ELECTRICAL ENERGY AUDIT IN PAKUWON CITY MALL 2 BUILDING FOR EFFICIENCY

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ABSTRACT

This study conducted an electrical energy audit activity at the Pakuwon City Mall 2 (PCM2) Surabaya Building to determine the utilization of electrical energy in the electrical system which includes the type of energy, amount of energy used, energy equipment, energy intensity, load profile, the performance of energy equipment, Energy Saving Opportunities (ESOs) and value of Energy Consumption Intensity (ECI) in an air-conditioned room. From the calculation results is obtained that the value of ECI in the PCM2 Surabaya Building for an AC room is 8.231 kWh/m2/month and 98.772 kWh/m2/year and is included in the efficient criteria. Based on the research that has been done, it is known that most of the rooms in the PCM2 Surabaya Building have ideal room temperatures. The results of measuring the strong level of lighting in PCM2 Surabaya's rooms, most of the values met the standards set by SNI 03-6197-2000 and the results of measuring the quality of electric power in PCM2 Surabaya met the standards set by PLN.

Keywords: *Electrical Energy, Audit, Energy Saving, Opportunities, Consumption*

1. INTRODUCTION

The PCM2 building is a multi-story building consisting of offices and shopping centers that require a lot of electrical energy. Nearly 50% of the electrical energy in PCM2 is used to supply the air conditioning, lighting, escalator, and elevator systems. An energy audit consists of detailing and evaluating how all facilities use electricity and costs. An energy audit can provide solutions so that electricity consumption is more effective and saves costs. An energy audit is very important to do at PCM2 which is still in the developing stage or where there are still many opportunities for improvement in all aspects. The amount of energy consumption obtained from the energy audit can be used to calculate its productivity.

To maintain the sustainability of energy sources, it is necessary to take strategic steps that can support the optimal supply of electrical energy to implement the national energy policy by the Regulation of the Minister of Energy and Mineral Resources No. 13 (2012) which contains about saving electricity consumption. One of these efforts is to increase energy consumption efficiency in buildings and several other large buildings [1]. Researchers [2] have obtained ECI values for each building which are different with ECI values between 26.89 – 77.74 kWh/m2 per year. After going through the Energy Saving Opportunity analysis phase, it results in savings in the lighting system and air conditioning systems. However, in this study the completeness of building data such as building plans and building electrical installation plans were incomplete, making it difficult to process the energy audit for each room and unable to determine the load installed on each cooling system. Research explains that the use of electrical energy in the building exceeds the established standards and the largest energy consumption is in the cooling system by 49%. To anticipate these problems, an energy audit of cooling and lighting systems and ESOs is carried out [3-4].

This study conducted an energy audit to find out about the utilization of electrical energy in the electrical system which includes the type, amount of energy used, energy equipment, energy intensity, load profile, performance of energy equipment, and ESOs. PCM2 is one of the buildings that use most of the electrical energy to run cooling systems, lighting systems, and escalators, so energy management is needed by conducting audits on cooling, lighting, escalator, and elevator systems as well as ESOs.

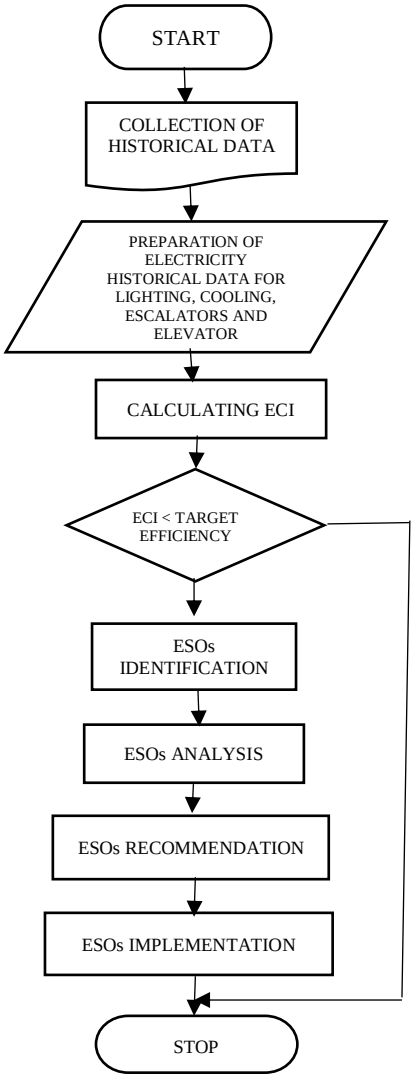

Figure 1. Flowchart of Energy Audit

2. METHODOLOGY

Calculation of data with a detailed mechanism is intended to obtain valid results to suit the energy audit analysis. The flowchart of the methodology for an energy audit is shown in Figure 1.

Research Procedures

The procedure for conducting energy audit activities at the PCM2 Building is as follows:

1. Collection and Compilation of Historical Energy Use data
   The following data is required, including
   a. The floor plan of the building
   b. Single-line diagram
2. After the data is obtained, calculate the Energy consumption intensity (ECI) of the previous year.
3. Checking the Efficiency Level of Electrical Energy Use
   From the ECI value obtained, the efficiency level of the building's use of electrical energy is determined based on predetermined standards, is it efficient or is it still in the wasteful category?
4. Energy Audit Parameter Measurement
   If the ECI does not meet the required standards, energy audit parameters are measured, such as current, voltage, power, power factor, lighting intensity in the building rooms as well as room temperature and humidity.
5. Data Processing
   An analysis of the measurement results and other data obtained through the measurement results is carried out.

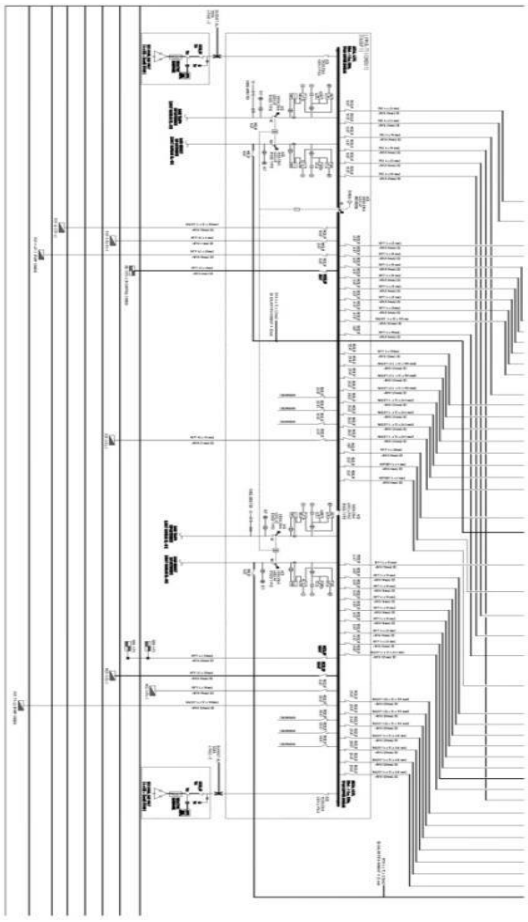

Figure 2. Single-line diagram

The PCM2 building is used as an office and shopping area. The building which consists of 3 floors has an area of approximately 46,000 m^2. Each floor in this building has a different room. Electrical energy is supplied by the State Electricity Company (PLN) which is distributed through a high-voltage distribution panel with a capacity of 3,200 kVA with a distribution voltage of 20 kV. Single-line diagram of the low-voltage distribution panel of the PCM2 Building, shown in Figure 2.

2.1 Lighting System

The lighting on PCM2 complies with the general electrical installation regulations (PUIL) standards and is grouped into lamps to facilitate control and maintenance of the installation. From the results of calculating the number of light points, Table 1 shows the energy consumption of lighting loads per day in the PCM2 building. From the calculation of the number of light points in Tables 1-3, it can be calculated the total number of lights on each floor and also the number of lamp power requirements in the PCM2 Building. Table 1 shows the grouping and power requirements of the lamps used in lighting installations on all floors.

Table 1. Daily Lamp Power Consumption on PCM2

Floor	Power Consumption **(KWh)**
Ground	712,339
1	911,290
2	1,031,501
Total	2,655,130

2.2 Cooling System

Cooling on (PCM 2) uses a chiller to obtain comfortable conditions for PCM2 Visitors who are shopping

Table 2. Chiller Specification Data

No.	Specification	Data
1	Chiller Type	Water Cooled Chiller
2	Cooling Capacity	1758 kW
3	Power Input	248.4 kW
4	COP	6.181
5	Compressor Type	Centrifugal
6	Refrigerant Type	R-134a
7	supply voltage	3 Phase 380Volt / 50Hz

Table 3. Chiller Operation Schedule

Chiller No.	Operational Hour												
	10	11	12	13	14	15	16	17	18	19	20	21	22
Chiller 1	1	1	1	1	1	1	1	1	1	1	1	1	1
Chiller 2	1	1	1	1	1	1	1	1	1	1	1	1	1

From the Chiller specification data and operational schedule shown in Tables 2 and 3, it can be explained that the Chiller operational procedure is as follows:
- Chiller 1 operates from 10:00 to 22:00
- Chiller 2 operates from 10:00 to 22:00

Table Description
- Orange color: shows the identity of chiller 1
- Blue color: indicates the identity of chiller 2
- Operational indicators are indicated by number 1 (On) and number 0 (Off).

Data retrieval

The data taken for this research include current and voltage data

Data of current

The current data taken is the electric current of the 3-phase R/S/T chiller on operating days. Shown in Table 4.

Table 4. Data of Current observed while operating

Time (hour)	The current of chillers 1 & 2 (Ampere) while operating
10:00	886.00
11:00	861.00
12:00	831.00
13:00	881.00
14:00	867.67
15:00	881.00
16:00	900.00
17:00	900.00
18:00	900.00
19:00	917.33
20:00	902.33
21:00	900.00
22:00	906.00

Data of voltage

The voltage data taken is the 3-phase voltage R-S / R-T / S-T during daily operations in Chiller 1 and Chiller 2 as shown in Table 5.

Table 5. Data of the observed voltage while operating

Time (hour)	Voltage of Chiller 1 & 2 (Volt) while operating
10:00	395
11:00	395.5
12:00	396
13:00	395.83
14:00	395
15:00	395
16:00	396
17:00	395.33
18:00	395
19:00	396
20:00	396
21:00	396
22:00	395

Table 6. Result of power used of 3 Floors every Day

Hour	Amount	I (Ampere)	V (Volt)	P (Watt)
10:00	2	886.00	395	699,940.00
11:00	2	861.00	395.5	681,051.00
12:00	2	831	396	658,152.00
13:00	2	881	395.83	697,452.46
14:00	2	867.67	395	685,459.30
15:00	2	881.00	395	695,990.00
16:00	2	900.00	396	712,800.00
17:00	2	900.00	395.33	711,594.00
18:00	2	900.00	395	711,000.00
19:00	2	917.33	396	726,525.36
20:00	2	902.33	396	714,645.36
21:00	2	900.00	396	712,800.00
22:00	2	906.00	395	715,740.00
The average total power used per day =				9,123,149

2.3 Escalator System

Escalators are used continuously even without being burdened, so the electricity demand can be reduced by adding an automatic start-stop device.

Escalator Operational Schedule

Table 7 is data on escalator specifications, while the escalator operational schedule is in Table 8.

Table 7. Data of Escalator Specifications

SPECIFICATION :	
ARRANGEMENT	: INDOOR,PARALLEL ARRANGEMENT
TYPE	: 9300AE-11-EN-30-100-K-R
VERTICAL RISE (mm)	: 5450
INCLINATION	: 30°
STEP WIDTH	: 1000
STEP RUN	: 2 FLAT STEPS
SPEED (m/s)	: 0,5
MOTOR CAPACITY	: 7,5kW / Unit
MAIN SUPPLY MOTOR	: 5x10mm2,25A FUSE PROTECT (BY OTHERS)
MOTOR NOMINAL CURRENT	: 18.7
MOTOR STARTING CURRENT	: 30,5A
MAIN SUPPLY LIGHTING	: 33X2,5mm2, 16A FUSE PROTECT (BY OTHERS)
POWER SUPPLY	: 3 PHASE 380V ±6%, 50HZ
LIGHTING SUPPLY	: 1 PHASE 380V ±6%, 50HZ

Table 8. Schedule of escalator operations while operation

Chiller No.		Operational Hour												
		10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Ground Floor	Escalator 1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Escalator 2	1	1	1	1	1	1	1	1	1	1	1	1	1
Floor 1	Escalator 1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Escalator 2	1	1	1	1	1	1	1	1	1	1	1	1	1
Floor 2	Escalator 1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 9. Number of escalators on all floors

Location	**Amount**	**Hour**	**I (Ampere)**	**V (Volt)**	**P (Watt)**
Ground Floor	2	12	30.3	380	276,336
Floor 1	2	12	30.3	380	276,336
Floor 2	1	12	30.3	380	138,168

From the operational schedule shown in Table 8 can be explained the operational procedures of the escalator during weekdays are as follows:

- Escalator 1 operates from 10:00 to 22:00
- Escalator 2 operates from 10:00 to 22:00

Data retrieval

The data taken for this research include data on the number of escalators on each floor.

2.4 Elevator System

The elevator will stop on the ground floor if there are no passengers. To determine the amount of energy required for each elevator, it can be determined through the following calculations:

Table 10. Data on Passenger Elevator Specifications

SPECIFICATION :	
FUNCTION	: PASSENGER ELEVATOR
SPEED	: 105 MPM (1.75 m/s)
CAPACITY	: 1000 kg (13 people)
SERVED FLOOR	: GROUND, 1 and 2
TOTAL TERMINATIONS	: 15 STOP / 14 OPENING
AVERAGE FLOOR AREA	: 950 m^2
NET FLOOR AREA	: 700 m^2
PEOPLE FLOORS	: 6 m^2/PEOPLE
TRACTION MACHINE	: AC - VVVF
DOOR OPEN SYSTEM	: CENTER OPENING (CO)
LIFT OPENING SIZE	: 1000 mm x 2100 mm
HOITSWAY SIZE	: 2350 mm x 2200 mm
PIT Elevator SIZE	: 1400 mm
MOVEMENT DISTANCE (TRAVEL)	: 52.8 m
FLOOR-TO-FLOOR HEIGHT	: 3 m
OVERHEAD SIZE	: 4300 mm

Elevator Operational Schedule

The elevator Operational Schedule is shown in Table 12.

The operational schedule in Table 12 can be explained that the elevator operational procedures during weekdays are as follows:

- elevator 1 operates from 10:00 to 22:00
- elevator 2 operates from 10:00 to 22:00
- elevator 3 operates from 10:00 to 22:00
- elevator 4 operates from 10:00 to 22:00

Table 11. Data of Freight Elevator Specifications

SPECIFICATION :	
FUNCTION	: FREIGHT ELEVATOR
SPEED	: 105 MPM (1.75 m/s)
CAPACITY	: 1600 kg (21 people)
SERVED FLOOR	: GROUND, 1 and 2
TOTAL TERMINATIONS	: 15 STOP / 14 OPENING
AVERAGE FLOOR AREA	: 950 m^2
NET FLOOR AREA	: 700 m^2
PEOPLE FLOORS	: 6 m2/PEOPLE
TRACTION MACHINE	: AC - VVVF
DOOR OPEN SYSTEM	: CENTER OPENING (CO)
LIFT OPENING SIZE	: 1000 mm x 2100 mm
HOITSWAY SIZE	: 2350 mm x 2200 mm
PIT Elevator SIZE	: 1400 mm
MOVEMENT DISTANCE (TRAVEL)	: 52.8 m
FLOOR-TO-FLOOR HEIGHT	: 3 m
OVERHEAD SIZE	: 4300 mm

Table 12. Schedule of Passenger elevator while operation

Elevator No	**Operational Hour**												
	10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Elevator 1	1	1	1	1	1	1	1	1	1	1	1	1	1
Elevator 2	1	1	1	1	1	1	1	1	1	1	1	1	1
Elevator 3	1	1	1	1	1	1	1	1	1	1	1	1	1
Elevator 4	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 13. Schedule of the freight elevator while operation

Elevator No	**Operational Hour**												
	10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Elevator 1	1	1	1	1	1	1	1	1	1	1	1	1	1
Elevator 2	1	1	1	1	1	1	1	1	1	1	1	1	1

The operational schedule in Table 13 can be explained as the elevator operational procedures on weekdays as follows :
- elevator 1 operates from 10:00 to 22:00
- elevator 2 operates from 10:00 to 22:00

Data retrieval
The data for this research is the balance data on the weight of the elevator in the building.

Table 14. Motor Current and Voltage Based on Carload

		Direction	**Motor Current**		**Source Voltage**	
%	**Kg**		**Start**	**Run**	**Start**	**Run**
0	0	Up	75.6 A	75.3 A	394.3 Vac	396.4 Vac
		Down	78.2 A	78.1 A	389.9 Vac	391.7 Vac
50	800	Up	7.3 A	7.2 A	395.6 Vac	395.9 Vac
		Down	7.7 A	7.6 A	395.3 Vac	396.4 Vac
100	1600	Up	70.3 A	70 A	390.7 Vac	392.1 Vac
		Down	68.7 A	67.6A	394.8 Vac	397.8 Vac

Table 15. Results of Power Measurements

Hour	Total of Elevator	I (Ampere)	V (Volt)	P (Watt)
10:00	6	75.40	395	178,698.00
11:00	6	7.40	392	17,404.80
12:00	6	7.35	393.6	17,357.76
13:00	6	7.48	394.2	17,691.70
14:00	6	7.50	391.8	17,631.00
15:00	6	7.00	393.7	16,535.40
16:00	6	7.60	396	18,057.60
17:00	6	7.90	395.8	18,760.92
18:00	6	7.55	394.9	17,888.97
19:00	6	7.95	396	18,889.20
20:00	6	7.90	392.5	18,604.50
21:00	6	7.80	396	18,532.80
22:00	6	7.10	395	16,827.00
The average total power used per day =				392,880

2.5 Energy Audits

Electrical energy is a form of energy that comes from a current source which is usually expressed in Watt-hours. The energy used by electrical equipment is the rate of energy use (power multiplied by time) during which the equipment is used. Mathematically it can be written in (1)[4]:

$$Power \times Time = Energy \quad (1)$$

Power: is the power of electrical equipment (Watts)
Time: is the time during which the equipment is used (hours)
Energy: is the electrical energy consumed by electrical equipment (Watt hour).

To calculate the amount of electrical energy consumption in buildings and to identify or find out energy-saving steps that can be taken to achieve efficiency in the use of electrical energy, an energy audit can be carried out. In general, an energy audit is an activity to identify where and how much energy is used and what steps can be taken in the context of energy conservation at an energy user facility.

Data collection is then followed by analysis and energy conservation activities that will be implemented. Energy audit activities start from simple data surveys to a detailed examination of existing data, analyzed and designed to generate new data. Through an energy audit, we can obtain a portrait of energy use in a building, namely an overview of the type, amount of energy use, energy equipment, energy intensity, and other data [6].

2.6 The Intensity of Electrical Energy Consumption

Energy Consumption Intensity (ECI) is used to express the amount of energy used in a building that has been implemented in several countries (ASEAN and APEC), expressed in kWh/m2/year [5]. ECI standard values for buildings in Indonesia can be seen in Table 16.

The ECI standard value for buildings in Indonesia has been established by the Ministry of National Education of the Republic of Indonesia in 2000 [5]. Rooms that use AC and without AC have ECI standards which can be seen in Table 17.

Table 16. ECI standards for buildings in Indonesia [5]

No	Building Type	ECI [kWh/m^2/ Year
1	Office (Commercial)	240
2	Shopping center	330
3	Hotels and Apartments	300
4	Hospital	380

Table 17. ECI standards for AC and non-AC rooms [5]

Criteria	AC room (kWh/m^2/month)	A room without AC (kWh/m^2/month)
Very Efficient	4.17 – 7.92	O.84 – 1.67
Efficient	7.92 – 12.08	1.67 – 2.5
Enough Efficient	12.08 – 14.58	-
Rather extravagant	14.58 – 19.17	-
Wasteful	19.17 – 23.75	2.5 – 3.34
Very wasteful	23.75 – 37.75	3.34 – 4.17

The energy consumption intensity value is calculated based on the data obtained from the energy audit activity in that building.

If the ECI value obtained through the initial energy audit is greater than the predetermined standard value, then a detailed energy audit needs to be carried out to obtain a profile of the building's energy use so that it can be identified which electrical equipment uses quite a large amount of energy. In a detailed energy audit, all energy analysis is carried out based on the data obtained from the measurement results. The measuring instrument used is a calibrated measuring instrument either in the form of a permanent measuring instrument at the agency or a portable measuring instrument.

Energy audits and energy-saving possibilities identified in the audits are best applied in energy management programs where operations, formally known, are an integral part of the overall management activities that are ongoing in an organization.

2.7 Energy Saving Opportunities

Based on the data that has been obtained, both from measurement results and historical data on energy use, the amount of electricity consumption energy intensity (ECI) is calculated and a building energy use profile is compiled. The calculated ECI size is then compared with the ECI standard used (ECI target). If the calculated ECI is equal to or less than the ECI target, then the detailed energy audit can be stopped or continued with the aim of getting an even lower ECI value. However, if the results of the ECI calculation are greater than the ECI target, it means that there is an opportunity to continue the detailed energy audit process to obtain energy savings.

The next thing to do is to make a list of possible energy-saving opportunities. Energy-saving opportunities that cannot be implemented or that are not desirable should be removed from the list and the remaining savings opportunities will then be evaluated or analyzed.

Analysis of energy-saving opportunities is carried out by comparing the potential for energy-saving gains with the costs to be paid for implementing the recommended energy-saving plans. Energy savings in buildings cannot be obtained simply by reducing the comfort of building occupants or productivity in the work environment.

Analysis of energy-saving opportunities can be done with efforts, including:
a. Minimizing energy use as little as possible (reducing installed/used power and operating hours).
b. Improve equipment performance.
c. Using a cheap energy source.

Energy Saving Recommendations

After conducting a survey and analyzing energy use data, the next thing to do is to make energy-saving recommendations. This recommendation is a suggestion that companies or building owners can make to improve the efficiency of energy use in the building. In general, recommendations can be:
a. Recommendations to replace the system, because the old system is considered inefficient.
b. Recommendations for system improvement, because the system is considered less efficient, so it is necessary to make a few changes so that efficiency can be increased.
c. Recommendations for installing new equipment.

Based on EMO (Energy Management Opportunity), recommendations can be divided into three categories based on their capital costs, namely:
a. Category 1: includes no-cost investment and does not change system operations. Usually only in the form of a recommendation to turn off the lights or AC when not in use, change the AC temperature setting so that it is not too low, etc.
b. Category 2: includes a low-cost investment with little change or improvement to the system. For example, installing a timer to turn off equipment, and replacing T8 fluorescent tube lamps with T5 fluorescent tubes.

Category 3: includes a high-cost investment with some changes and improvements to the system. For example, installing power factor correction equipment, and installing a variable speed drive.

3. RESULT AND DISCUSSION

A. Calculate the consumption of electrical energy for lighting, it can be calculated based on the number of lamps installed and the amount of power available, assuming the usage time (Wp) is 12 hours a day and 1 month (30 days).
   a. Ground Floor
      Ke.pn = Be.pn x Wp = 712.339 x 30 = 21,370.17 kW/month
   b. 1st floor
      Ke.pn = Be.pn x Wp = 911.290 x 30 = 27,338.7kW/month
   c. 2nd Floor
      Ke.pn = Be.pn x Wp = 1,031.501 x 30 = 30,945.03 kW/ month
   Total power consumption for 1 month is 79,653.9 kW/month
   Total power consumption for 1 year: 79,653.9 kW/month x 12 (months) = 955,846.8 kW/year

   Information :
   - Ke.pn: Total Power Usage
   - Be.pn: Power Usage Load
   - Wp: Usage Time

B. To calculate the consumption of electrical energy in the cooler, the available power can be calculated, assuming the usage time (Wp) is 12 hours a day and 1 month (30 days).

   Ground Floor + 1st Floor + 2nd Floor
   Ke.pn = Be.pn x Wp = 9,123,149 x 30 = 273,694.47 kW/month

   The total power consumption for 1 month is 273,694.47 kW/month
   Total power consumption for 1 year: 273,694.47 kW/month x 12 (months) = 3,284,333.64 kW/year

C. Calculate the consumption of electrical energy on the Escalator, it can be calculated based on the amount of power available, assuming the usage time (Wp) is 12 hours a day and 1 month (30 days).
   a. Ground Floor
      Ke.pn = Be.pn x Wp = 276,336 x 30 = 8,290,080 kW/month
   a. 1st floor
      Ke.pn = Be.pn x Wp = 276,336 x 30 = 8,290,080 kW/month
   a. 2nd Floor
      Ke.pn = Be.pn x Wp = 138,168 x 30 = 4,145,040 kW/month
   Total power consumption for 1 month = 20,725,200 kW/month
   Total power consumption for 1 year = 20,725,200 kW/month x 12 (months) = 248,702,400 kW/year

D. calculate the consumption of electrical energy for elevators, it can be calculated based on the amount of available power, assuming the usage time (Wp) is 12 hours a day and 1 month (30 days).

   Ke.pn = Be.pn x Wp = 392,880 x 30 = 11,786,400 kW/month
   Total power consumption for 1 month = 11,786,400 kW/month
   Total power consumption for 1 year = 11,786,400 kW/month x 12 (months) = 141,436,800 kW/year

3.1 Energy Consumption Intensity (ECI)

Energy Consumption Intensity (ECI) is the division between energy consumption and a unit area of a building. Energy Consumption Intensity (ECI) is a term used to determine the level of energy consumption in a building. From the calculation of the Lighting System, Cooling System, Escalator, and Elevator in the building at PCM2 Surabaya. The area has a total area of 46,000 m^2 with 3 floors.

ECI Calculation Results (Energy Consumption Intensity):
1. Total kWh per day (kWh/m^2.day) x for 30 days (1 month)= 12,621.159 kWh/day x 30 days = 378,634.762 kWh/month

2. Total kWh per day (kWh/m^2.day) x for 365 days (1 year) = 12,621.159 kWh/day x 365 days = 4,606,722.935 kWh/year

The calculation of ECI is as follows (SNI 03-6196-2000). The building area is 46,000 m^2, so the average ECI value in 2021 is:
ECI = Total Power Consumption per Year (kWh/Year)

$$\text{ECI} = \frac{4{,}606{,}722.935}{46{,}000} = 100.146\ \text{kWh/year}$$

It is obtained that the amount of electricity ECI per unit area is 100.146 kWh/year. Where the ECI PCM2 Surabaya value has entered the standard ECI, which is not more than the maximum ECI building limit of 330/year.

For AC Room Criteria (kWh/m^2/month)
ECI = Total Power Consumption per Month (kWh/month)/total area

$$\text{ECI} = \frac{378{,}634.762}{46.000} = 8{,}231\ \text{kWh/month}$$

ECI = $8{,}231\ \text{kWh/month}$ x 12 (months) = $98{,}772\ \text{kWh/year}$

It is obtained that the amount of electricity ECI per unit area is 8,231 kWh/month and $98{,}772\ \text{kWh/year}$. Where the ECI PCM2 Surabaya value for AC room area (kWh/m2/year) has entered the Efficient criteria

4. CONCLUSION

This research was conducted to measure the level of efficiency of electrical energy at PCM2 Surabaya. The results of the calculations carried out, obtained that the cooling system (Chiller) is the largest power user of the total power (Kwh) or the equivalent of 72.285%. The value of Energy Consumption Intensity (ECI) for PCM2 Surabaya is 8,231 kWh/m2/month and 98,772 kWh/m2/year for rooms with air conditioning, including efficiency. Based on the research that has been done, it is known that rooms in the PCM2 Surabaya Building have ideal room temperatures, but there are still rooms that have light intensity below the standard value by SNI 03-6197-2000. The efficiency of electrical energy in the PCM2 Surabaya Shopping Center Building can be increased by adding or replacing lamps in rooms where the light intensity is lacking, improving the power factor as well as implementing an energy-saving culture in the PCM2 Surabaya environment.

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