Chapter 4

Case Study of Energy Managment System Deplyoment for Office Buildings

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Chapter 4

Case Study of EMS Deployment for Office Buildings

1. Summary of the First-Year Study

1.1. Good practices of BEMS implementation

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

(1) Omotesando Hills (Tokyo, Japan)

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

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

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

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

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

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

(2) Sengokuyama Mori Tower (Tokyo, Japan)

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

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

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

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

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

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

(4) Marunouchi Heat Supply (Tokyo, Japan)

Marunouchi Heat Supply is one of the advanced cases of district heating and cooling system in Japan. The system controls boilers and chillers, reducing significant amount of CO_2 emissions. One of the major advantages is the efficient operation due to the centralisation of boilers and chillers. It reduces primary energy consumption by 20–25 percent compared with stand-alone heating and cooling system.
The company uses and installs both turbo and absorption chillers to realise the best mix of electricity and gas consumption. It mainly uses turbo chillers for making cold water because the coefficient of performance of turbo chiller, combined with inverters, is as high as 25. However, during peak day-time hours, it uses absorption chillers that are low in coefficient of performance (between 5 and 6) but do not consume electricity. By doing this, the company saves the demand charge of its electricity tariff.

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

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

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

1.2. Case studies in Indonesia and Thailand

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

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

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

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

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

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

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

Figure 4.1: Air Intake at Machine Room

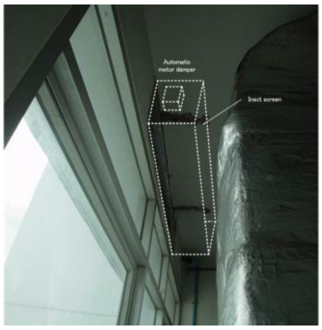
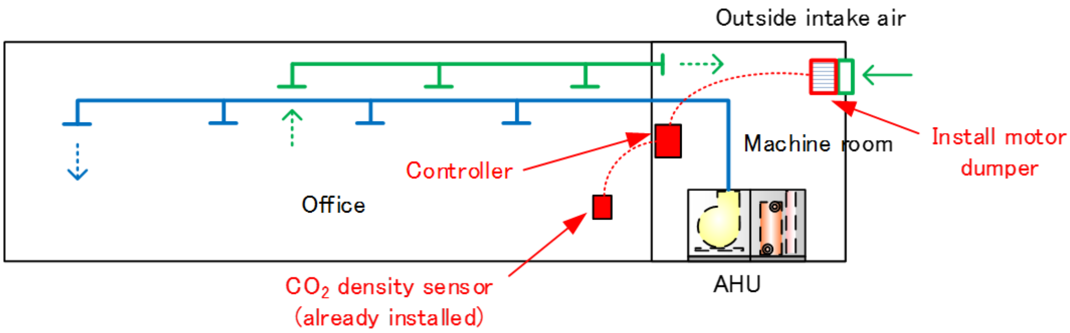


Figure 4.2: Image of Motor Damper

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

Figure 4.3: Recommended Schematics of Air flow with Motor Damper



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

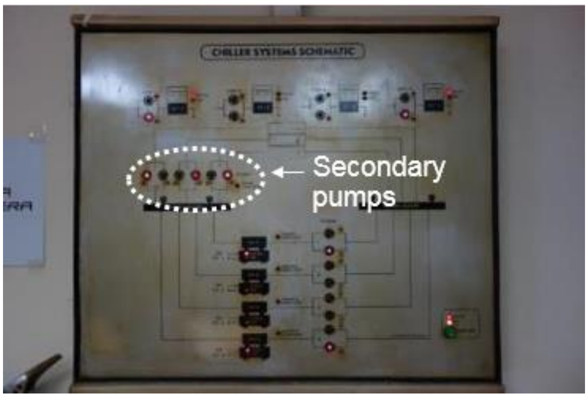
(2) To control the frequency of motor power of compressors using inverters

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

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

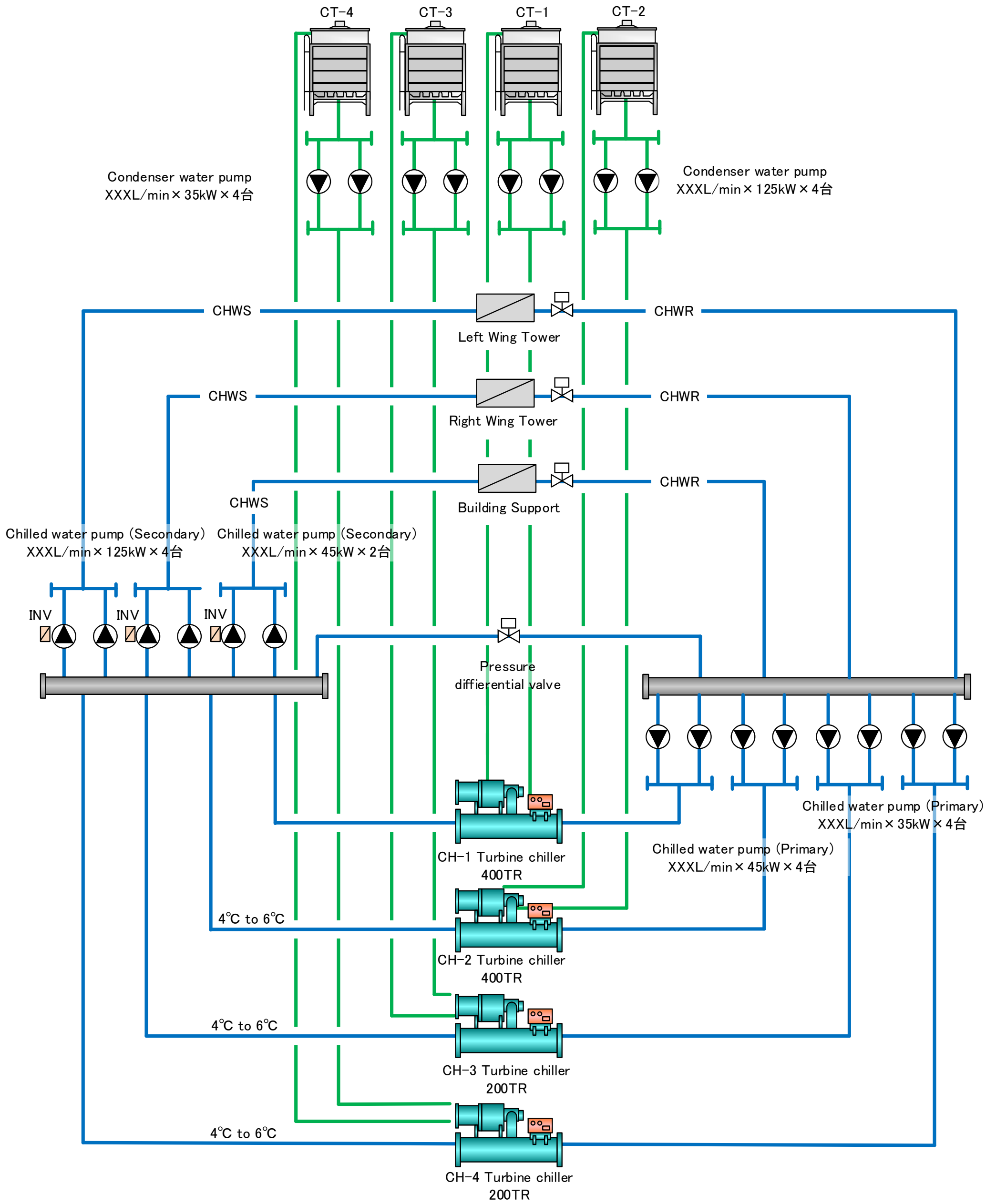
In addition, the study also argued that, on a longer-term basis, more attention should be paid to energy efficiency through the introduction of advanced building structure. For example, the Green Building program in the United States, the regulation of energy saving in new buildings by the Ministry of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

Figure 4.4: Monitor Panel



Source: Author. .

Figure 4.5: Diagram of Chilled Water Supply System



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

Source: Author.

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

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

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

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

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

2.1. About the case study site

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

Table 4.1: Overview of EVN Head Office

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

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

Source: Study Team, using EVN data.

2.2. Observations from the survey

(1) Overview of the installed facilities

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

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

Chilled water supply system:

(1) Daily operating hours: 9 hours (7:00 to 18:00).
(2) Chillers: 4 No 900RT units installed, but only 2 units are normally in operation.
(3) Chilled water supply temperature is set at 7°C during the hottest months (June–July), but the setting is relaxed during other months, ranging from 8°C to 12°C.
(4) Condenser water supply temperature setting is variable, ranging from 32°C to 37°C.
(5) Chilled water delivery primary pump system is composed of 5 units (1 unit as standby), 9 secondary pump units (3 units as standby).
(6) Chilled water secondary pumps and condensate water pump have speed converter control installed for energy saving.

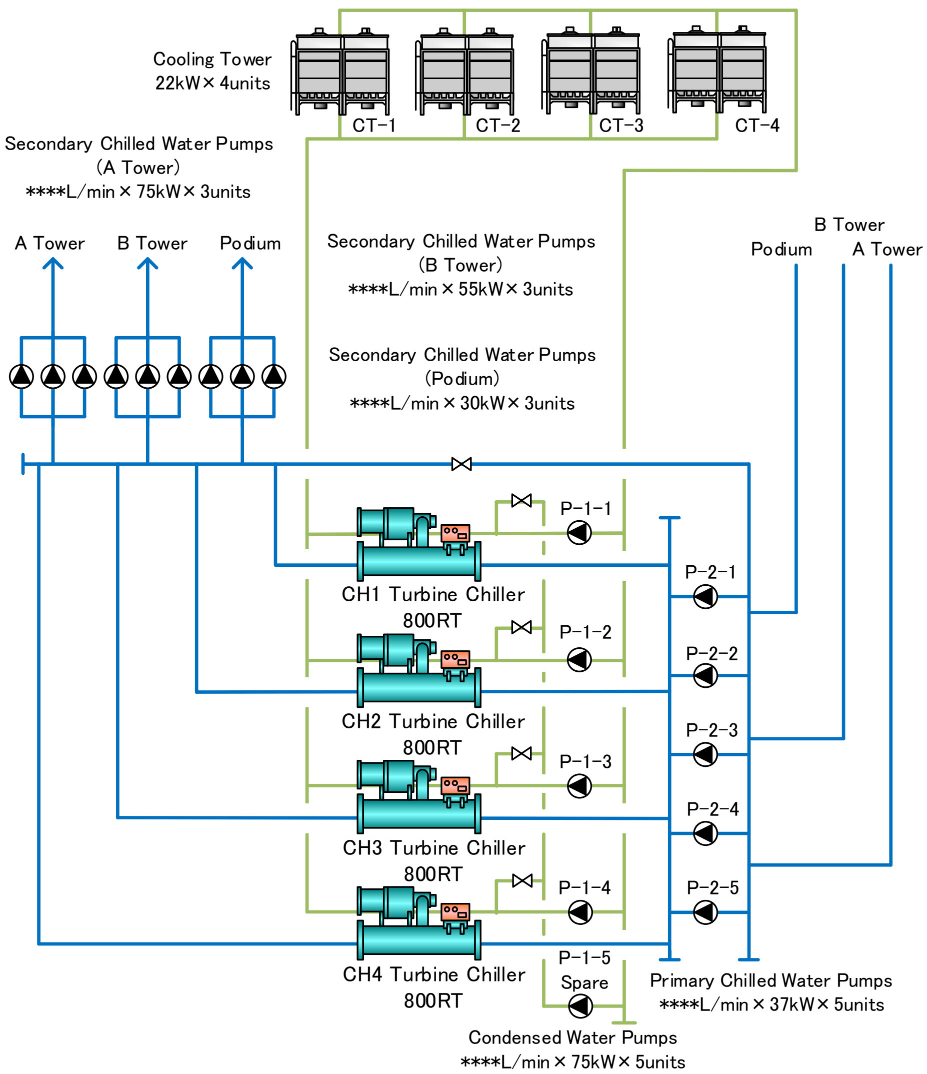
Cooling and ventilation system:

(1) Temperature control and ventilation for standard floor space offices is provided by air handling units.
(2) Temperature control and ventilation for common areas on lower levels is provided by fan coil units.
(3) Air-conditioning units are installed on machine rooms on each floor and have built-in variable ventilation volume control depending on the indoor temperature and the variable rotation of the inverters. A check inside the twenty-third floor machine room confirmed that the inverter rotation was at 14 Hz.

(4) Sensors are installed within the air-conditioning unit return ducts to detect the CO_2 and control intake of fresh air.
(5) 2 Supply air fan units (1 unit as standby), 2 extraction fan units (1 unit as standby) are installed to provide ventilation for the drive-in car park, operating hours at 7:30–18:30 (9 hours).

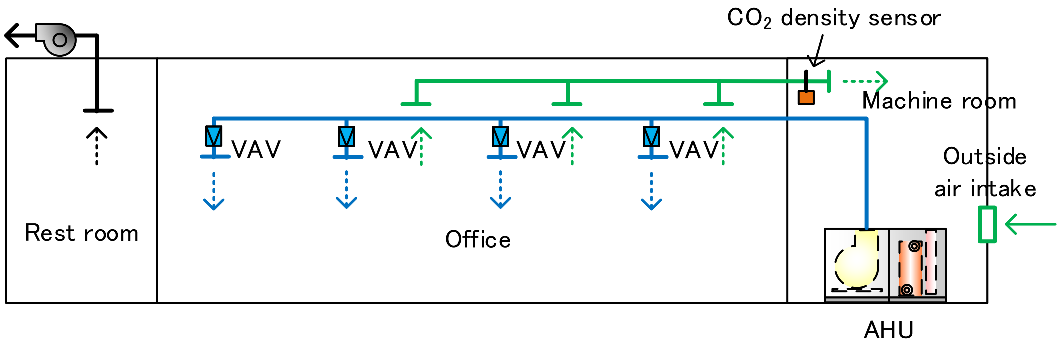
Lighting system:
(1) 1 40-watt fluorescent tube per lighting unit is deployed to provide lighting for standard floor space offices, with switches for window and indoor lights on a separate circuit.
(2) Window lighting is normally on although there is sufficient illumination indoors.
(3) 3 fluorescent lamp units each at 40 watts are deployed for corridor lighting. Lighting units have been disabled for energy saving.

Figure 4.6: Simplified Diagram of Chilled Water Supply System



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

Figure 4.7: Simplified Diagram of Air Conditioning and Ventilation



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

(2) Energy use conditions

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

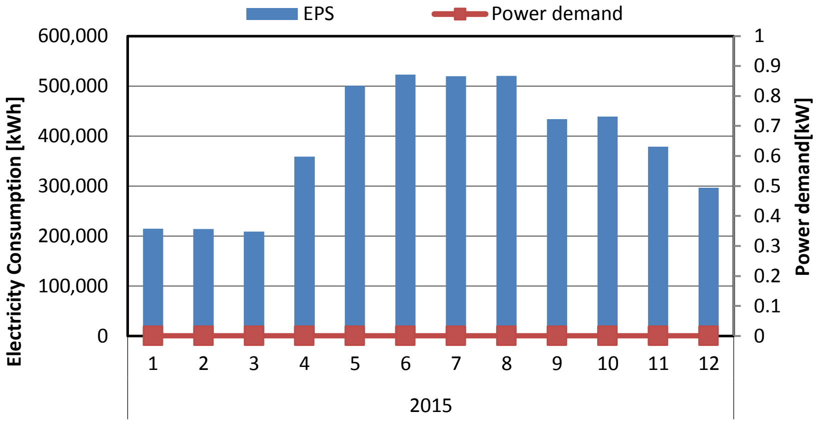
As regards the amount of energy for 2015, January–March is the minimum and May–August is the maximum.

Table 4.2: General Information on Annual Energy Use

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

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

Figure 4.8: Annual Electricity Consumption, 2015



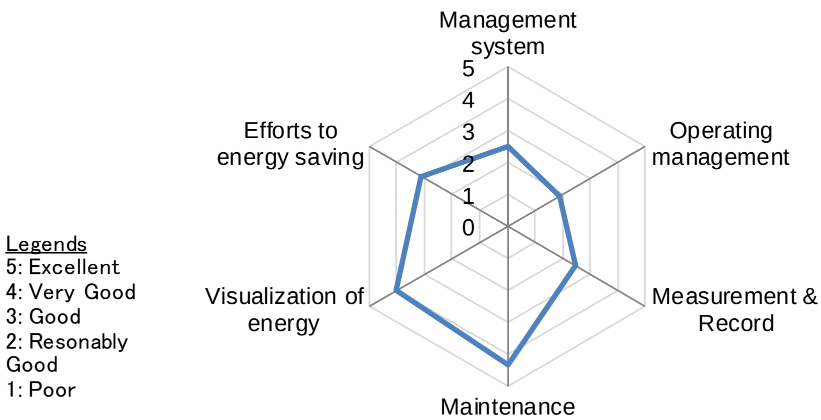
EPS = external power supply, kWh = kilowatt-hour.
Source: Author.

(3) Energy management conditions

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

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

Figure 4.9: Energy Management Conditions



Source: Author.

Table 4.3: Evaluation on Energy Management Conditions

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

Source: Author.

(4) Implemented energy-saving measures in past years

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

2.3. Discussion on possible solutions

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

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

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

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

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

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

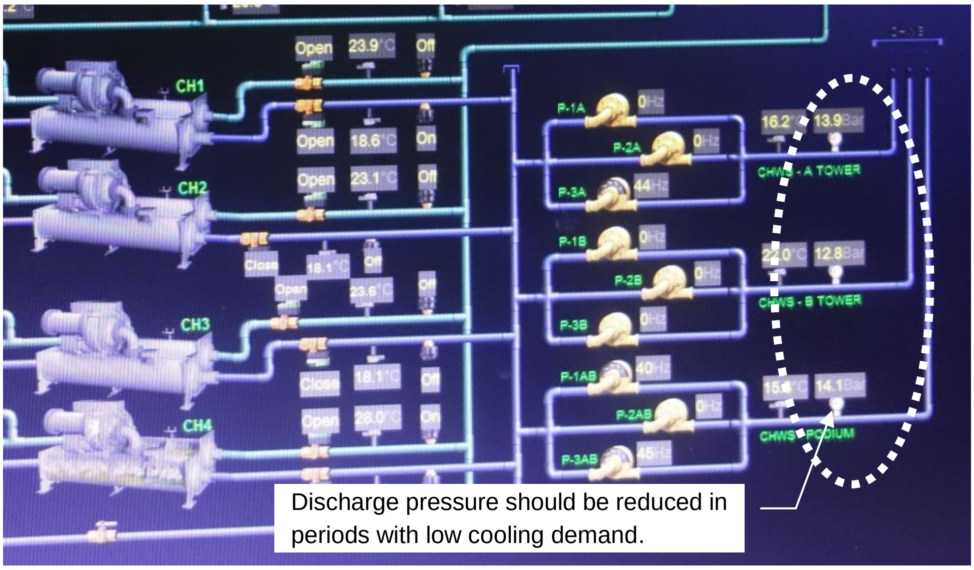
Target systems	Secondary chilled water pumps
Energy saving effect	43,300 kWh/year

Present condition

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

Measures

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



Calculation of effectiveness

Secondary pumps operation (assumed)

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

Electricity reduction

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

Calculation condition ↓

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

Inverter efficiency: 0.9

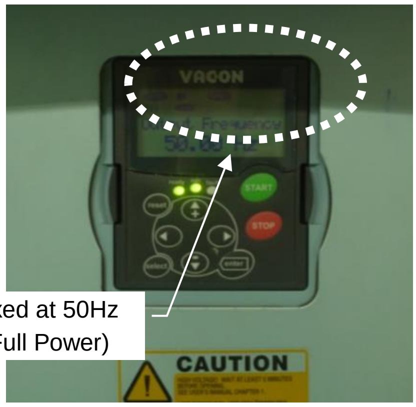
Pump efficiency: 0.8

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

Annual saving cost 69,280,000 VND/year

Matters that should be noted

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



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

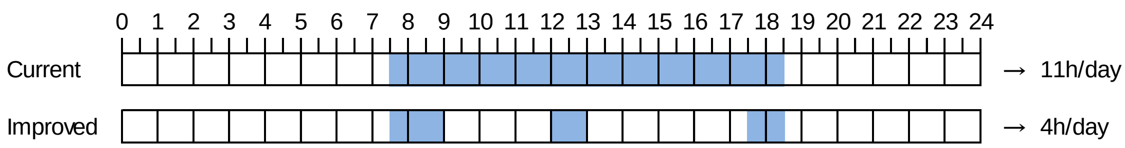
Target systems	Supply fans and exhaust fans
Energy saving effect	118,800 kWh/year

Present condition

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

Measures

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



Calculation of effectiveness

Supply fan capacity	11 kW×1 unit×3 floors
Exhaust fan capacity	11 kW×1 unit×3 floors
Operation hours (current)	11 hours×240 days/year
Operation hour (improved)	4 hours×240 days/year
Electricity unit price (assumed)	1,600 VND/kWh
Electricity reduction	11 kW×2 units×3 floors×(11h-4h)×240 days/year
	= 118,800 kWh/year
Annual saving cost	190,080,000 VND/year

Matters that should be noted

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

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

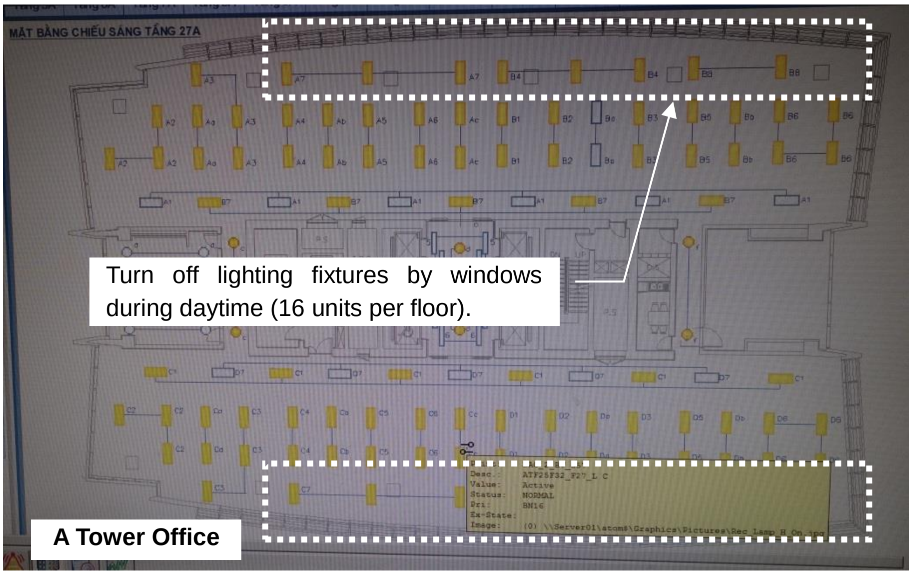
Target systems	Fluorescent lighting fixtures
Energy saving effect	138,500kWh/year

Present condition

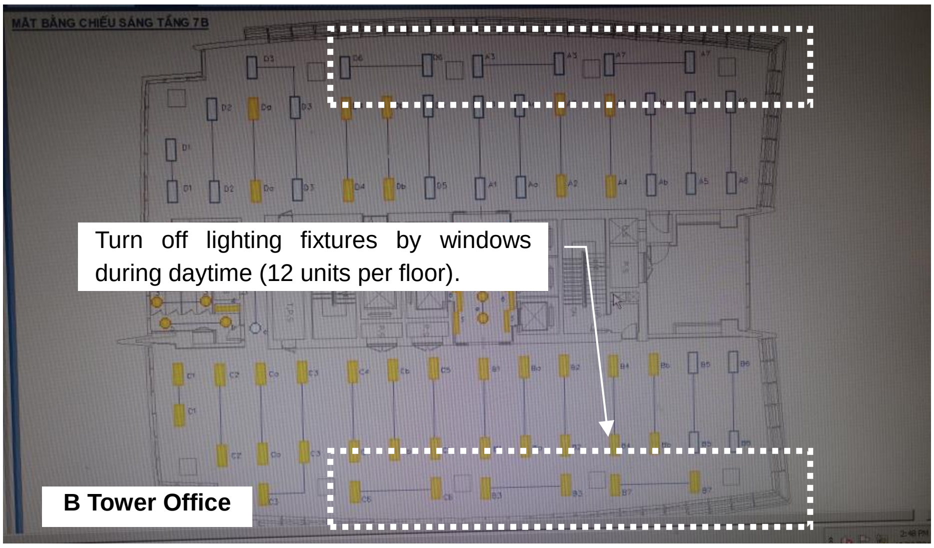
The surface area of office window glazing is large, providing sufficient daylight, but the lighting fixtures by the windows are usually on. On the day of the survey, the sky was cloudy and there was sufficient illumination of around 860 lx, suitable for normal working conditions at desks even with all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

Measures

Turn off lighting fixtures by windows to reduce power consumption.



Source: Author.



Source: Author.

Calculation of effectiveness

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

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

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

Usage rate of the fixtures (assumed) 70%

Electricity unit price 1,600 VND/kWh

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

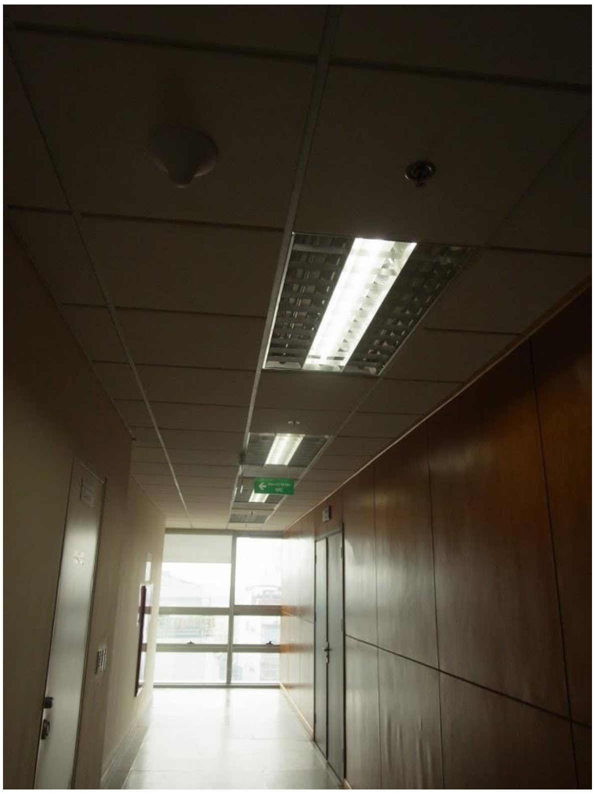
B Tower (40 W×3)×12 units×25 floors×2,160×0.7=54,400 kWh

Sum 138,500 kWh/year

Annual saving cost 221,600,000 VND/year

Matters that should be noted

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



Source: Author.

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

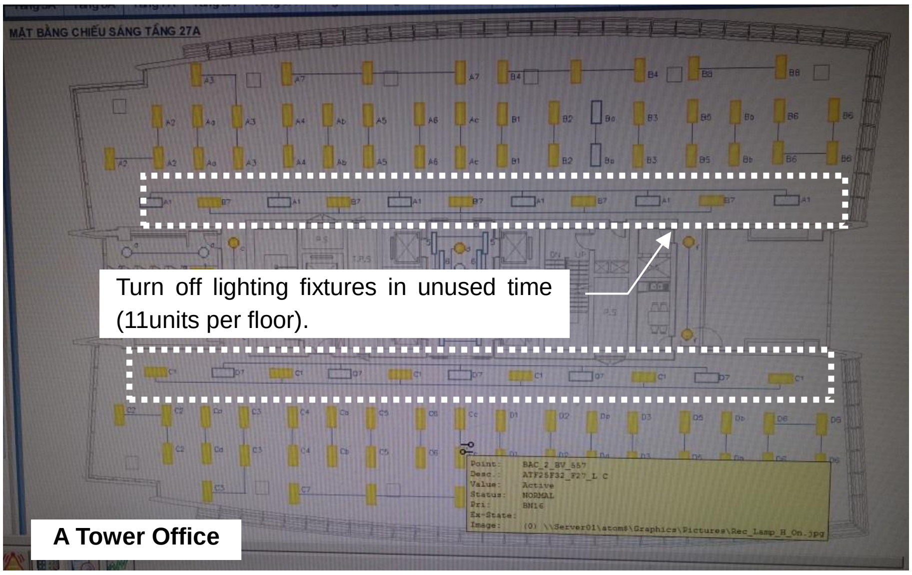
Target systems	Fluorescent lighting fixtures
Energy saving effect	41,300 kWh/year

Present conditions

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

Measures

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



Source: Author.

Calculation of effectiveness

Lighting fixture by windows A Tower:		(40 W×3 bulbs)×11units×29 floors (5th to 33rd)
Annual lighting hours		9 hours×240 days/year=2,160 hours/year
Light-out rate		50%
Electricity unit price		1,600 VND/kWh
Electricity reduction	A Tower	(40 W×3)×11 units×29 floors×2,160×0.5=41,300 kWh
Annual saving cost		66,080,000 VND/year
Investment cost (estimate)	228,500,000 VND	
Recovery period		3.5 years

3. Key Findings from the Case Studies

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

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

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

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

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

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

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

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