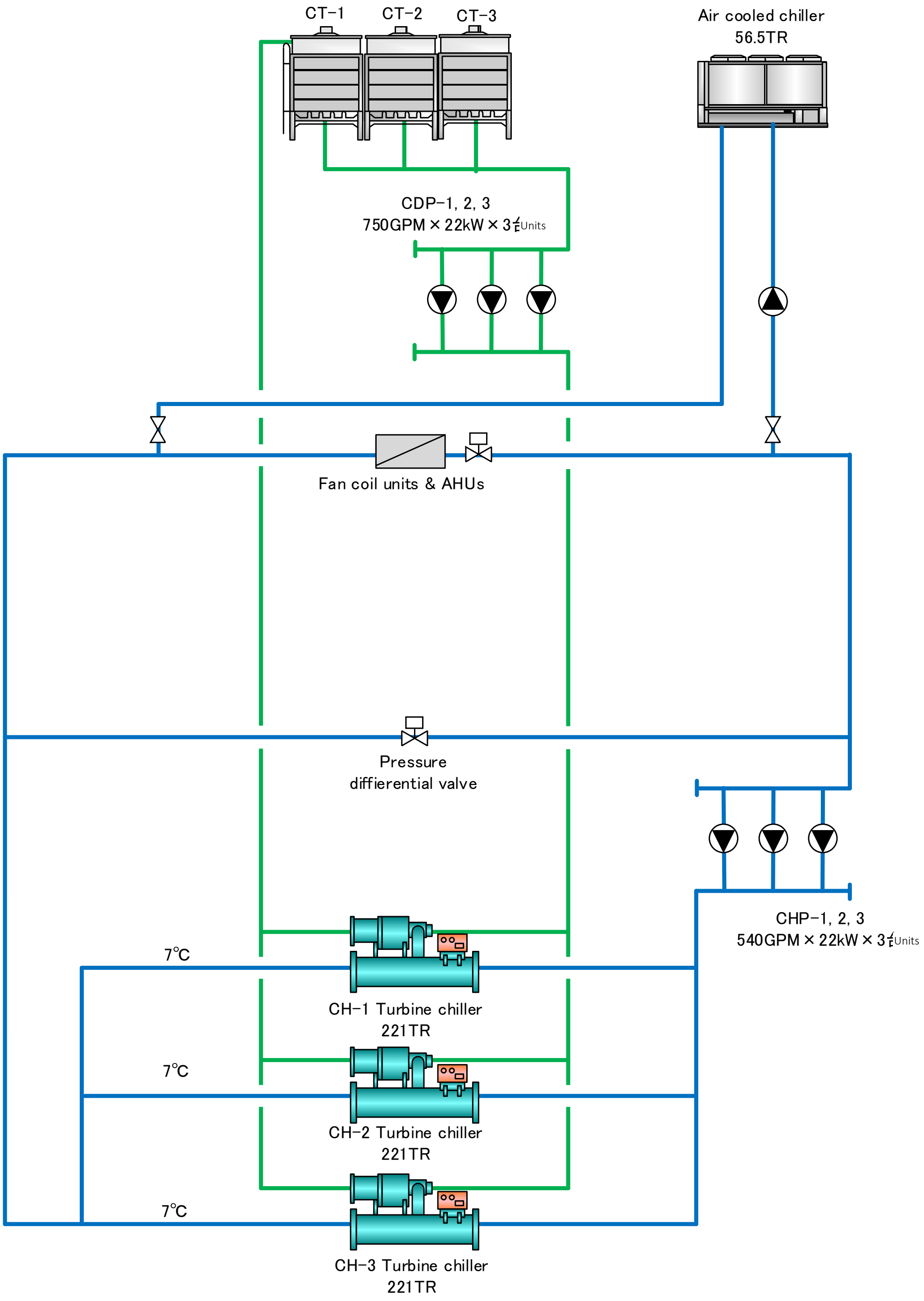
<u>Chilled water supply system</u>

- Daily operating hours: 9 hours (07:30 to 15:30)
- Chiller units: 221 TR × 3 units are installed but only two units are operating regularly
- Chilled water supply temperature settings: 7°C, condenser water supply temperature: 32°C.
- Chilled water pump: three units, water supplied by primary pump system
- Additional automatic control works were installed, with the introduction of automatic operation control for three chiller units, and of chilled water and condensed water pump inverter control. (These control works are recently installed, so results shall be monitored)

<u>Cooling and ventilation</u>

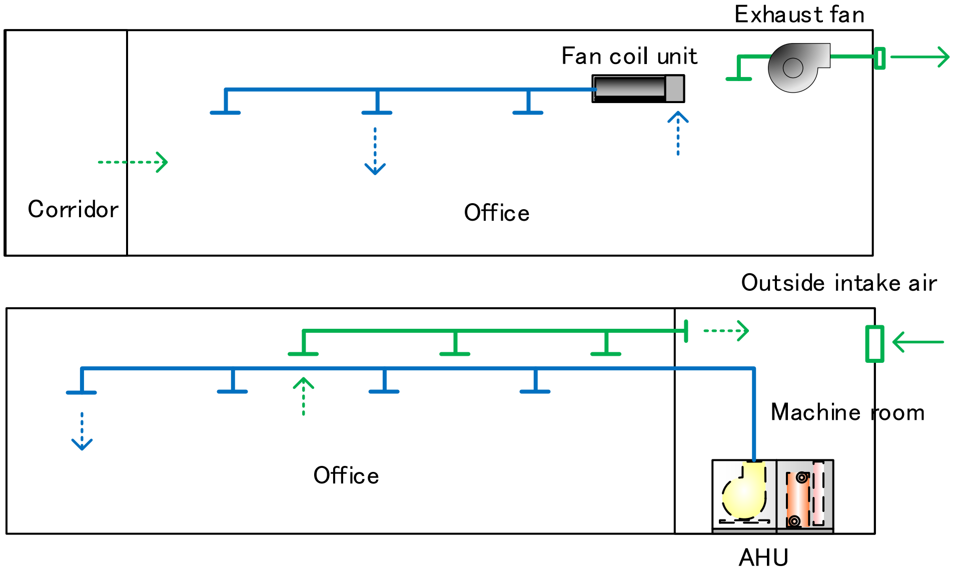
- In each cooling area, two types of cooling systems are in use. One is cooling and ventilation by FCU, with air supplied to rooms from corridors, supplying the air volume exhausted by ceiling fans. Air-conditioning units also provide cooling and ventilation.
- Air-conditioning units are installed in the machine room. Fresh air flows into the machine room via air return chambers in various rooms. Air intake is naturally provided by holes in the wall and there is no built-in air volume control.
- CO_2 density gauges are installed in each office and are monitored (i.e. no automatic control).
- There is natural ventilation on three car park floors (3rd to 5th). Some lighting fixtures also switch off selectively to reduce energy consumption.

Figure 4-4. Simplified Diagram of Chilled Water Supply System, Nonthaburi District Office



Source: Authors.

Figure 4-5. Simplified Diagram of Air Conditioning and Ventilation, Nonthaburi



Source: Authors.

3.1. Energy usage conditions

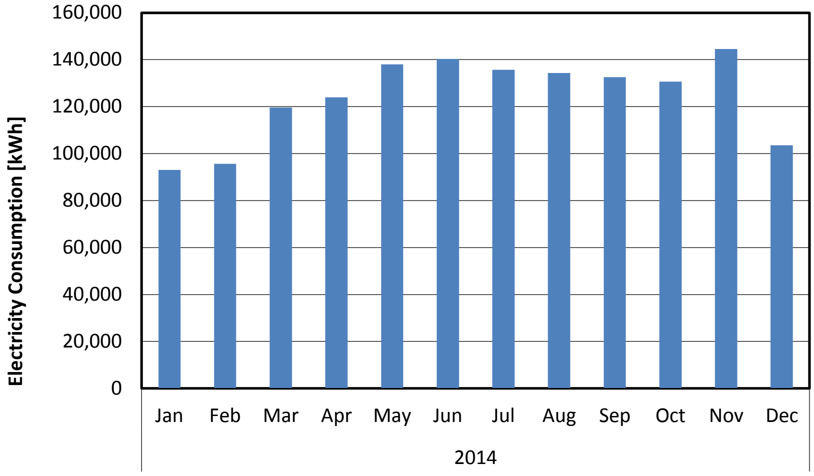
Table 4-4 presents the energy consumption at the MEA Nonthaburi facilities. It gives an assessment of the annual energy consumption and calculation conditions used to calculate the proposed energy savings.

In 2014, monthly energy usage declined from December to February; there were no big changes in the other months. There was an increase in November but this was due to the number of events and seminars held at the facilities.

Table 4-4. Energy Usage, MEA Nonthaburi Facilities

Items	Conditions	Remarks
Annual electricity consumption (Jan 2014 to Dec 2014)	1,492,055 kWh	Including power consumption by servers in the computer block
Electricity consumption density	135 kWh/m^2/year	Total floor area: 13,081 m^2
Electricity unit price	3.38 B/kWh	Unit price for energy reduction calculations

Figure 4-6. Annual Electricity Consumption, 2014



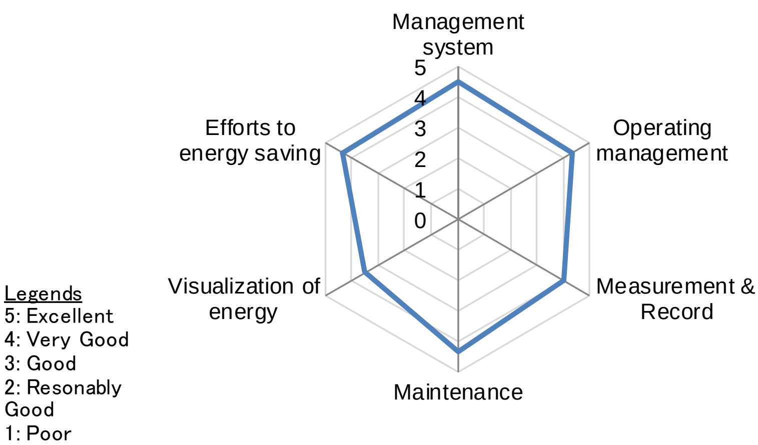
Source: Prepared by the study team using Metropolitan Electricity Authority data.

3.2. Energy management status

Based on the results of the site walk-through and interviews, the current state of EMS of the MEA Nonthaburi building was evaluated using six criteria. Each criterion was scored from 1 (lowest) to 5 (highest) (4-7). Each criterion is further broken down into four or five evaluation items (Table 4-5).

Results show high scores for each criterion. It was noted that the establishment of the EMS is well interrelated with office employees' awareness of energy efficiency.

Figure 4-7. Energy Management Conditions: MEA Nonthaburi



Source: Authors.

Table 4-5. Evaluation on Energy Management Conditions

	Items	Point to be checked	Grade	Score	Sum
Management system	Organisation in place?	Is there a designated person or post with responsibility for energy management	In practice	1.00	4.5
	Announcement of main goals	Any promotion by posters, slogans etc.	In practice	1.00	
	Coordination with related posts	Are several members of personnel actively participating?	In practice	1.00	
	Record of activities	Are energy management activities recorded?	Under review	0.50	
	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	4.4
	Operation managers	Are there any designated operation managers in accordance with standards?	In practice	1.25	
	Peak power management	Is attention paid to peak power using demand meter etc?	Under review	0.63	
	Review of standards	Are operating standards revised on an as needed basis?	In practice	1.25	
Measurement & Record	Energy consumption	Are there records (paper chits, memos etc.) of energy usage?	In practice	1.00	4
	System operation period	Are operating times recorded for main combustion, cooling, lighting systems etc.	Under review	0.50	
	Separate energy measurements	Knowledge of energy usage according to different departments or application?	In practice	1.00	
	Data on system operation conditions	Are measurements of temperature, illuminance, current etc. taken?	In practice	1.00	
	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?	Under review	0.63	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-builts and system drawings maintained?	In practice	1.25	
	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	3.5
	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?	No action	0.00	
	Data analysis	Is analysis of increases or decreases in energy usage carried out?	In practice	1.00	
Efforts to energy saving	Target setting	Are there any target settings for energy saving?	In practice	1.25	4.4
	Target review	Is there a review of energy saving targets?	Under review	0.63	
	System improvement	Is there any implementation or review of system improvements or remedial measures?	In practice	1.25	
	Results of improvement	Is there any verification of the efficacy of improvements or remedial measures?	In practice	1.25	

Source: Authors.

3.3. Proposals for improvement

The following is a list of energy saving proposals drafted during the site survey. These are divided into three categories. Proposals in A and B require no investment or have costs that can be recovered within five years, and thus can be implemented promptly.

No.	Energy saving measures	Electricity consumption saving [kWh/year]	Saving cost [1000B]	Initial cost [1000B]	Pay back period [Year]
A No Cost Measures (Improvements in operational practices)					
A-1	Chilled water temperature change	1,800 kWh (0.1%)	6	—	—
Sum		1,800 kWh (0.1%)	6		
B Low Cost Measures (Remodling to recover investment capital within 5 years)					
B-1	Adjust outside air volume to AHUs	11,700 kWh (0.8%)	40	176	4.5
B-2	Variable flow control for primary pumps	31,100 kWh (2.1%)	105	504	4.8
Sum		42,800 kWh (2.9%)	145	680	

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		
Reduced Energy Consumption (Electricity)		
A only	1,800 kWh/year	(0.1%)
A & B together	44,600 kWh/year	(3.0%)

A No Cost Measures (Improvements in operational practices)	
A-1	Chilled water temperature change
Target systems	Turbo chillers
Energy-saving effect	1,800 kWh/year

Present condition

Chiller water supply temperature is about 7°C.

Measures

The cooling and dehumidification effectiveness of the FCU was slightly reduced. However, changing the chiller temperature setting from the current 7°C to 8°C reduces chiller energy consumption. Chiller energy consumption, according to MEA, is about 55 percent of the annual energy consumption.

Calculation of effectiveness

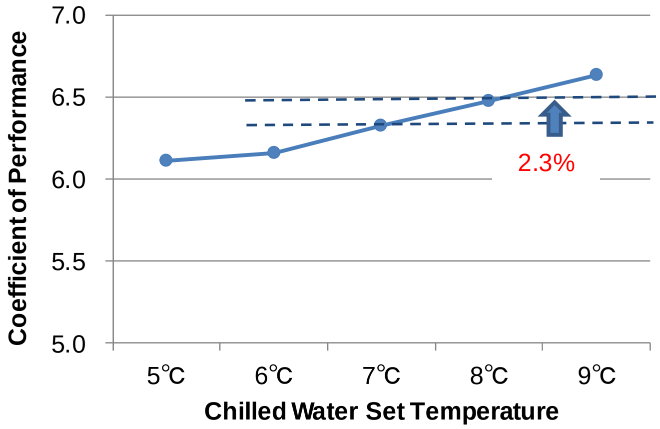
Chiller electricity consumption (assumed) 1,492,055 kWh/year × 55%=820,600 kWh/year

Rate of electricity reduction (figure below) 2.3%

Electricity unit price THB3.38/kWh

Electricity reduction 820,600 kWh/year × 2.3% = 1,800 kWh/year

Saved energy cost THB6/year



Matters that should be noted

Further reductions in energy consumption can be achieved if the chiller temperature's setting is not restricted to the proposed 8°C and instead increased to 9°C. The chillers' chilled water temperature setting and the relative humidity of the office are related, and this study therefore proposes that temperature and humidity gauges be installed in some offices and monitored accordingly.

B Low Cost Measures (Remodelling to recover investment capital within 5 years)	
B-1	Adjust outside air volume to AHUs
Target systems	AHUs
Energy saving effect	11,700 kWh/year

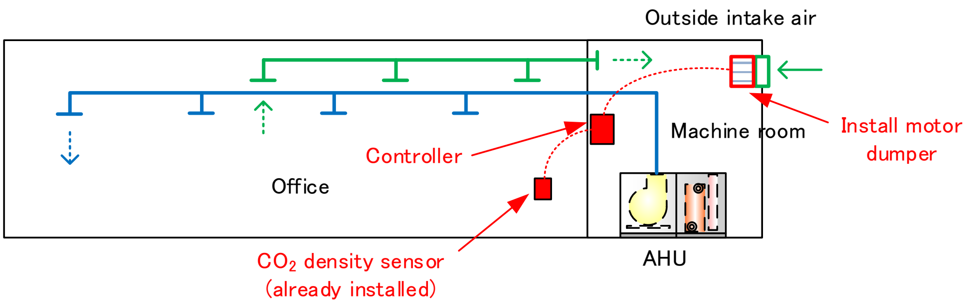
AHU = air handling unit.

Present conditions

AHUs provide fresh air intake via wall openings in the machine room but with no control damper installed.

Measures

The installation of a motor damper in wall openings and sensors to measure CO_2 in offices (and controlled from a centralised panel in the machine room) can provide variable intake of fresh air based on the CO_2 density. These measures shall reduce the energy required to cool down areas.



Calculation of effectiveness

Outside air intake	13,900 m3/h×1.2 kg/m^3×40%=6,600 kg/h
Operating time	9 h (7:30 to 15:30) ×240 day/year=2,160 h/year
Outside CO_2 density	400 ppm

Average inside CO_2 density 587 ppm

Acceptable inside CO_2 density 900 ppm

Possible reduction of air intake 40% [1-(587-400)/(900-400)=0.40]

Cooling load reduction 6,600 kg/h × 2,160 h/year × 40% × 22.3 kJ/kg/1000

= 127,164 MJ/year → 35,300 kWh/year

COP of existing chillers (assumed) 3.0

Electricity unit price THB3.38/kWh

Electricity reduction 820,600 kWh/year ÷ 3 = 11,700 kWh/year

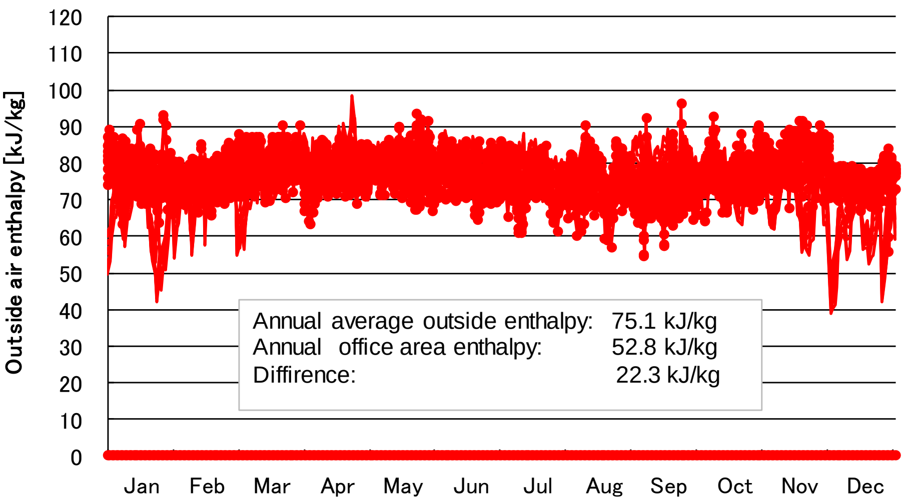
Saved energy cost THB39,500/year

Investment cost (estimated roughly) THB176,000 (AHU × 4 units)

Recovery period 4.5 years

Floor	Use	Unit No.	Supply air volume GPM	Supply air volume m^3/h	AC operation	Average CO_2 density [ppm]
1	Service	AHU-1-01	12,000	2,700	7:30 to 15:00	615
6	Canteen	AHU-6-01	14,000	3,200	Lunch time only	
7	Office	AHU-7-01	14,000	3,200	7:30 to 15:00	591
7	Office	AHU-7-02	14,000	3,200	7:30 to 15:00	603
9	Office	AHU-9-01	21,000	4,800	7:30 to 15:00	542
Roof	Conference	AHU-CONF-01	15,000	3,400	as needed	
Sum				13,900	except 6th & Roof floor	

AHU = air handling unit.



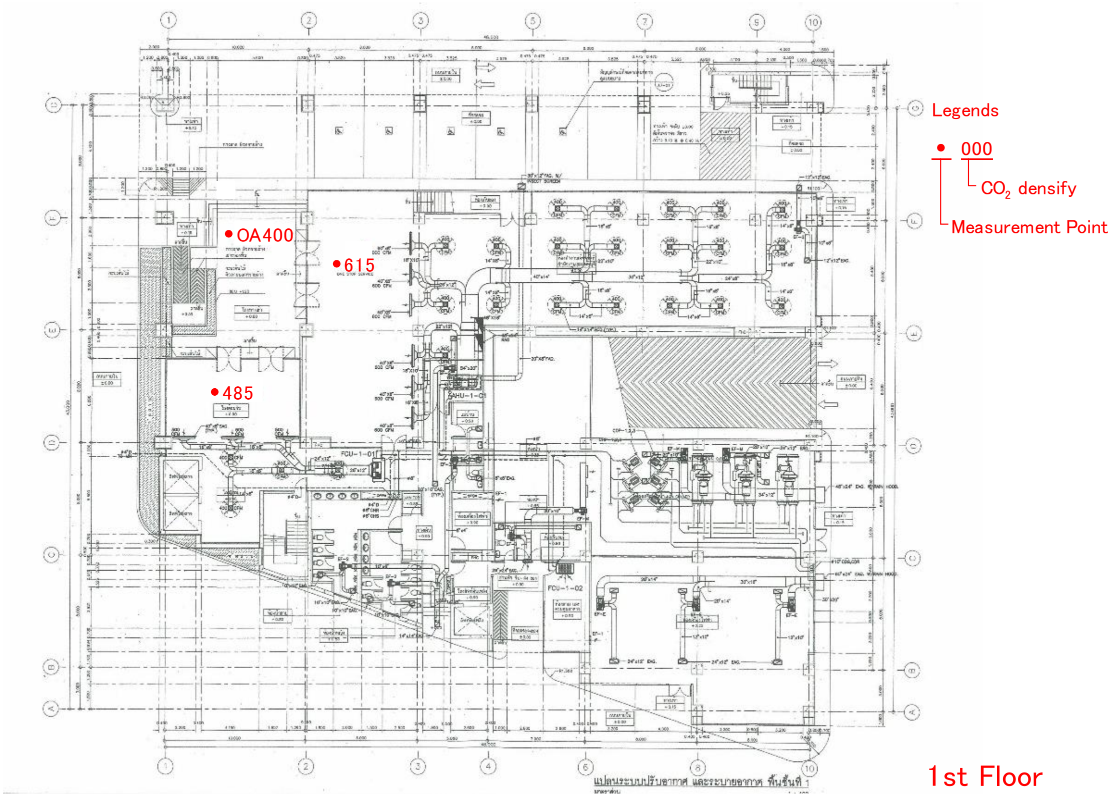
Monthly average anthalpy [kJ/kg]

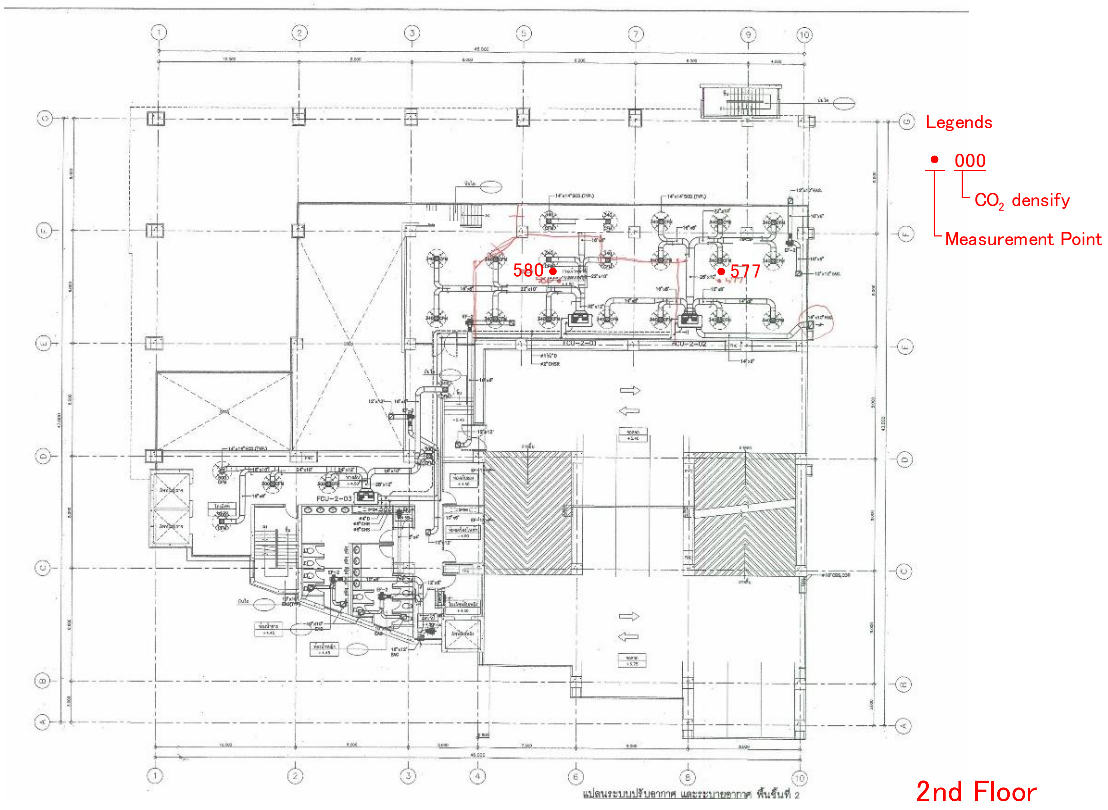
Outside	66.6	74.2	76.2	82.0	78.0	79.7	78.0	74.6	81.2	77.2	71.2	62.6
Office area	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8
Diff.	13.8	21.4	23.4	29.2	25.2	26.9	25.2	21.8	28.4	24.4	18.4	9.8

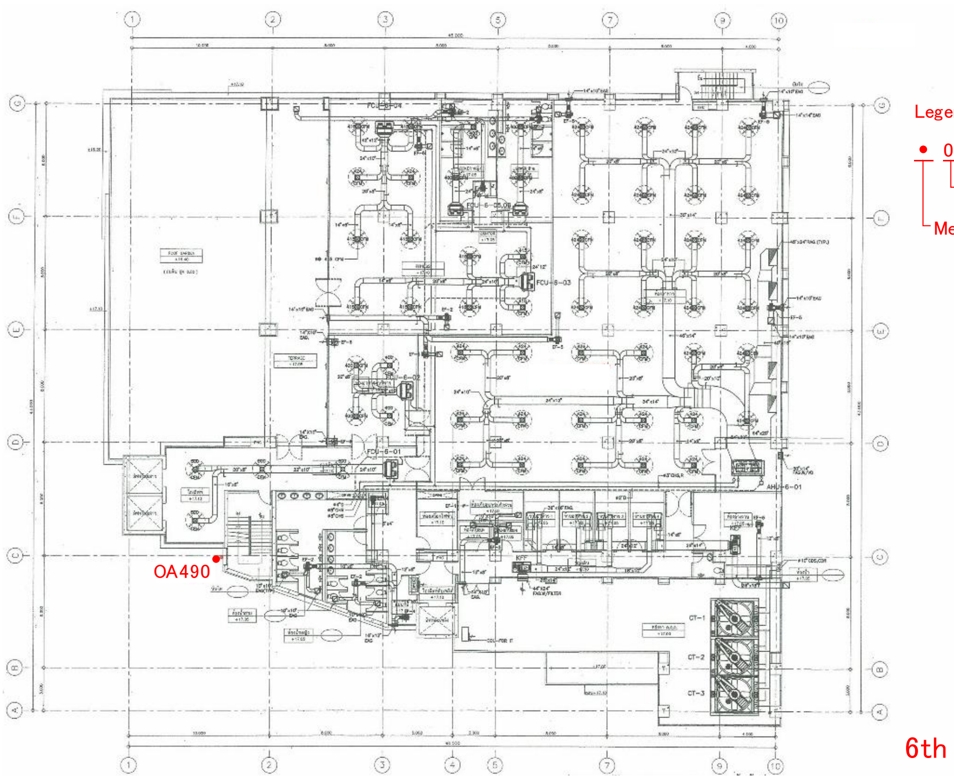
Room condition: temperature 25°C & relative humidity 55% (assumed)

Matters that should be noted

As a prerequisite to the proposals here, one must first measure and confirm the volume of air intake from the machine room’s wall opening (for fresh air intake).



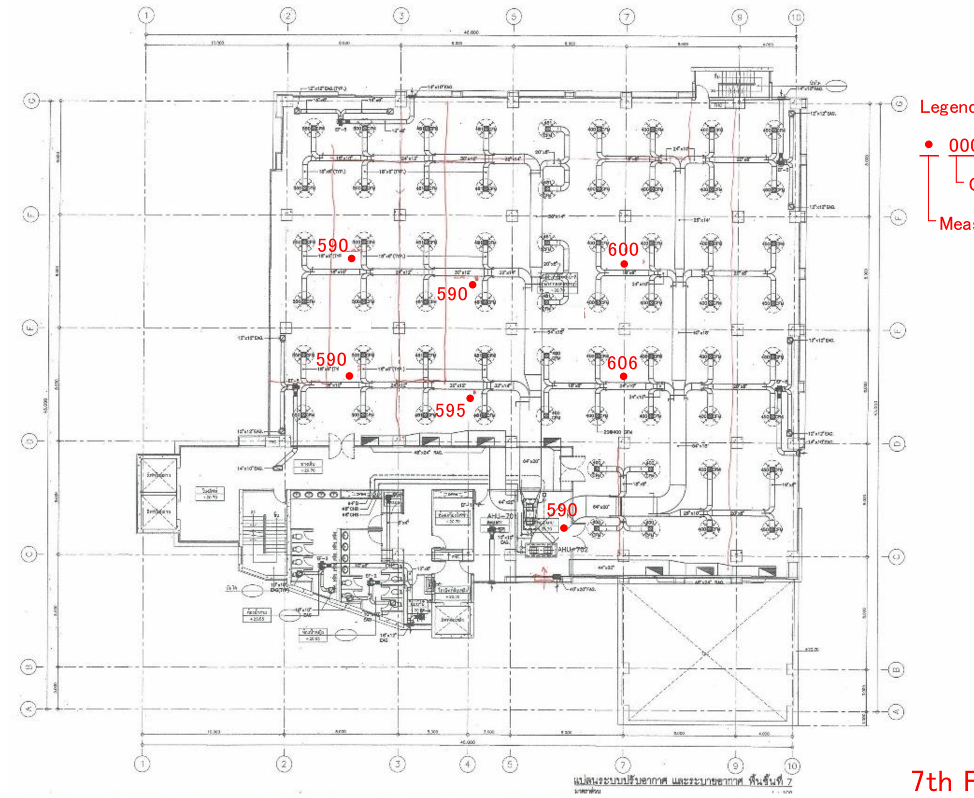

Legends
000
CO_2 densify
Measurement Point
580
577
FCU-2-03
2nd Floor



Legends

● 000 — CO_2 densify — Measurement Point

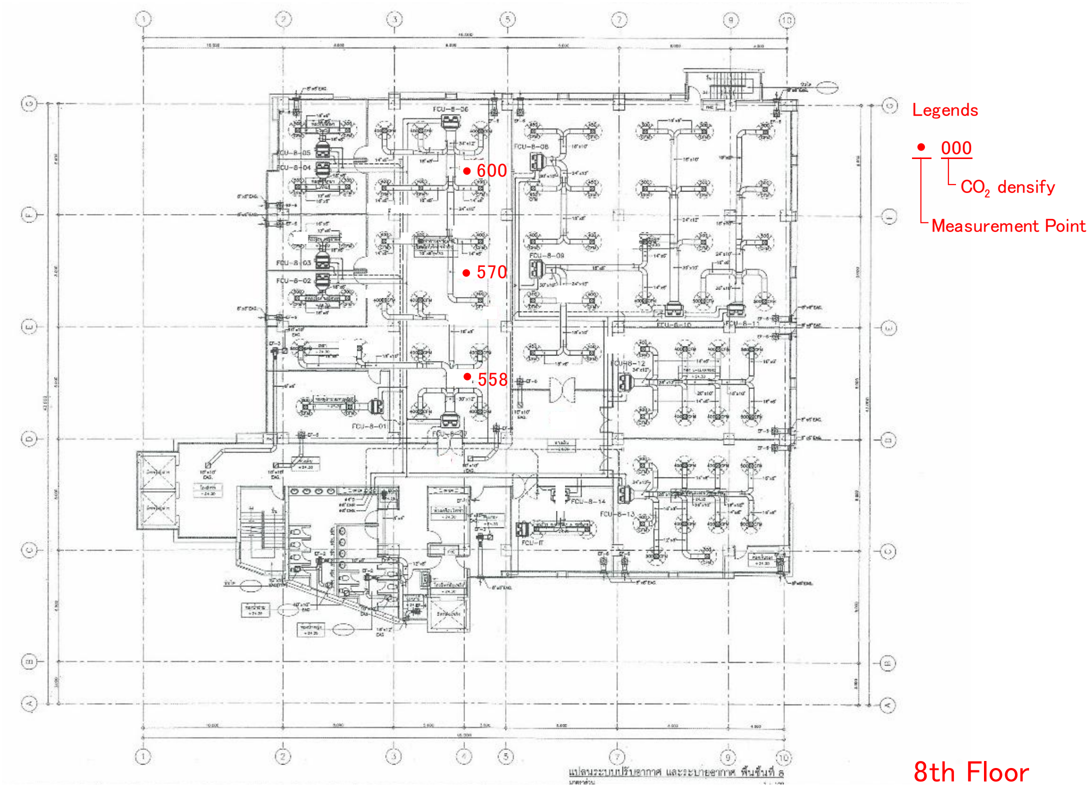
6th Floor

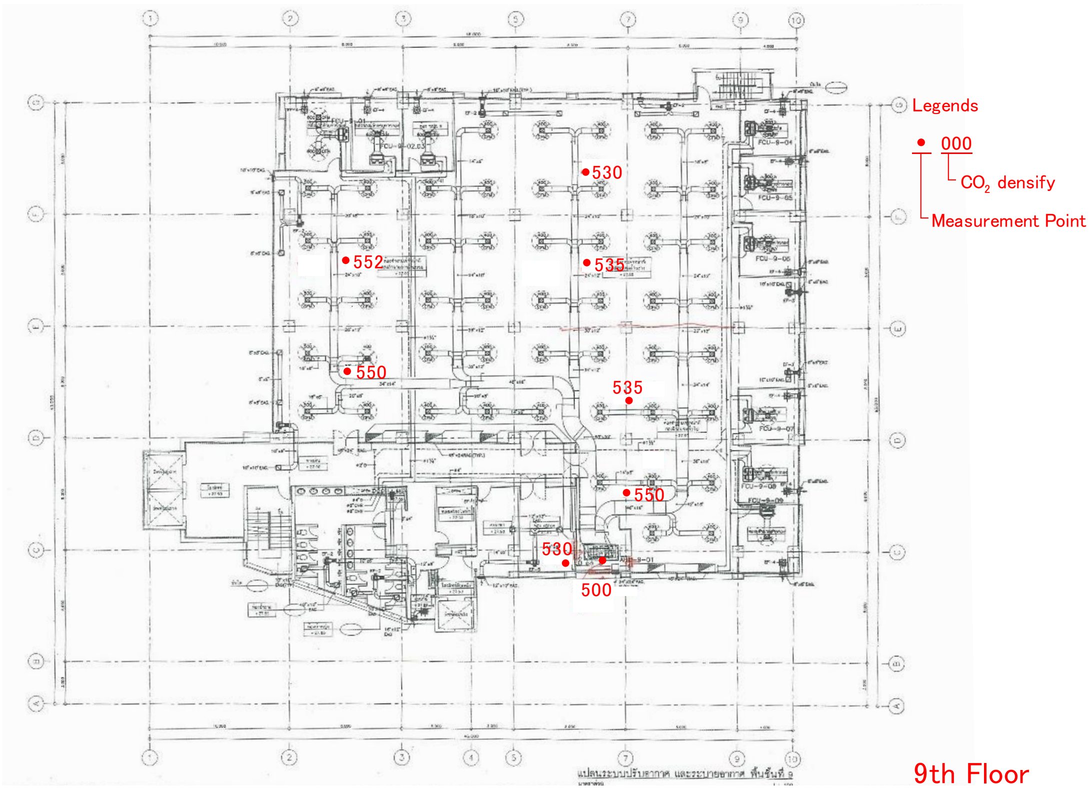


Legends

● 000 — CO_2 densify — Measurement Point

7th Floor





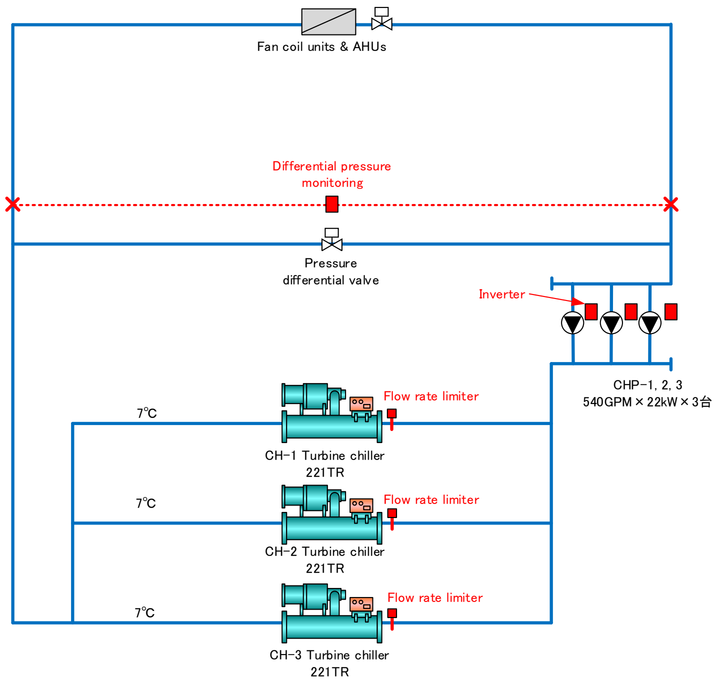
B-2	Variable flow control for primary pumps
Target systems	Primary pumps
Energy saving effect	31,100 kWh/year

Present conditions

Two units of primary pump units (CHP-1 to 3) each run at a fixed speed throughout the year.

Measures

Heat load based on the number of occupants, outside climate conditions, and the absence of insulation on the windowpanes, varies with the time of day. The existing turbo chiller has a variable flow rate. If the primary pump motor has an inverter to control frequency variations, then the variable flow control can be added to the primary pump to reduce power consumption.



Calculation of effectiveness

Pump capacity 22kW × 2units
Electrical load factor 0.8
Operation hour 9h (7:30 to 15:30) × 240 days = 2,160h/year
Annual average thermal load 0.75 (here the annual average of 0.75 has been adopted for daily enthalpy against the high value for fresh air enthalpy)
Rate of electricity reduction $1-0.75^3 \div 0.9 \div 0.8 = 0.41$
Invertor efficiency: 0.9 Pump efficiency: 0.8
Electricity unit price THB3.38/kWh
Electricity reduction 22kW × 2units × 0.8 × 2,160h/year × 0.41=31,100kWh/year
Saved energy cost THB105,100/year
Investment cost (estimated roughly) THB504,400 (Inverter and control)
Recovery period 4.8 years

Matters that should be noted

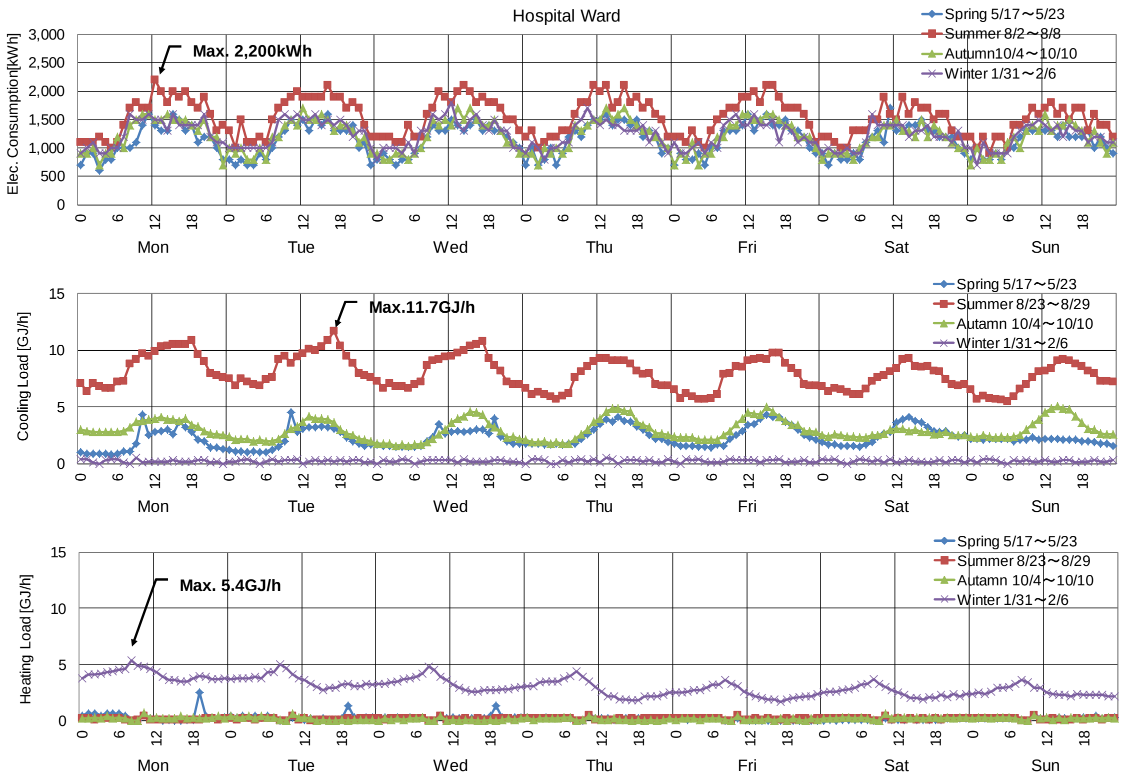
Generally, 50 percent is the minimum chilled water flow rate of turbo chillers (Note that this varies depending on the manufacturer). Under the said flow rates, operational issues may occur. Adding a flow limiter to avoid falling below the minimum flow rates may be considered.

3.4. Examples of EMS data analysis

Data on energy consumption gathered by the BMS can be used to determine the pattern of energy usage throughout the building, the operational performance of the chillers, etc. Some methods of data analyses are explained below.

<u>Representative weekly graph</u>

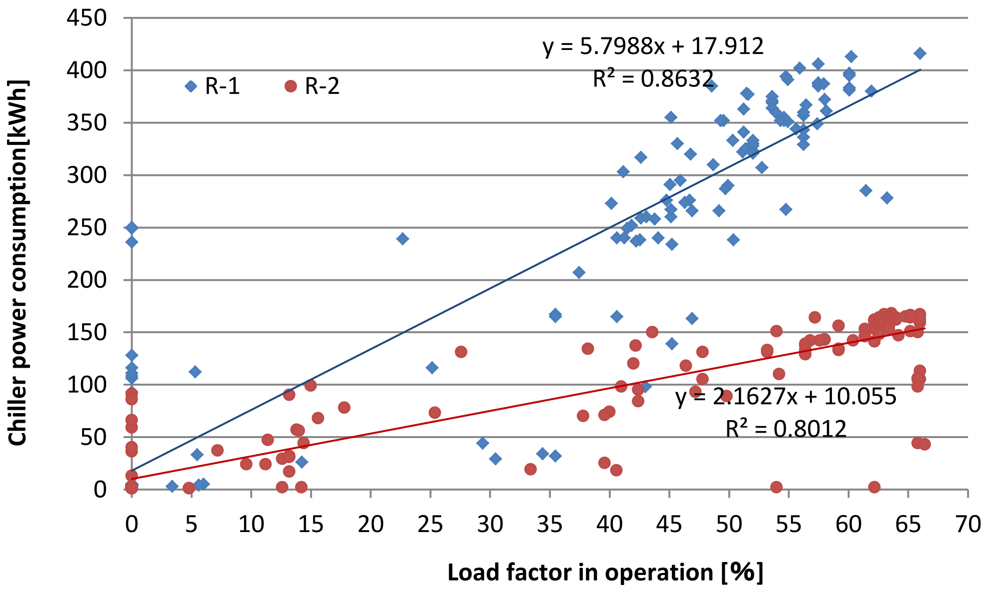
By looking at data on a weekly basis, the differences in energy consumption patterns during weekdays and holidays become apparent. In Japan, there are seasonal changes in temperature and humidity. The graphs below show energy consumption in a hospital in spring, summer, autumn and winter.



<u>Chiller power consumption and operating load factor correlation</u>

Figure 4-8 shows the correlation between chiller power consumption and operating load factor (ratio of rated capacity against operational capacity). It can verify whether the chiller operates according to standards and whether any deterioration increases the power consumption even if the load factor remains constant.

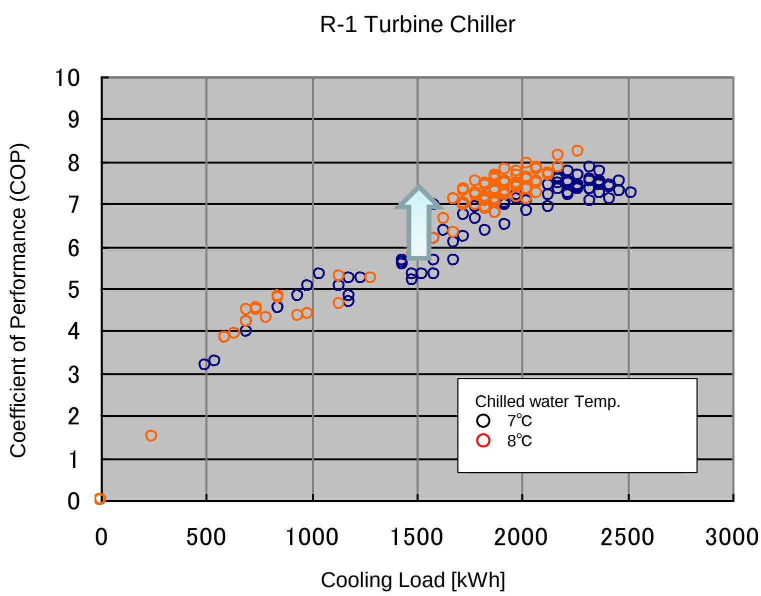
Figure 4-8. Correlation Between Chiller Power Consumption and Operating Load Factor



Correlation between cooling load and COP

There is a correlation between cooling load and COP. The graph below evaluates the turbo chiller's (650 TR) performance, and confirms that changing the chilled water temperature setting from 7˚C to 8˚C improves the COP.

Figure 4-9. Correlation Between Cooling Load and COP



Chapter 5

Interim Findings (FY2014) and the Way Forward

1. Interim Findings (FY2014)

In the first year of study, the analysis focused on the potential of disseminating and deploying EMS technologies in the EAS region, especially for office buildings.

Case studies within EAS countries show that the key factors of energy savings through xEMS deployment are: *visibility* (to grasp the actual situation of energy consumption), *accessibility* (to easily check the collected date), and *comparability* (to compare with other users with similar load profile). The most efficient mix of measures are selected to optimise the economic benefit versus the cost.

Case studies were conducted in two sites: one in Indonesia and another, in Thailand. First, the desk-based research on energy-saving actions/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. There are mainly two points to improve in air conditioners of office buildings. One is to adjust the intake volume of fresh air from outdoors. The other is to adjust the frequency of motor power using inverters.

The first suggestion (i.e. adjustment of air intake) solves problems associated with excessive ventilation. Too much ventilation causes the load to increase as chillers and refrigerators lose energy by unnecessarily exhausting cold air outside. This study suggests 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 intake volume of fresh air can be made via *adjustment of air intake* and *adjustment of air exhaust*. In EAS countries, it is a common practice for air exhaust in each floor to lead to the washroom or hot water supply room, regardless of the CO_2 density. It is not feasible to control the air exhaust at these points. Therefore, this study suggests adjusting the air intake by introducing motor dampers in the ventilation to decrease the electricity load of chillers and refrigerators.

For the next step, this study recommends that the VAV be installed. While this can help decrease the power consumption, it may require additional costs.

The second suggestion reduces the energy consumption of compressors by controlling the frequency of motor power using inverters. The field survey in the EAS region showed that users allow their unit's motor to operate at maximum output even in sites where inverters were already installed and that adjustment of inverters is not yet a common practice.

This study has identified the benefits of induction motors and synchronous motors, and inverters are an essential part of these. By adjusting the frequency of inverters and optimising the rotation, high energy savings can be expected. Specifically, the energy consumption of motor power can be reduced remarkably by decreasing the rotation by half.

In the long term, more attention should be paid to energy efficiency through the introduction of advanced building structures. As references, the Green Building program in the United States, the regulation on energy savings in new buildings by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan and the Top Runner Program were discussed in the study.

2. The Way Forward: Second Year (FY 2015)

The second year of the study focuses on a more in-depth analysis of energy-efficiency potential over and beyond office buildings.

Energy efficiency in the industrial sector, which may be more complicated than the EMS in office buildings because of the variety of energy-consuming appliances and the differences among different types of manufacturing, will be discussed. This analysis is expected to drive the study on the deployment of factory energy management System and EMS technologies for the industrial sector.

The study will explore the recent trend on EMS technologies deployment such as the possibility of CEMS, which covers energy consumption in a much wider area—that is, EMS beyond that in a single building or factory.

Various types of CEMS have been pilot tested, with some—e.g. the regional cogeneration model, industrial complex cogeneration model, commercial district model (being implemented by the Ministry of Economy, Trade and Industry of Japan's New Energy and Industrial Technology Development Organization and remote-island micro-grid model—already nearing their stage of commercialisation. This study will cover those that may be applicable and effective in the EAS region. One of these is the remote island micro-grid model.

The remote island micro-grid model may be more suitable for less developed locations, while other models are mainly for relatively developed areas. This model's economic feasibility cannot be evaluated universally among different countries because there are various factors to consider such as each country's density of energy demand, availability and costs of resources for power generation (both conventional resources and new resources such as photovoltaics), and connectivity to the large main grid of power supply.

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