Chapter 3

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

This chapter should be cited as

Li, Y. (2015), 'Case Study: PT PLN (Persero) Head Office in Jakarta, Indonesia', in *Advancing the Energy Management System in the East Asia Summit Region*. ERIA Research Project Report 2014-39, Jakarta: ERIA, pp.75-94. Available at: http://www.eria.org/RPR_FY2014_No.39_Chapter_3.pdf

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.

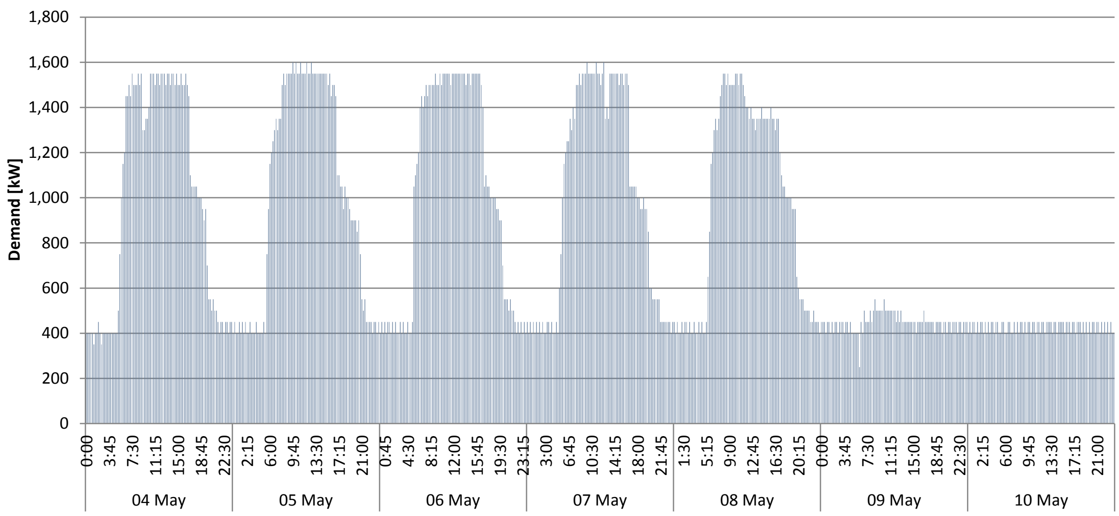
2. Preliminary Study

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)

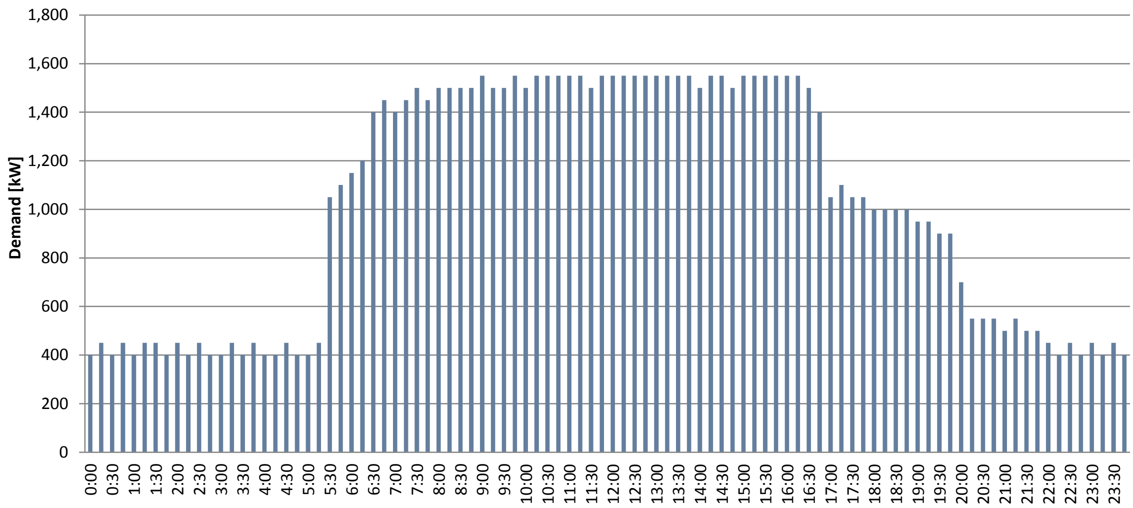


Source: Prepared by the study team using PT PLN (Persero) data.

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

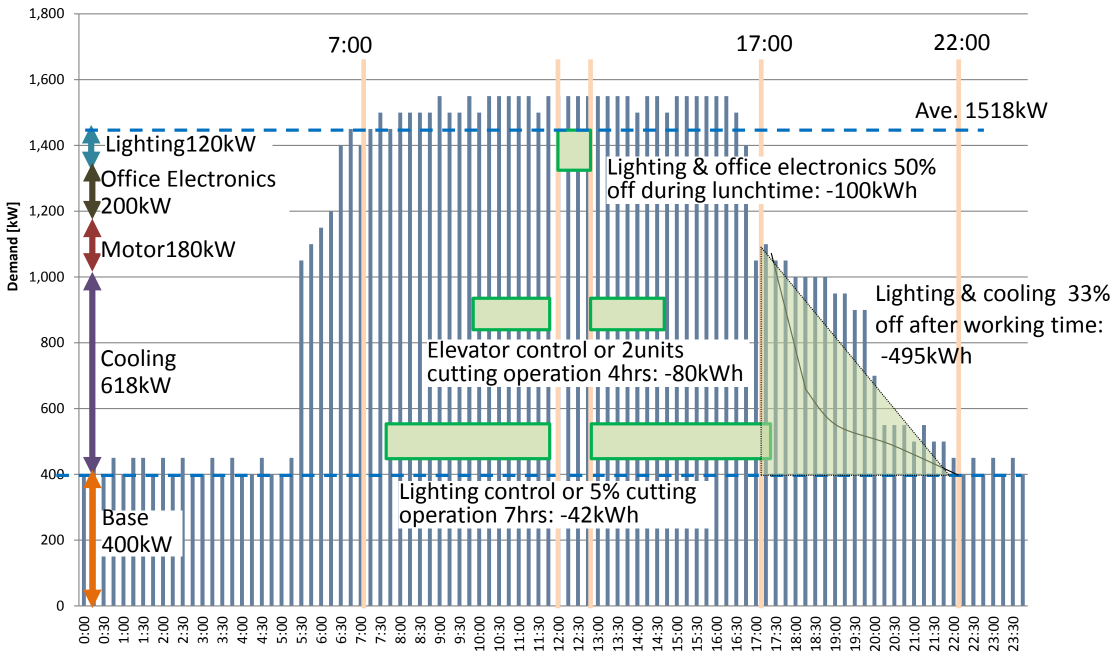
The study team estimated the energy savings by simply changing the operational practices—i.e. without additional investment—to be 717 kWh/day, which is equivalent to 2.8 percent of the daily power consumption on weekdays of 25,523 kWh/day.

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.

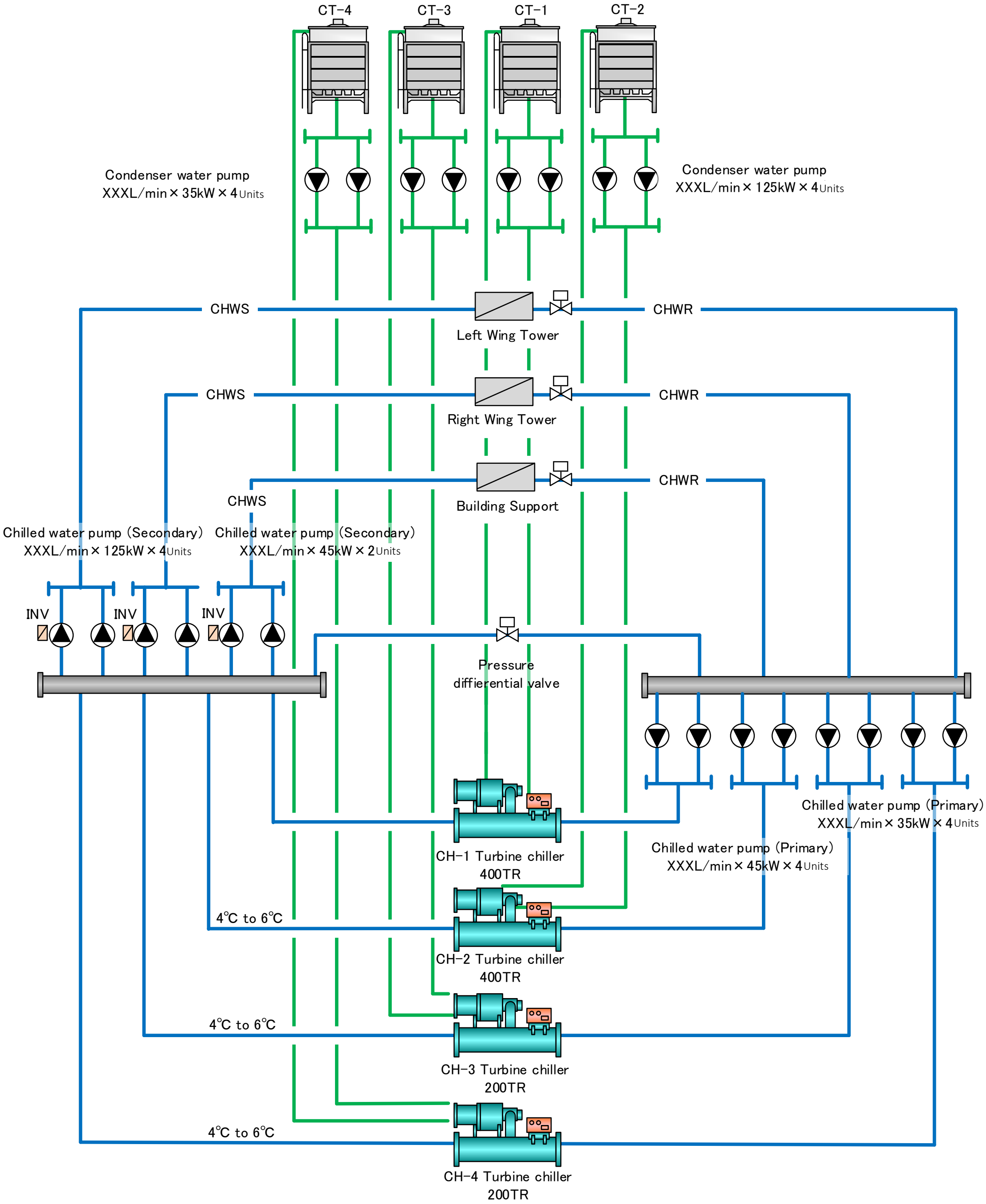
<u>Chilled water system</u>

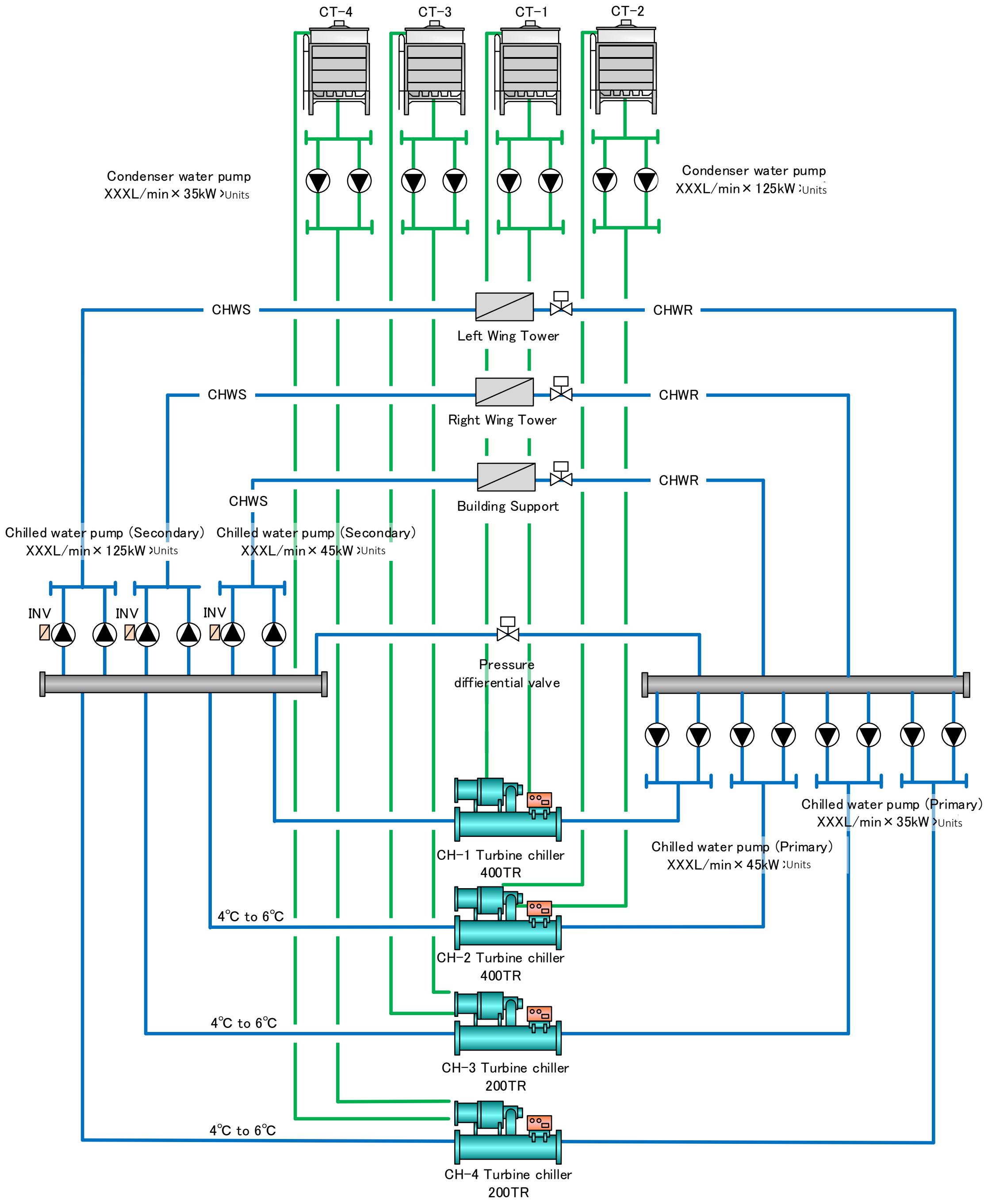
- 10 hours operation per day (06:00 to 16:00)
- Four chiller units installed. Two units (200TR and 400TR) are normally in operation
- Chilled water supply temperature setting is 4°C to 6°C, condenser water supply temperature setting is 22°C to 25°C
- Two chilled water pumps, two condenser water pumps 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

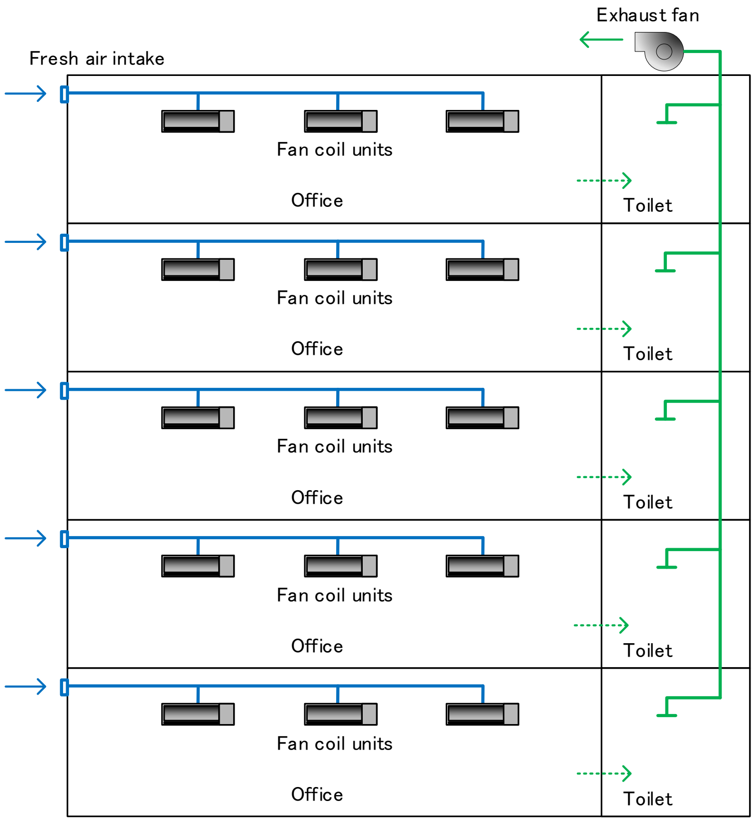
Figure 3-4. Simplified Diagram of Chilled Water Supply System





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.

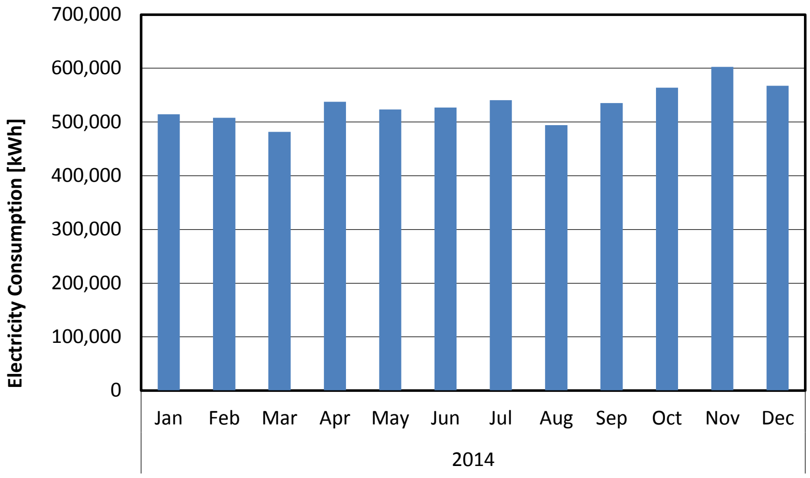
Based on the monthly power consumption for 2014, there were no large variations for each month, and the average monthly value fluctuated slightly around 533,000 kWh. The average value for November showed the largest increase, but this was due to the number of events and seminars held during the said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

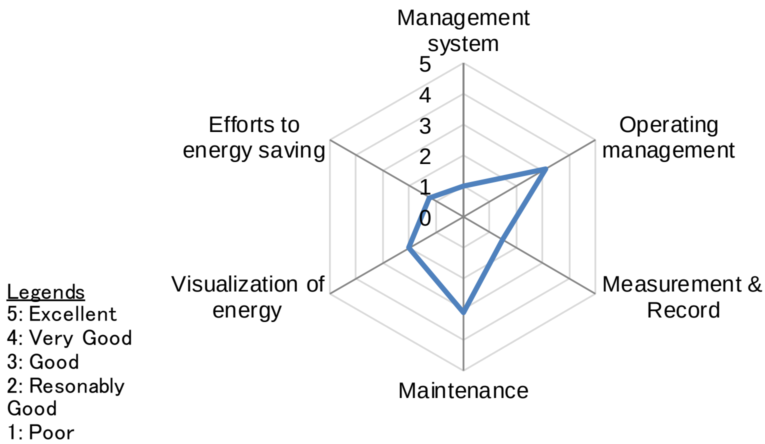
3.2. Energy management status

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

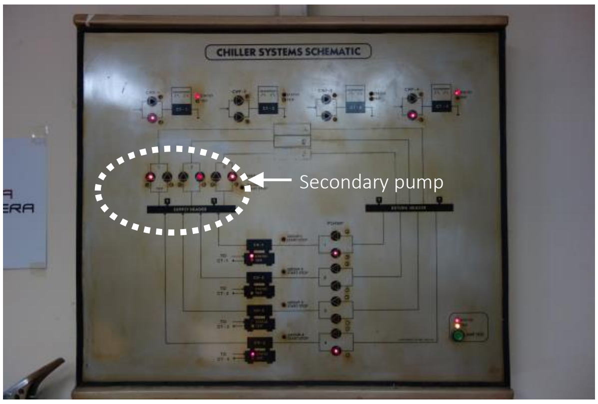
Matters that should be noted

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: $[(40\ \text{Hz}/50\ \text{Hz})^3-(30\ \text{Hz}/50\ \text{Hz})^3]\div0.9\div0.8=0.41$ 45 kW: $[1-(40\ \text{Hz}/50\ \text{Hz})^3]\div0.9\div0.8=0.67$ 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

45 kW × 0.8 × 2,400 h/year × 0.67 = 57,800 kWh/year

254,600 kWh/year

Saved energy cost IDR 303,483,000 /year

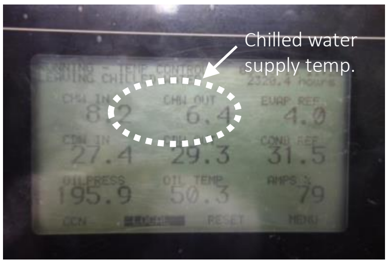
Matters that should be noted

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

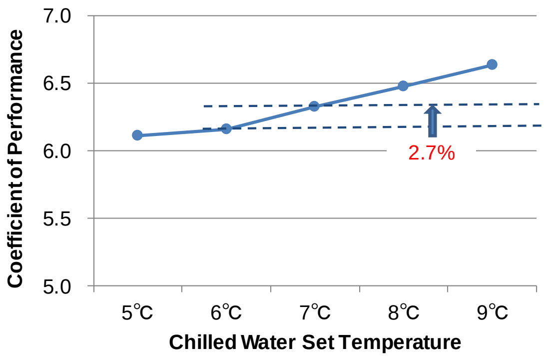
Chiller electricity consumption (assumed) 6,396,300 kWh/year × 40%=2,558,000 kWh/year

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.