Chapter 4

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

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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	580 kW
1) Heat source: AC, etc.	60%
2) Lighting	12%
3) Office Electronics and Motors	28%

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

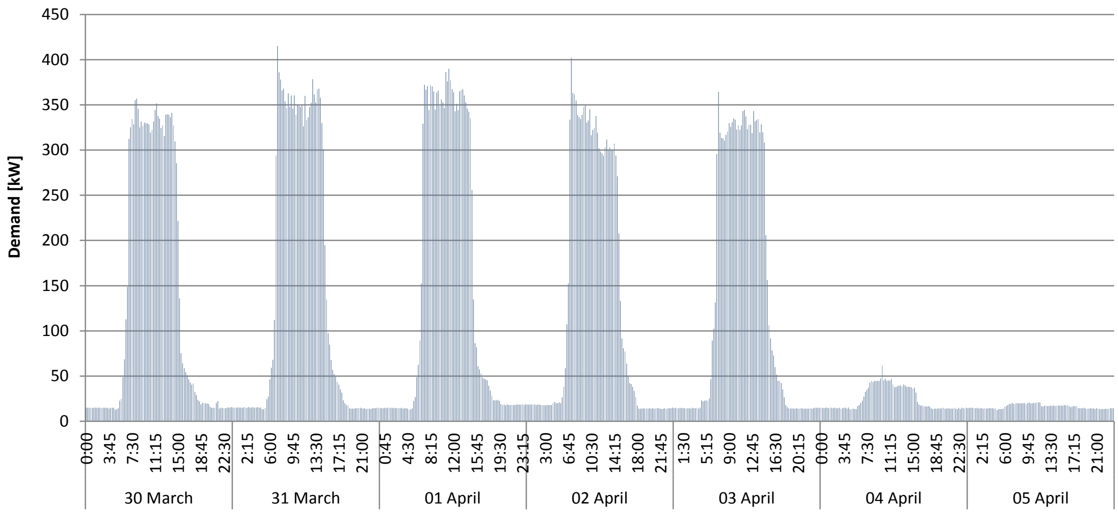
2. Preliminary Study

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)

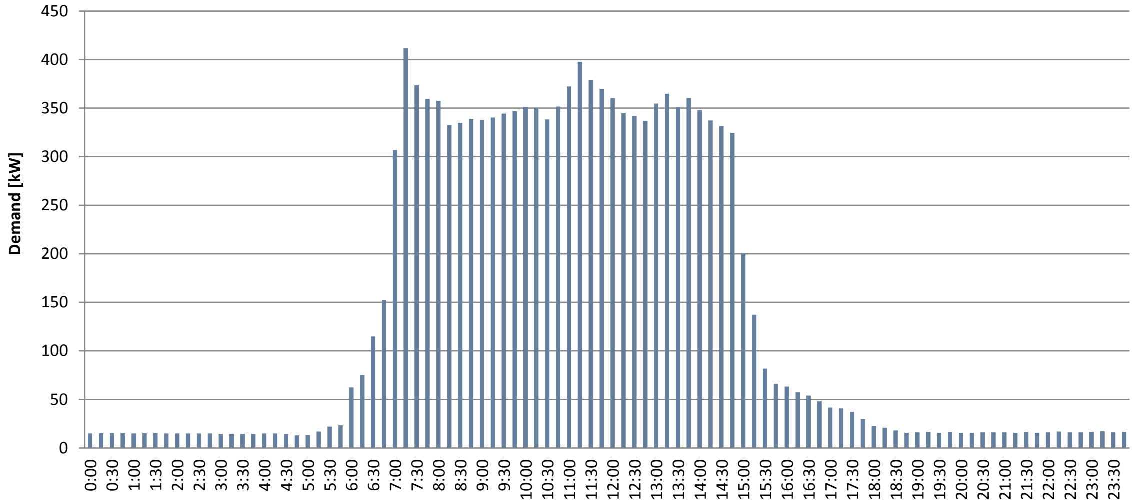


Source: Prepared by the study team using Metropolitan Electricity Authority data.

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) -

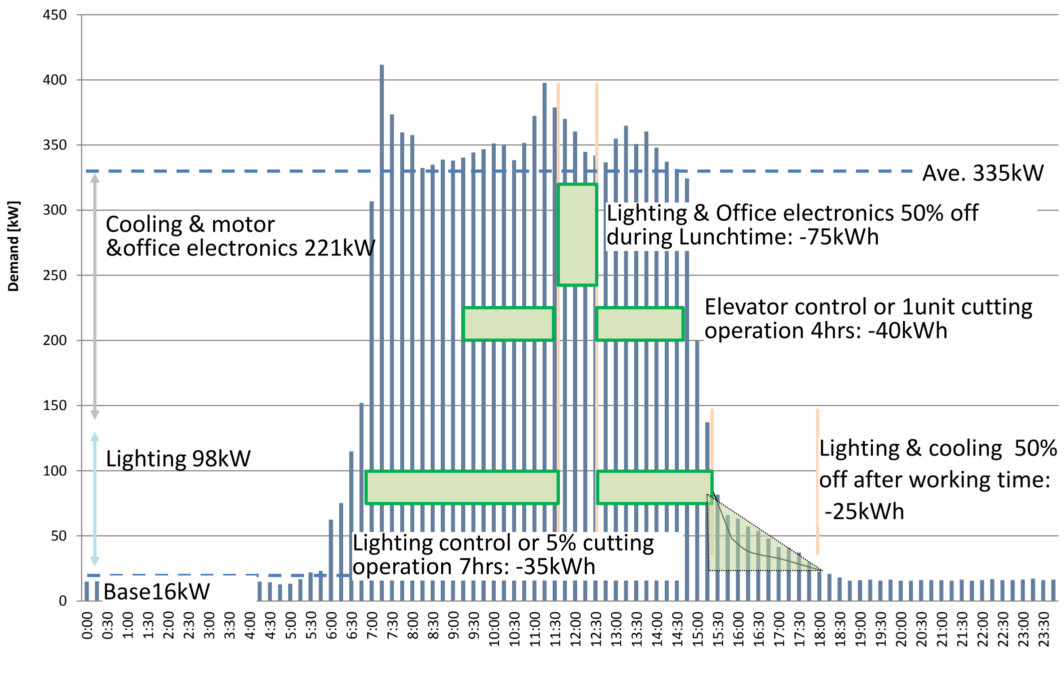
Source: Metropolitan Electricity Authority.

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.

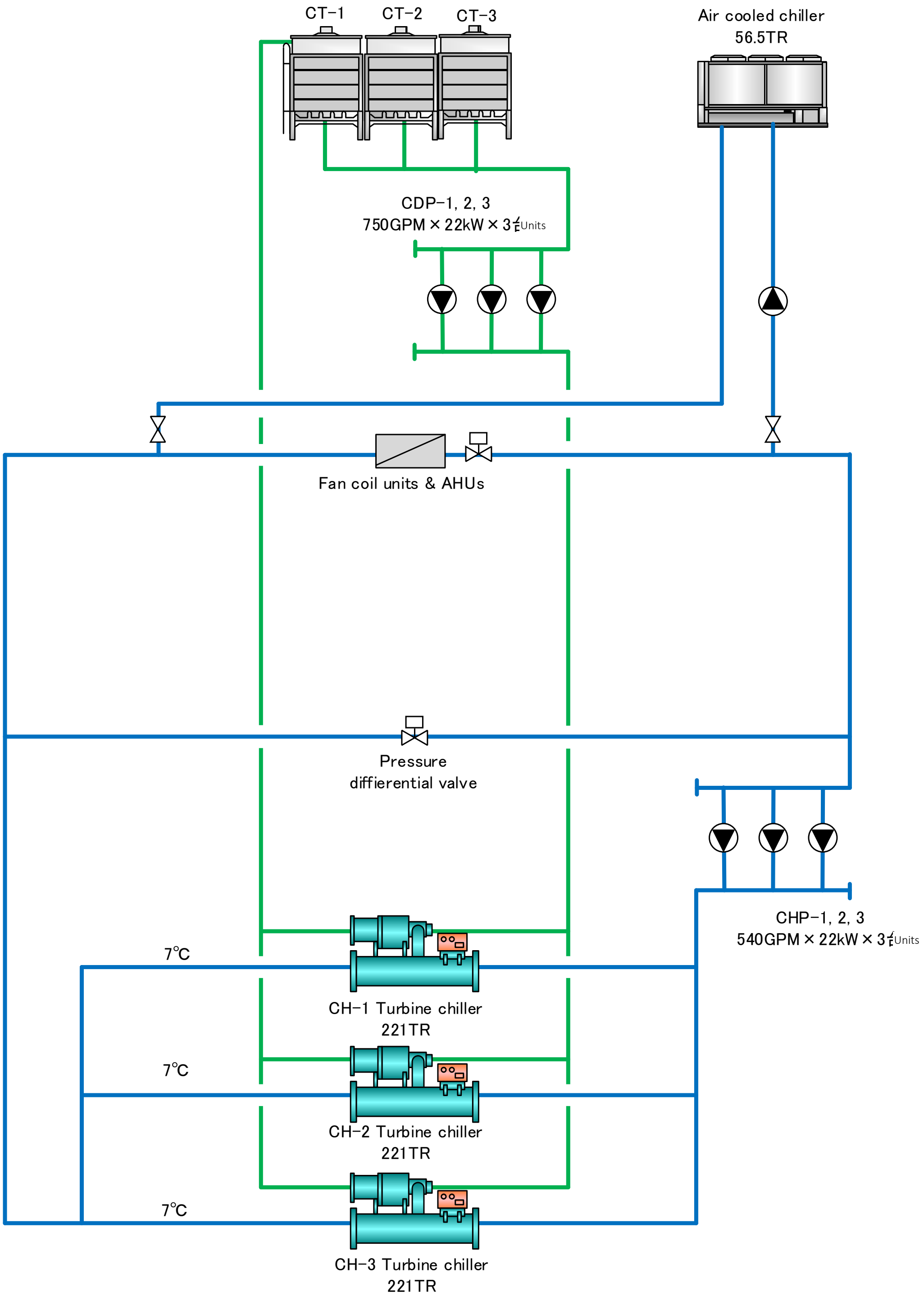
Chilled water supply system

- 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)

Cooling and ventilation

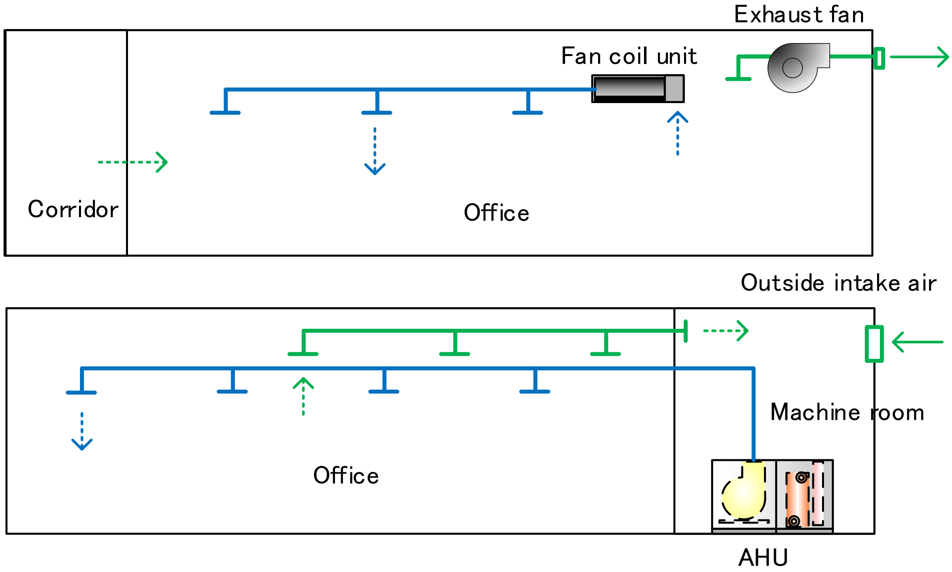
- In each cooling area, two types of cooling systems are in use. One is cooling and ventilation by FCU, with air supplied to rooms from corridors, supplying the air volume exhausted by ceiling fans. Air-conditioning units also provide cooling and ventilation.
- Air-conditioning units are installed in 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

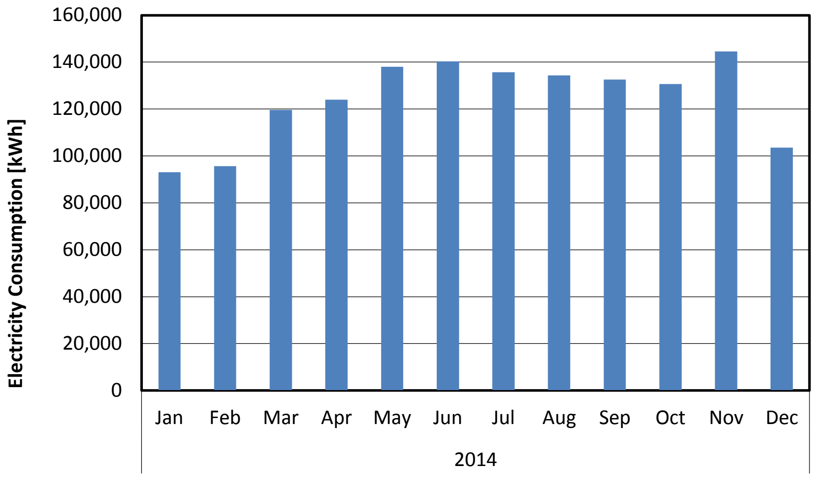
Table 4-4 presents the energy consumption at the MEA Nonthaburi facilities. It gives an assessment of the annual energy consumption and calculation conditions used to calculate the proposed energy savings.

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



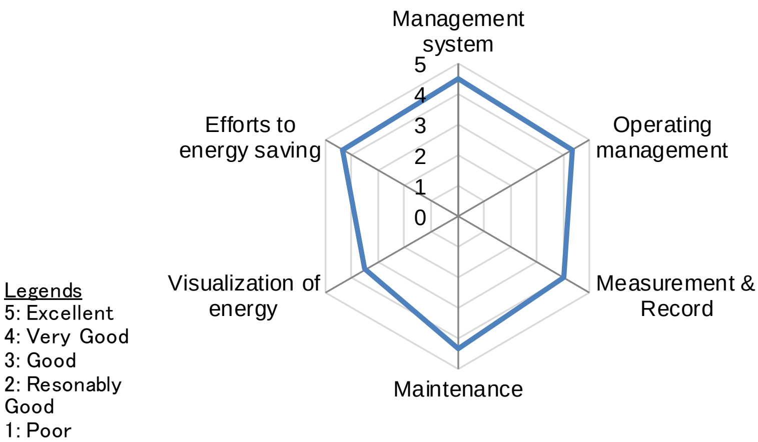
Source: Prepared by the study team using Metropolitan Electricity Authority data.

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

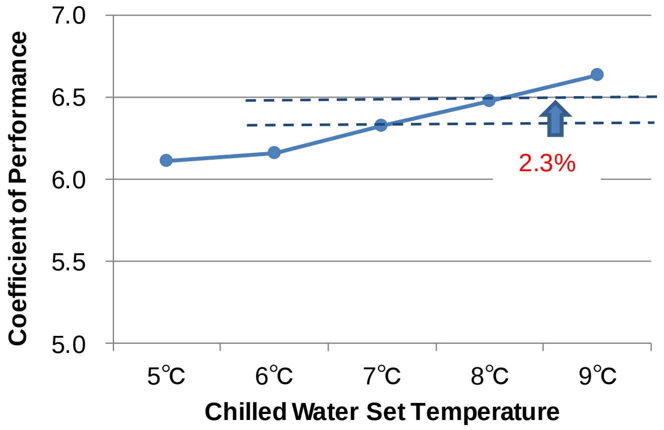
Chiller electricity consumption (assumed) 1,492,055 kWh/year × 55%=820,600 kWh/year

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

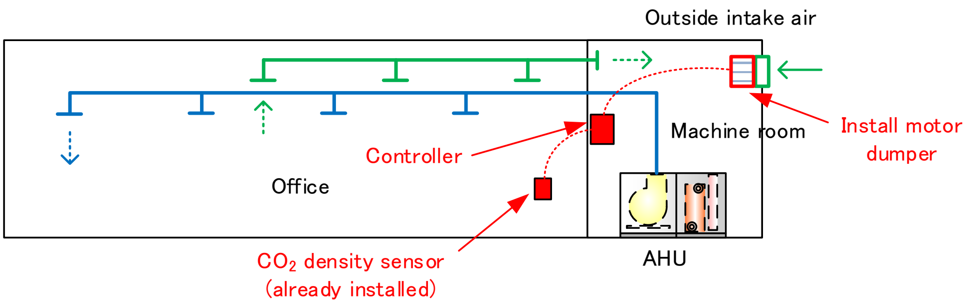
AHU = air handling unit.

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

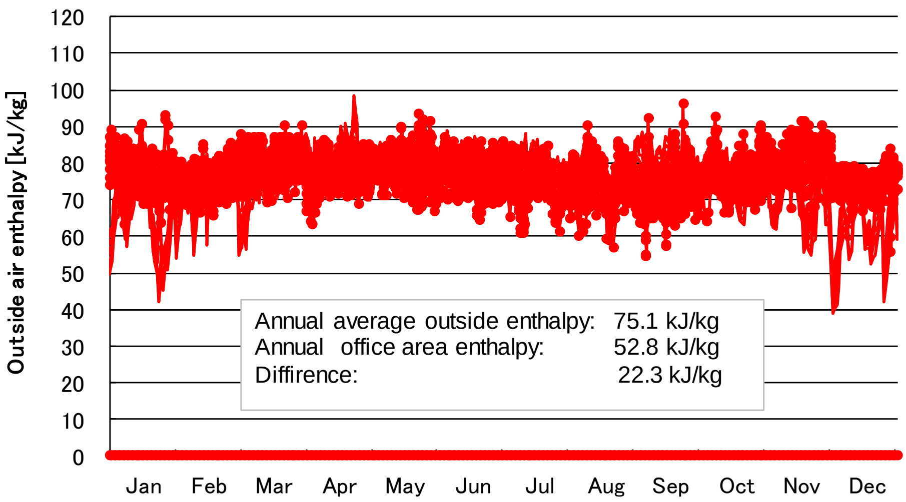
Saved energy cost THB39,500/year

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

Recovery period 4.5 years

Floor	Use	Unit No.	Supply air volume GPM	m³/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.



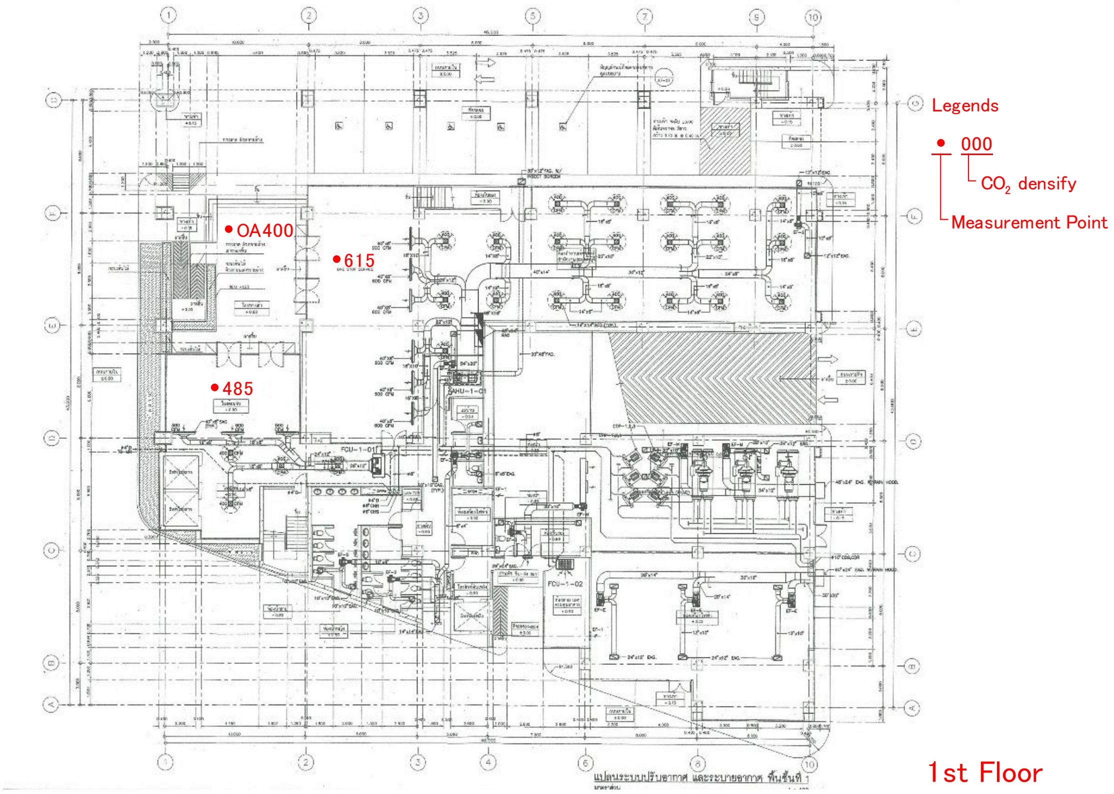
Monthly average anthalpy [kJ/kg]

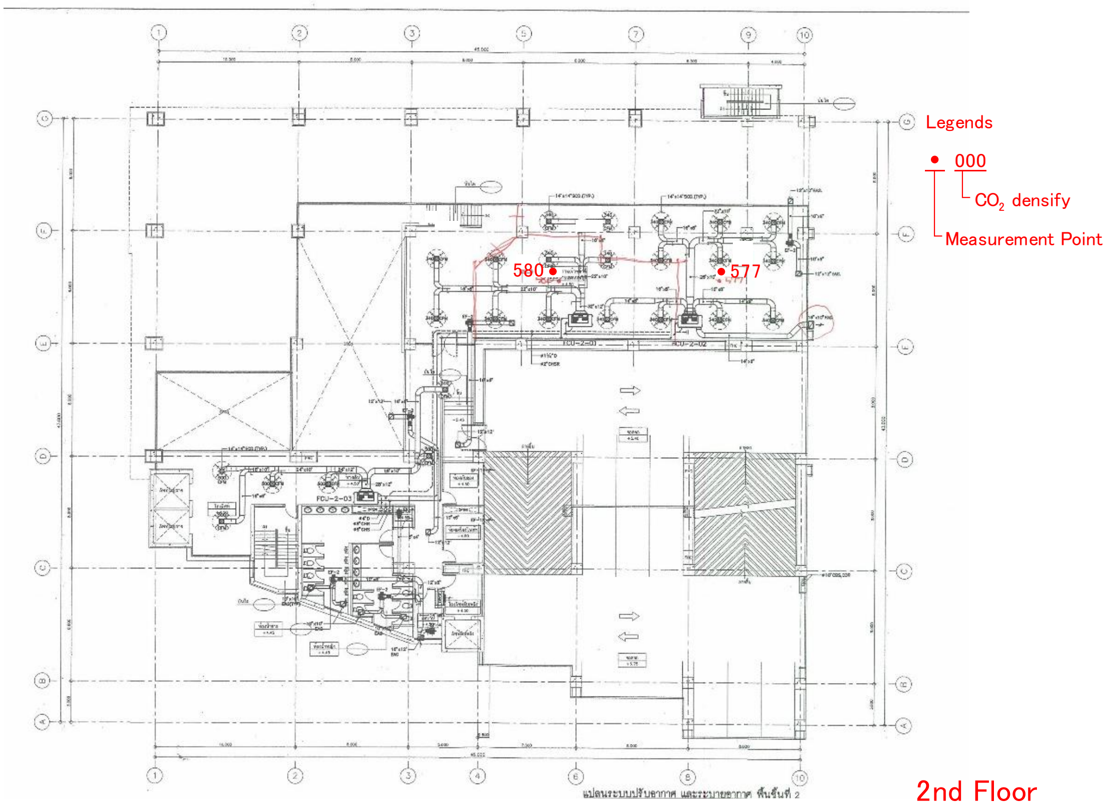
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Outside	66.6	74.2	76.2	82.0	78.0	79.7	78.0	74.6	81.2	77.2	71.2	62.6
Office area	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8
Diff.	13.8	21.4	23.4	29.2	25.2	26.9	25.2	21.8	28.4	24.4	18.4	9.8

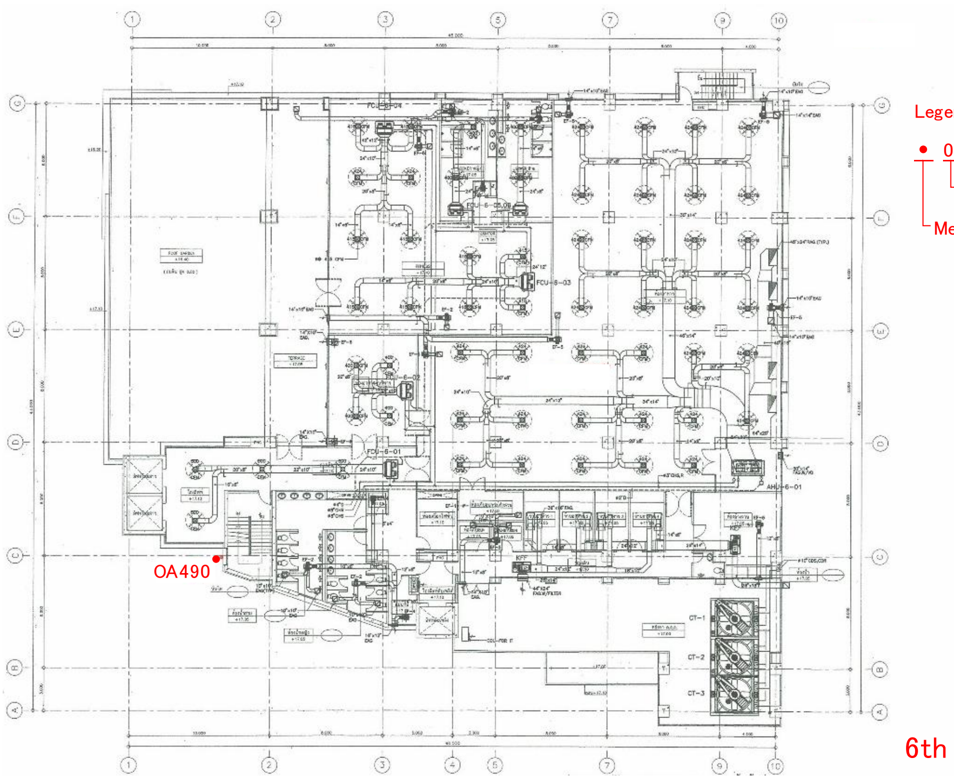
Room condition: temperature 25°C & relative humidity 55% (assumed)

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).



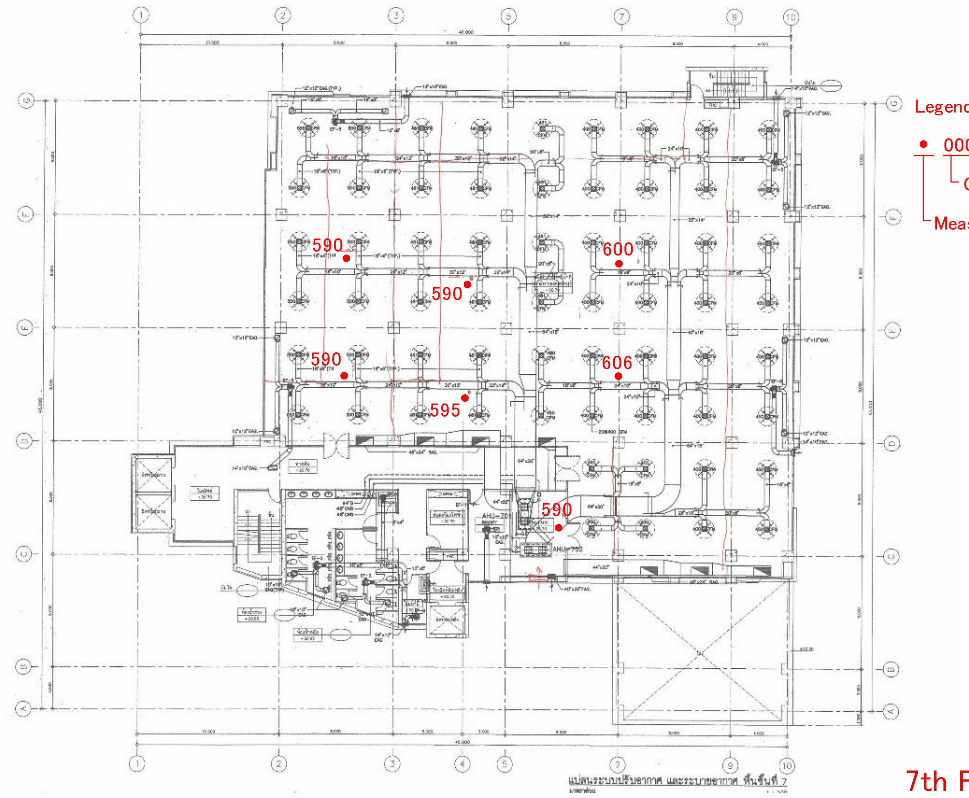

Legends
000
CO_2 densify
Measurement Point
580
577
2nd Floor



Legends

● 000
└ CO_2 densify
└ Measurement Point

6th Floor



Legends

● 000
└ CO_2 densify
└ Measurement Point

7th Floor

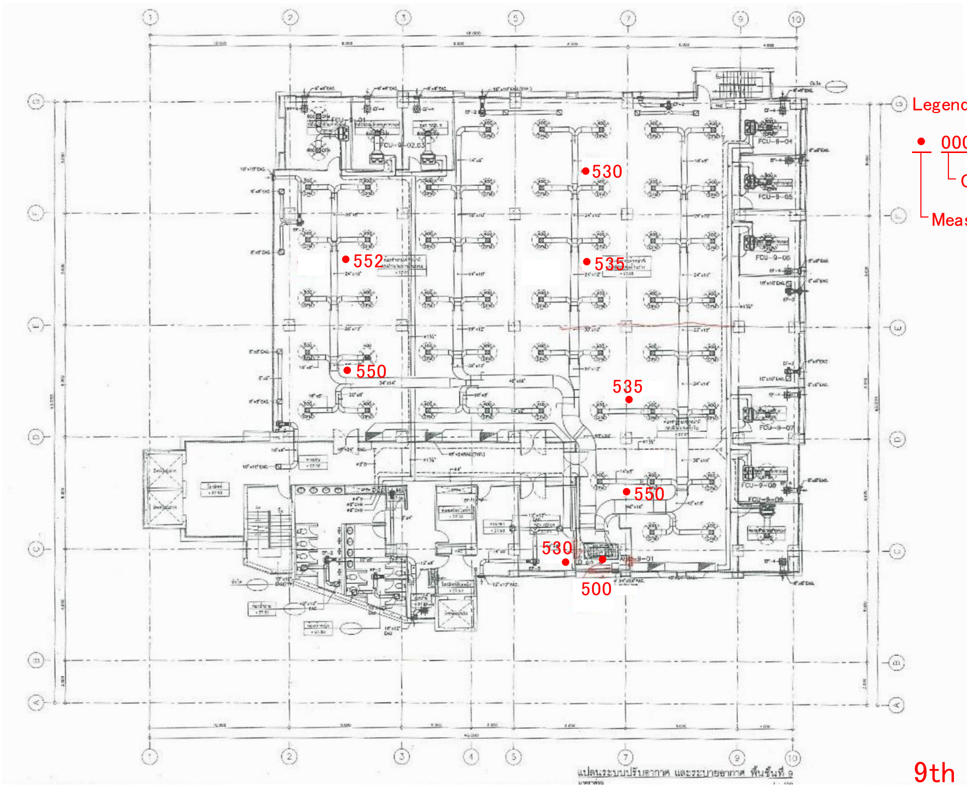
Legends

● 000

CO$_2$ densify

Measurement Point

8th Floor



Legends

● 000

CO$_2$ densify

Measurement Point

9th Floor

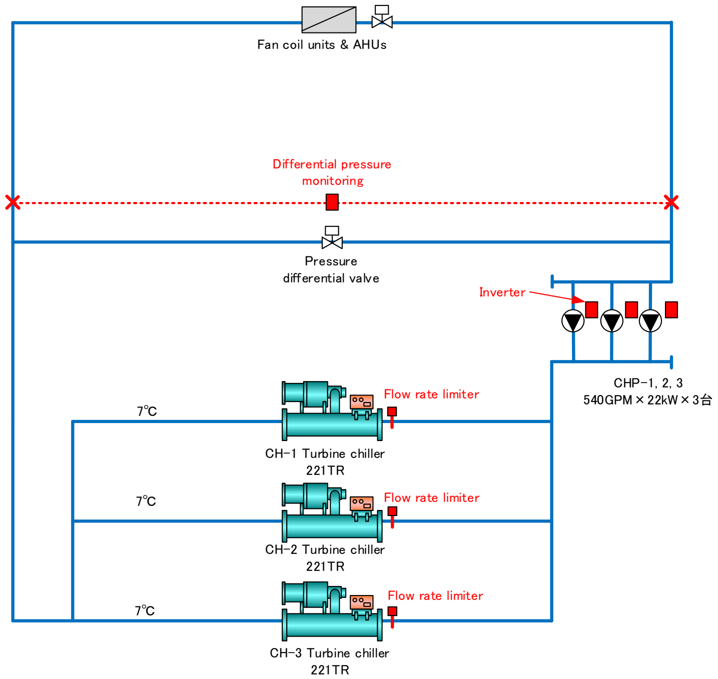
B-2	Variable flow control for primary pumps
Target systems	Primary pumps
Energy saving effect	31,100 kWh/year

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

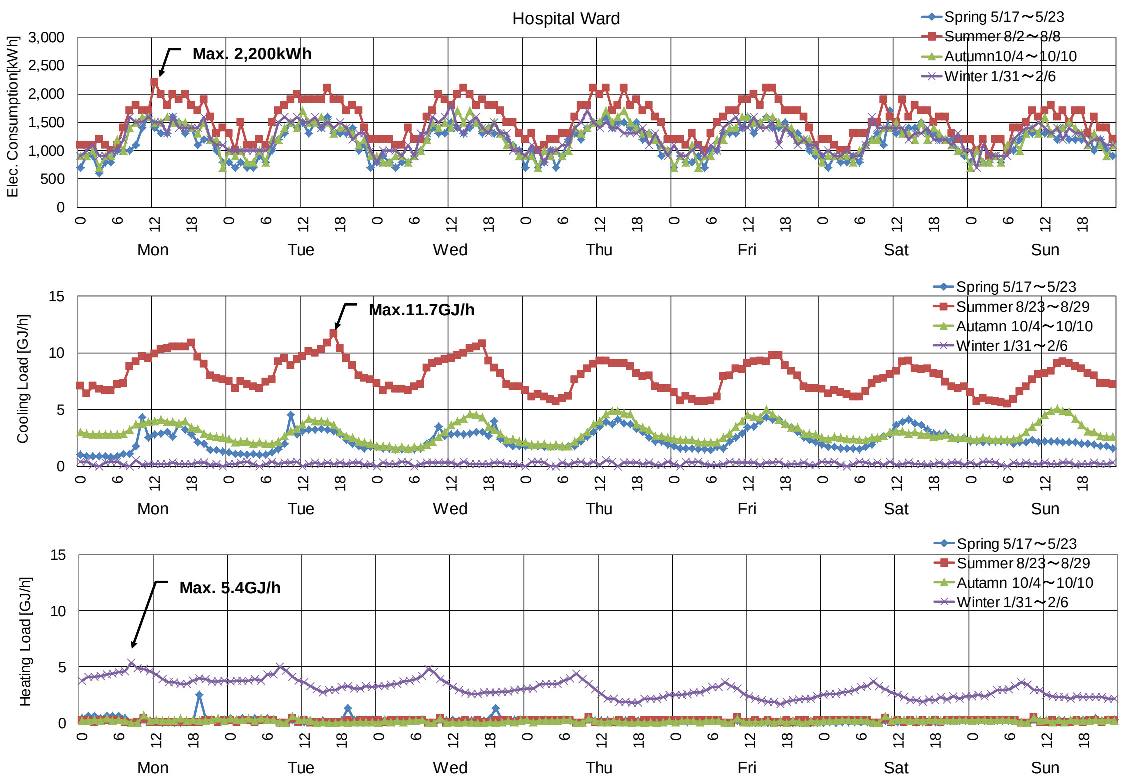
Generally, 50 percent is the minimum chilled water flow rate of turbo chillers (Note that this varies depending on the manufacturer). Under the said flow rates, operational issues may occur. Adding a flow limiter to avoid falling below the minimum flow rates may be considered.

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.

Representative weekly graph

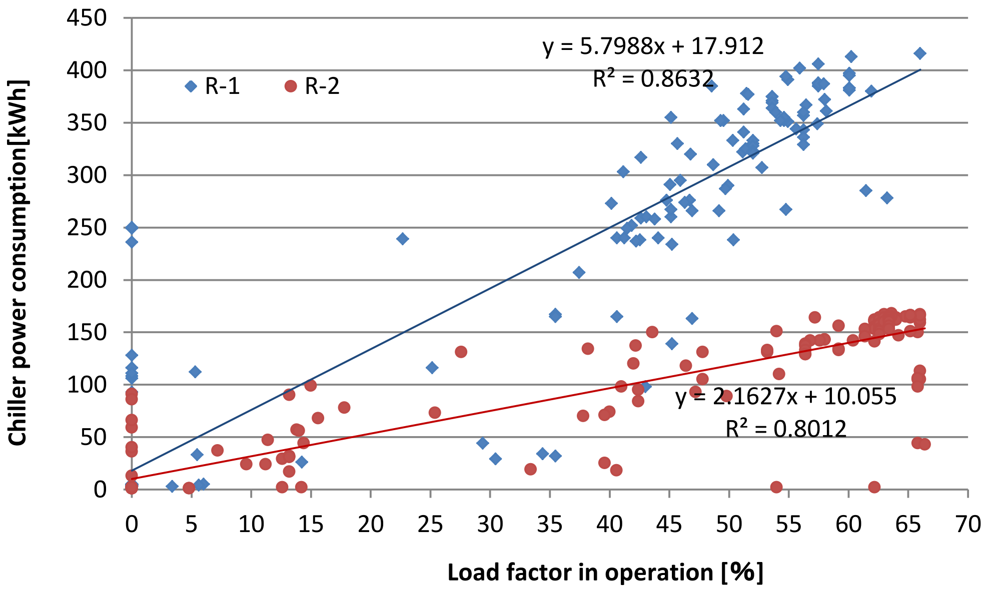
By looking at data on a weekly basis, the differences in energy consumption patterns during weekdays and holidays become apparent. In Japan, there are seasonal changes in temperature and humidity. The graphs below show energy consumption in a hospital in spring, summer, autumn and winter.



Chiller power consumption and operating load factor correlation

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