International Journal of
Innovation in Mechanical Engineering & Advanced Materials (IJIMEAM)
https://publikasi.mercubuana.ac.id/index.php/ijimeam

Vol.4 (No.1). 2022. pp. 7-11
Published online: August 12, 2022
ISSN: 2477-541X

EVALUATION ENERGY SAVINGS AT MALUKU PROVINCE OFFICE BUILDING IN JAKARTA

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Abstract

Electricity is very important to support activities in office building. Equipment like an air conditioning (AC) needs more electricity to be operated. There is almost 60% of electricity used to support this AC system. This percentage describes that the AC system is an equipment that needs more electricity in the office and becomes inefficient in using electricity. To overcome this problem, we need to efficiently using energy. According to preliminary energy audit, it seems that energy consumption intensity (EUI) can reach 79,15 kWh/m²/year which is lower than ASEAN–USAID standard of 240 kWh/m²/year. According to energy audit, energy use intensity (EUI) is 49,5310 kWh/m²/year. The first preliminary audit is shown that more energy, which is 60% (213.973kWh/year) is used to operate the AC system and 30% (103.452 kWh) is to operate the lighting system. EUI for the lighting system is 13.1 watt/m², below the maximum standard which is 15 watt/m².

Keywords: Conservation Energy, Energy Audit, Lightning System, Air Conditioning System.

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1. Introduction

1.1 Background

The increasing of development followed by the progress and growth of Indonesian economy will also increase the need on national energy.

National energy supply currently is very limited because of non-renewable energy sources such as fossil fuels, gas, coal and oil are decreasing.

Some of the efforts to overcome the limited energy supply and the reduction of greenhouse gases in accordance with the national energy policy are to take energy saving measures by conducting energy audits and implementing the results. The opportunity for energy conservation in Indonesia is very large and the survey results show the building sector has the potential for energy savings of 10 to 30 percent. Many buildings in Indonesia have carried out energy conservation, including changing equipment and implementing great methods in their operation, but there are many obstacles in the implementation because they have not carried out the energy audit process, so that energy saving opportunities has not been identified properly and correctly, and implementation is based on thoughts and estimates only.

In addition, the problem of funding for an energy audit work is a big obstacle. To overcome this problem, in 2013 the government has launched an energy conservation partnership program, and this program is a voluntary agreement between building managers and industry interested in implementing energy conservation with the government, financial institutions and suppliers of energy efficient equipment. Energy conservation programs at the national level aim to reduce energy subsidies, the gap between energy supply and demand, greenhouse gas emissions that affect global warming, climate change and increase national competitiveness.

Energy conservation must be part of all stages of energy management, starting from sustainable energy on the upstream side (exploration, exploitation, refinery and electric power) and the use of energy on the downstream side which is applied in national energy saving. Regulation of the Minister of Energy and Mineral Resources No. 13/2012 concerning energy conservation states that all buildings, office buildings both under central and regional orders, must carry out energy saving programs, both in air conditioning systems, lighting and supporting equipment. One of the research activities related to energy conservation work in a building is to conduct a study on energy conservation opportunities at the Maluku Provincial Representative Office in Jakarta.

Energy needs that increase continuously in one hand and shortage on the other require energy conservation activities to be carried out, which is a form of good and exact energy management and the main tool is an energy audit. An energy audit is an activity of tracing energy power from its entry to the end user, looking for losses or leaks that occur and then making a recommendation for improving the energy utilization system of a facility. It is also necessary to review active and passive designs, namely all building activities that use energy, including roofs, glass walls, windows and doors, structures in a building that do not use energy.

The final target is to measure the voltage and current (amperes) of electricity on the electrical power distribution panel to determine fluctuations in the use of electric power for 1 day (24 hours)
The purpose of this research is to know and measure the EUI (Energy Use Intensity) of Maluku Provincial Representative Office in Jakarta and to know the trend of the usage of electric voltage and current (amperes) on electrical power distribution panels.

This research was conducted on lighting systems, air conditioning installations, and panels power distribution in only 1 building. Electrical energy audit is guided by SNI 03-6196 of 2011, the lighting system in the building is guided by SNI 03-6197-2000, and the air conditioning installation system is guided by SNI 03-6390-2011[3,4,7].

2. Fundamental Theory

2.1 Energy Audit

This is the most basic activity that must be obtained by anyone who will carry out an energy control program:

a. Research on the behavior of system equipment facilities that have been installed in terms of their energy consumption.
b. Analyze whether the products produced by the equipment are able to cover the cost of energy usage.
c. Intensify energy saving opportunities[7].

2.2 Energy Use Intensity (EUI)

EUI is the comparison of electrical energy over a certain period of time with the building area unit. The parts that can be calculated are as follows:

a. Total building area (m^2)
b. Building energy consumption/year
c. Building EUI/year (kWh/m^2/year)
d. Building energy costs (Rp/kWh)[5].

According to the results of research conducted by ASEAN USAID in 1987 whose report was only published in 1992, the target size of the electricity EUI for Indonesia is as follows:

a. Office: 240 kWh/m^2/year
b. Hospital: 380 kWh/m^2/year
c. Shopping center: 330 kWh/m^2/year
d. Hotels and apartments: 300 kWh/m^2/year

Looking for total power to use lightning system the building is:

$$\text{Total power } \left(\frac{w}{m^2}\right) = \frac{total\ lamp\ (n)\ x\ Ampere}{building\ area\ (m^2)} \quad (1)$$

EUI after measurement is:
EUI = (total kWh -kWh saving)/(building area)
341,942 - (10,664 x 12))/4320 = 49,5310 kWh/m^2 /year = 4,127 watt/m^2/year

3. Research Methodology

3.1 Research Flow

The flow diagram of this research is shown in Fig. 1.

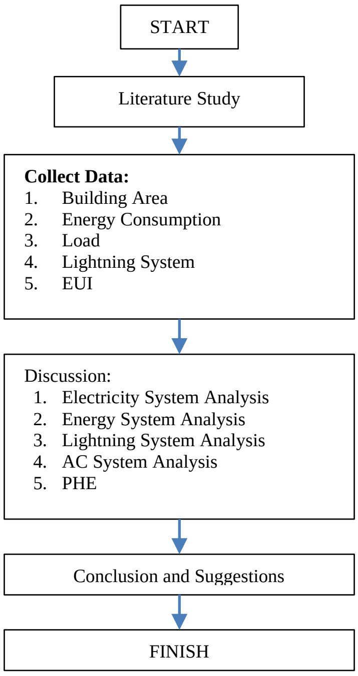

Fig 1. Flow diagram

The method used in this research is observation and energy conservation. This process includes an energy audit, where the preparation includes initial meetings and interviews with building employees, surveys of buildings and their operational systems to see how far there are energy saving opportunities in the building.

3.2 Observation and Measurement Method

The observation and measurement is done by observing the working system of electrical equipment installed and collecting primary data (measurement results) and secondary data

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(interviews, log sheets, electricity bills, building plans, building area) for the purpose of analyzing electricity consumption.

4. Results and Discussion

4.1 Existing EUI

Sources of the research is a discussion, data collection and questionnaire about AC system and lighting system, LVMDB panel, MVMDB panel on the building, and electricity energy usage on the building according measurement of voltage, ampere. cos phi, and frequency.

Table 1. Historical data on energy consumption

Month	Actual Power Consumption /Month (kWh)	Cost kWh/month
Aug 2019	30,000	45,000,000
Sept 2019	27,666	41,500,000
Oct 2019	29,266	43,900,000
Nov 2019	29,446	44,200,000
Dec 2019	26,666	40,000,000
Jan 2020	32,000	48,000,000
Feb 2020	25,800	38,700,000
Mar 2020	29,000	43,500,000
Apr 2020	25,266	37,900,000
May 2020	26,000	39,000,000
June 2020	31,166	46,750,000
July 2020	29,666	44,500,000
Total	**341,942/year**	**514,450,000/year**

The value of the EUI of the building can be calculated from data in Table 1 as follows:

Known total electricity consumption for 1 year = 341,942 kWh
Building area = 4,320 m²
EUI = (Total energy consumption)/ (Building area)
= 341,942/4,320 kWh/m²/year
= 7.00 kWh/m²/month

The results of the calculation of the EUI of this building of 7.00 kWh/m²/month which indicate that the use of electrical energy in this building is efficient according to the EUI standards of air-conditioned and non-AC buildings.

4.2 Lighting System Analysis

In conducting the research, it was found that building activities lasted from morning to evening and the use of artificial light as room lighting was still the most important because there were rooms that were not covered by natural light.

In Table 2 the value of the kWh difference is obtained from the difference in the kWh reduction in the field with the standard kWh value and then multiplied by the area. It is known that the number of lamps on the 1st floor produces an average lighting of 143.58 lux with a total power consumed of 70.95 kWh or still below the standard value of 247.5 E (lux). Therefore, the lighting on the 1st floor is considered still not bright except for the meeting room. It is considered still efficient because the lighting value is 245 E (lux) and the dining room 2 is 251 E (lux) exceeding the standard figure above.

Table 2. Comparison of light on the 1 floor

No	Area	Light Intensity Lux		Compari-son to SNI
		Field Measu-rement	SNI Std. 6197-2000	
1	Lounge	189.00	300	Under SNI
2	Main Lobby	185.00	300	Under SNI
3	Office	155.00	300	Under SNI
4	Control Room	197.00	300	Under SNI
5	Meeting Room	245.00	300	Under SNI
6	Kitchen 1	109.70	300	Under SNI
7	Dining Room 1	0.45	300	Under SNI
8	Toilet 1	0.45	300	Under SNI
9	Kitchen 2	198.80	75	Under SNI
10	Lift	151.20	300	Under SNI
11	Stair	147.00	300	Under SNI
12	Toilet 2	143.00	300	Under SNI
13	Bed Room1	140.00	75	Under SNI
14	Bed Room2	135.00	300	Under SNI
15	Bed Room3	140.00	300	Under SNI
16	Dining Room 2	251.00	300	Under SNI
17	Sitting Room	80.00	300	Under SNI
18	Terrace	165.00	300	Under SNI
19	Hall	175.00	300	Under SNI
20	Panel Room	87.00	300	Under SNI

4.3 Air Conditioning System Analysis

Before installing the AC, it is necessary to pay attention to the efficiency level of the AC. EER (Energy Efficiency Ratio) is one way to see the efficiency level of an AC unit. EER is the ratio of the cooling capacity BTU/h with the incoming electrical energy (kW, watts) at the time of operation of the AC. The higher the EER value, the better the performance of a company.

From Table 3, it can be calculated that the average room temperature on the 2nd floor is 23.13°C. The temperature is categorized as optimal comfort. Optimal comfort in a conditioned room is divided as follows:

1. Cool comfort: 21°C – 22.9°C

Vol.4 (No.1). 2022. pp. 7-11
Published online: August 12, 2022
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2. Optimum comfort: 23°C- 25.7°C
3. Warm and cozy: 25.8°C

Table 3 EUI 1st Floor AC room

Location	EUI (kWh)		kWh Diff.	Recom-menda-tion
	Field Measu-rement	Stan-dard		
Sitting Room	30	12.7	519	Change
Lobby	25	12.7	620	Change
Office	24	12.7	334	Change
Control Room	10	12.7	-27	-
Meeting Room	12	12.7	-21	-
Kitchen	11	12.7	-34	-
Eating Room	9.12	12.7	104	-
Kitchen	10.2	12.7	-15	-
Lift	8.75	12.7	-94.	-
Storage	10.2	12.7	-45	-
Panel Room	8.5	12.7	-92	-
Bed Room1	11.3	12.7	-17	-
Bed Room2	9.8	12.7	-69	-
Bed Room3	9.5	12.7	-51	-
Dining Room	11	12.7	-	-
Lounge	8.75	12.7	-59	-
Terrace	9	12.7	10	-

From Table 3, the value of the difference in kWh is obtained from the difference in kWh on site or field measurements with standard kWh multiplied by the area of the room. It is known that the EUI for the 1st floor air conditioner can be categorized as wasteful/not wasteful use of electrical power with an EUI value of 12,830 kWh/m²/month, the standard EUI of a room with AC installed is 7.9-12.4. The biggest waste is in the sitting room 519 kWh/m²/bill, the main lobby is 620 kWh/m²/month, the liaison office staff room is 271.2 kWh/m²/month. To save energy, the AC units in these 3 rooms must be replaced immediately with air conditioners that are more energy efficient.

4.4 Energy Saving Potential (ESP)

ESP can be categorized as follows:

Table 4 ESP Categories

Area	Unit	PK	BTU hour	Power watt	Temp
Tenant1	1	1	17.700	1650	22,2
Tenant2	1	1	19.100	1850	22,1
Tenant3	1	1	19.100	1650	23,4
Tenant4	1	1	17.750	1850	22,8
Tenant5	1	1	18.000	1900	21,9
Tenant6	1	1	17.750	1800	24,0
Tenant7	1	1	19.100	1900	23,7
Tenant8	1	1	18.000	1800	22,5
Tenant9	1	1	18.000	1800	23,6
Tenant10	1	1	18.000	1800	23.5

4.5 Low cost (Replacement of AC Units)

Table 5 Savings on AC unit replacement

No	Area	Floor	Power (kWh)	Cost (Rp)
1	Main Lobby	1	620	930,000
2	Office	1	334	501,000
3	Bed Room1	1	142.08	231,100
4	Bed Room2	1	146.4	219,600
5	Bed Room3	1	262	393,000
6	Dining1	1	126	189,000
7	Sitting Room	1	216	324,000
8	Tenant 1	2	326.4	489,600
9	Tenant 2	2	253.4	380,100
10	Lobby	8	390.4	585,000
11	Function	8	528	792,000
12	Dining2	8	148	192,000
		Total	3472.68	5,208,425

We can see in Table 5 that the savings on AC replacement are 3,472.68 kWh or Rp5,208,425/ month. Savings are made by replacing the old AC with a new AC unit. By paying attention to the quality and the flow of electricity, it is suggested to install a capacitor bank. With the installation of this device, it can get electricity savings of 7191 kWh/month or Rp10,786,500/ month.

4.6 Calculation of the EUI According to the Measurement Results

The details of the total savings are obtained, after performing the calculations as follows:

kWh savings = kWh low cost + kWh high cost
= 3,472.68 + 7,191.39 kWh
= 10,664.07 kWh = Rp15,996,105

EUI = (total kWh - kWh savings)/ (Total area of the building)
= (341,942- (10,664 x 12)) /4,320
= 49,5310 kWh/m²/year
= 4,127 Wh/m²/month

4.7 Recommendations

By using ESP, the following recommendations are given:

4.1.1. Lighting System

1. Caring for lamps and lamp armatures from dirt and dust so that the rays that come out of the lamps are maximized.

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Published online: August 12, 2022
ISSN: 2477-541X

2. Adjust the level of light intensity with the area of the room because a large room requires more light than a smaller room.
3. The color of the walls of the room should be brighter because it can help the reflection of light.
4. Replacing the TL (tube lamp) with energy saving lamp.

4.1.2. Air Conditioning System

1. Caring for and placing the AC position according to the installation standards so that the AC can work optimally.
2. Adjusting the AC power to the size of the room because the bigger the room, the harder the work of an AC unit to cool the room.
3. Maintain the standard room temperature (24°C) and improve the condition of the room used to match the requirements of an air-conditioned room.
4. Putting or maintaining plants in the room to make it more comfortable and natural.
5. Replacing a larger AC power with a smaller AC power

5. Conclusions and Suggestions

The value of the EUI for the Maluku Provincial Representative Office in Jakarta is 79,532 kWh/m²/year or 7 kWh/m²/month including the use of electrical energy in an efficient AC unit. The load that consumes a lot of electrical power is AC with a power consumption of 213,973 kWh/year and a load on the lighting system of 103,412 kWh/year. Opportunity to save energy at a low cost of bill if the savings are made, it will save electricity costs of Rp 38,372,500 per month. The use of natural light needs to be increased because it is very useful for lighting systems in room. The role of humans or occupancy is very important for the success of energy saving according to the energy saving program set by the government.

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