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Analysis of Electrical Energy Management Performance in Asri Hotel Building

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Abstract -- The Energy Efficiency Index (EEI) records a building's performance and provides a baseline for energy consumption. Analyzing a power system using EEI involves total energy consumption, electricity consumption for each zone, and energy consumption distribution. This study aims to determine the electrical load profile and building profile of electrical energy consumption at Hotel Asri, analyze the performance of electrical energy use, and provide optimization conclusions. The electrical load profile includes installed loads (computers, TVs, hairdryers, refrigerators), cooling loads (Air Conditioning), lighting loads, and other loads (pumps, water filters). Hotel Asri's building area is 3446 m^2, with an average total electrical energy consumption of 39.98967 kWh per year. After measuring Light Intensity and calculating installed and cooling loads, the IKE calculation for buildings with air conditioning is 7.8 kWh / m^2 per month (highly efficient) and without air conditioning is 1.19 kWh / m^2 per month (highly efficient). The IKE of the entire Asri Hotel building is 139,225 kWh/m^2 per year, below the IKE target for hotels. Although Hotel Asri's IKE is highly efficient based on Indonesian building standards, many lighting measurements do not comply with the Indonesian National Standard for artificial lighting (SNI 03-2496-2001).

Keywords:
Energy Efficiency Index (EEI),
Electrical Energy Consumption,
Electrical load,
SNI 03-2496-2001

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I. INTRODUCTION

Hotel Asri Plaza Asia Tasikmalaya is the perfect business and leisure venue. The hotel has everything needed for a comfortable stay. Since the establishment of Asia Plaza Mall, energy use has never been analysed in the Asri Hotel. The use of energy at the Asri hotel is carried out by analyzing the calculation of energy consumption.

The energy use in beautiful hotels is carried out based on the number of visitors. Starting from the long use of electrical energy for lighting, air conditioning, and other installed loads, to the use of water. The electrical energy calculation based on visitors coming in narrows down again with the calculation of energy based on the type of room rented by hotel guests. (Dolge et al., 2020)

The use of electrical energy is efficient. Therefore, the use of electrical energy must be optimized. To optimize energy use, it is necessary to observe the performance of electrical or electrical energy management. Electrical energy performance or energy management management is carried out using the Efficiency Energy Index as an indicator used to track energy consumption contained in a building. (Dolge et al., 2020) Energy efficiency and energy management in the Efficiency Energy Index are closely related to monitoring and controlling energy consumption in buildings. With the current increase in global energy consumption, the main concern is how to produce the energy needed and how to improve energy efficiency to ensure the energy supply is sustainable and can meet the demand to ensure the optimal operation of the building's energy system. [1]

This study's findings report that the energy efficiency level in each dimension appears to be different. Differences are observed in all three dimensions of energy efficiency – economic, technical, and environmental. Its indices can be constructed for different periods to investigate the dynamics and evolution of EEI and its dimensional sub-indices over time. According to Zuberi M. J. S. in the Energy Efficiency Index EEI and its dimensional sub-indices over time, the index can be built for different periods. According to Zuberi M. J. S. in the Energy Efficiency Index (EEI) to obtain energy efficiency levels for all sectors reviewed in this regard, To investigate the dynamics and evolution of the EEI and its dimensional sub-indices over time, the index can be constructed for different periods. This will make it possible to identify such sub-sectors. (Dolge0et0al.,02020) According to N. Madlool, the Energy Efficiency Index (EEI) is an indicator that records the performance of a building and acts as a reference point that provides a baseline for the energy consumption of a building. EEI is also known as the Building Energy Index (IDX).

II. LITERATURE REVIEW

A. Electricity Energy Management

Energy management is an organized activity within a company that applies management principles with the aim of energy conservation, so that energy costs, which are one of the components of production/operating costs, can be minimized as much as possible. In general, energy management can be defined as management that directly impacts the organization, techniques, and actions that are economically efficient in order to minimize energy consumption, including energy used for production/activities, as well as minimizing the consumption of raw materials and other supplementary materials.

B. Electricity Energy Management

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C. Electricity Energy Efficiency

Hidayanto (2012) states that, in essence, energy efficiency is a part of energy conservation. In the national energy policy, it is mentioned that energy conservation is a systematic, planned, and integrated effort to preserve domestic energy resources and improve the efficiency of their utilization. In Indonesia, energy conservation efforts are of great importance given the significant gap between the demand side and the supply side of energy.

D. Energy Efficiency Index

The Energy Efficiency Index (EEI), or sometimes referred to as the Building Energy Index (BEI), is the most commonly used index as a Key Performance Indicator (KPI) to track and compare energy consumption performance in buildings. The concept of this index is widespread because it is useful to have a universal index for energy efficiency practices in buildings. In general, EEI can be viewed as the ratio of energy input to factors related to components that consume energy. [1]

$$\text{EEI}=\frac{energy\ input}{factor\ related\ o\ the\ energy\ using\ components} \tag{1}$$

TABLE I.
ENERGY EFFICIENCY INDEX (IKE) STANDARDS FOR BUILDINGS IN INDONESIA

No	Types of Buildings	IKE (kWh/m²/bulan)
1	Office Buildings (Commercial)	240
2	Shopping Centers	330
3	Hotels and Apartments	300
4	Hospitals	380

Buildings with Air-Conditioned Rooms (kWh/m²/month)		Buildings with Non-Air-Conditioned Rooms (kWh/m²/month)	
Very Efficient	4,17 – 7,92	Very Efficient	0,84 – 1,67
Efficient	7,92 – 12,08	Fairly Efficient	1,67 – 2,50
Fairly Efficient	12,08 – 14,58	Inefficient	2,50 – 3,34
Tends to be Inefficient	14,58 – 19,17	Very Inefficient	3,34 – 4,17
Inefficient	19,78 – 23,75		

E. Types of Electrical Loads

1) Lighting

Lighting sources can be divided into two types: First, natural lighting is the source of illumination derived from natural sunlight during the day, typically for about 120 hours per day. To obtain sufficient sunlight, the position and width of the windows must be considered. The window area for natural lighting should be approximately 20% of the room's floor area. Natural lighting is influenced by several factors, including the season, time of day, hour, proximity to neighboring buildings, and the size of the entryway for natural lighting. [3]

2) Ventilation

An air conditioner, commonly referred to as an AC, is a device capable of conditioning the air. In other words, an AC functions as an air cooler. ACs are used to obtain cool, fresh, and comfortable air for the body. The use of air conditioning is more prevalent in tropical regions with relatively high temperatures, such as in Indonesia, where the climate often requires cooling systems to maintain comfort. [4]

3) Water Pump

A pump is a device used to transfer fluid from one location to another, operating based on the conversion of mechanical energy into kinetic energy. The mechanical energy provided by the pump is used to increase the velocity, pressure, or elevation (height) of the fluid.

4) Installed Load

Installed load refers to the total capacity of all loads based on the rated capacity marked on the nameplate and electrical equipment. The ratio of peak load to installed load represents the degree of simultaneous service for all installed loads. This can be explained by how the total installed load significantly affects the load service pattern. For example, commercial and industrial consumers have a higher service level compared to residential consumers. The installed load can be determined through field surveys or secondary data from electricity supply companies.

5) Lighting System in Buildings

SNI 03-6575-2001 is a technical guideline for artificial lighting systems that serves as a reference for designers and builders when designing artificial lighting systems in buildings. It also serves as a guide for building owners or managers in operating and maintaining artificial lighting systems, ensuring that the system meets health and comfort standards and complies with regulations applicable to buildings. [5]

TABLE II.
Recommended Minimum Lighting Levels and Color Rendering

Room Functions	Lighting Level (Lux)	Color Rendering Group
Hotel and Restaurant		1
Lobby, Corridor	100	1
Ballroom/Conference Room	200	1
Dining Room	250	1
Cafeteria	250	1
Bedroom	150	1 atau 2
Kitchen	300	1

6) Air Conditioning System

Energy conservation in air conditioning systems refers to systems that operate efficiently without compromising their functional requirements. In air conditioning systems, the unit or component that regulates the system is called the AHU (Air Handling Unit). The AHU is responsible for circulating and conditioning the air within a building, ensuring that the temperature, humidity, and air quality meet the desired standards while minimizing energy consumption. Efficient design and operation of AHUs contribute significantly to energy savings in air conditioning systems.

7) Cooling Load

TABLE III.
Cooling Load

Room Functions	Color Rendering Groups
Apartment	0,5 – 1,0
Hotel	1,0 – 1,5
Campus	1,5 – 2,0
Office	1,5 – 2,0
Hospital	1,0 – 1,5

For detailed calculations, the following parameters need to be known: the dimensions of the room (length, width, and height), the outdoor temperature (t_0) and humidity (RH_0), the indoor temperature (t_1) and humidity (RH_1 typically around 50-80%), the building envelope, the height of the windows and ceiling, as well as the building occupancy level.

$$\text{Occupancy} = \frac{L_{bruto}}{L_{per-person}} \quad (2)$$

Where:
$L_{per-person}$= area per person, typically ranging between 15-20 m^2

8) Building Sensible Load

To calculate the sensible load, both the heat load through glass surfaces and the heat load caused by the transmission through wall surfaces, it is necessary to first determine the relevant values. As shown in the table below:

TABLE IV.
BUILDING SENSIBLE LOAD

Building Envelope	Heat Load (BTU/hour/m³)
Glass	0,5 – 1,0
North Side	800
South Side	400
East Side	900
West Side	1000
Walls	
North Direction	2.15 $(t_0 - t_1)$
South Direction	2.15 $(t_0 - t_1)$
East Direction	2.15 (t_0 – t_1)
West Direction	2.16 (t_0 – t_1)

Note: For Indonesia, $(t_0 - t_1) = 5^{\circ}C$
Therefore, the Building Sensible Load (BSB) is:
$BSB = Area\ building\ x\ Heat\ Load$

9) Internal Heat Load

The internal heat load consists of the sensible heat load from people, which is calculated based on the metabolic rate for specific activities, or alternatively, the values for Sensible Heat Load from People (BSO) and Latent Heat Load from People (BLO) can be used.

$BSO = Occupancy. 200$
$BLO = Occupancy. 250$

For the Sensible Load from Fluorescent Lights (BSL), use the formula:
$BSL = (\Sigma watt)(1,25)(3,4)$

10) Ventilation or Infiltration Load

The air requirement can be calculated using the following approximate formula:

A) CFM Infiltration (CFM_1)

$$CFM_1 = \frac{P.L.T.AC.35,31}{60} \quad (3)$$

Where:

P = Room Length (meters)

L = Room Width (meters)

T = Room Height (meters)

AC = Air Changes per Hour (using Table 2.6 or minimum AC = 2)

B) Ventilation Load

$$CFM2 = [(t_0 - t_1).1,08 + (RH_0 - RH_1).0,67] \quad (4)$$

Therefore, the Cooling Load (BP) is:

$$BP = BSB + BSO + BLO + BSL + CFM_1 + CFM_2 \quad (4)$$

Where:

BSB = Building Sensible Load

BSO = Sensible Heat Load from People

BLO = Latent Heat Load from People

BSL = Sensible Heat Load from Lights

CFM_1 = Infiltration Load

CFM_2 = Ventilation Load

Air Handling Capacity:

Capacity = $\frac{BP}{12000} TR$

11) Occupancy Rate

According to Sugiarto (2000:85), the room occupancy rate is expressed using a specific ratio, which is the percentage of room occupancy or occupancy percentage, commonly referred to as single occupancy. Shite (2004:141) in his journal states that the room occupancy rate can be calculated based on the percentage (Juhari, 2016), using the following method:

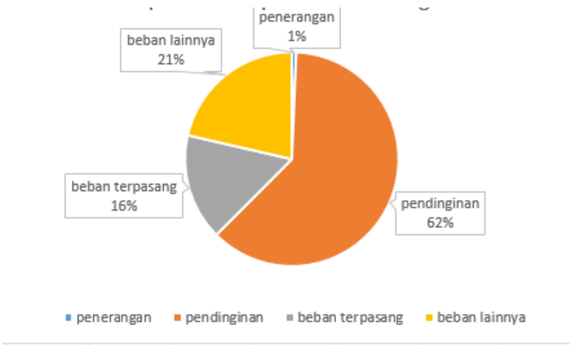

Figure I Porsi segmentasi beban listrik Hotel Asri Tasikmalaya

$$\text{Occupancy rate} = \frac{Number\ of\ Rooms\ Sold}{Number\ of\ Rooms\ Available}\ x\ 100\% \quad (5)$$

III. METHOD

A. Research Flow Diagram

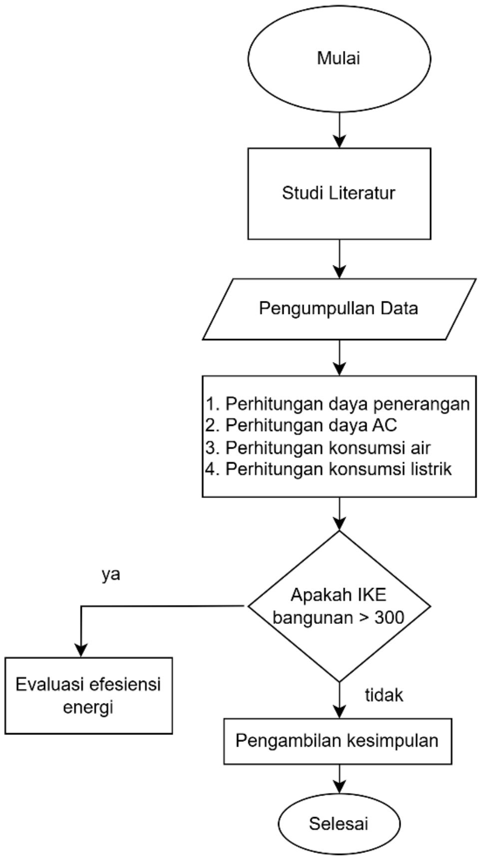

Figure II. Flow Diagram

In Figure II, the research was conducted through literature study, data collection, illumination power calculation, AC power calculation, installed power calculation, and analysis of IKE.

IV. RESULTS AND DISCUSSION

A. Energy Consumption Data

The electricity consumption at Hotel Asri Tasikmalaya is divided into several categories, such as lighting, cooling, installed load, and other loads.

In Figure 4.1, it can be concluded that the largest portion of electricity usage at Hotel Asri is 62%, followed by other loads such as pumps and water filters at 21%, installed loads like TVs, refrigerators, computers, dispensers, and others at 16%, and finally, energy consumption for lighting at 1%.

B. Occupancy Rate Data

The occupancy rate at Hotel Asri Tasikmalaya is influenced by activities held at the hotel, as well as weekly holidays, public holidays, and long weekends.

From the occupancy rate data for 2019-2020, it can be calculated using equation 2.15, and the average occupancy rate at Hotel Asri Tasikmalaya is obtained to be 51%.

C. Building Profile in Relation to Electricity Consumption

1) Building Floor Plan

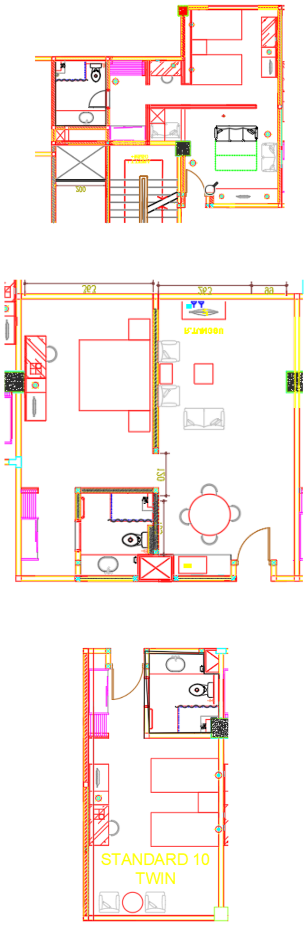

Figure III Deluxe Room Floor Plan

Hotel Asri has 2 floors, consisting of a lobby, manager's office, workspace, storage room, 58 guest rooms, a coffee shop, 7 driver rooms, men's and women's toilets, and a laundry room. Figure 4.1 shows the floor plan of Hotel Asri's first floor, which includes the lobby, manager's office, workspace, storage room, 2 royal suite rooms, 2 suite rooms, 26 deluxe rooms, 7 driver rooms, men's and women's toilets.

On the second floor of Hotel Asri, there are 2 royal suite rooms, 2 suite rooms, 23 deluxe rooms, and a laundry room. Table 4.2 provides the floor area details of Hotel Asri. The total area of Hotel Asri is 3446 m², with 2150 m² of air-conditioned rooms and 1332 m² of non-air-conditioned rooms.

D. Energy Consumption Data

Table 5
Energy Consumption Data

Month	WBP Tariff (kWh)	LWBP Tariff (kWh)	Total Energy Consumption (kWh)	Energy Usage Cost (Rupiah)
September	15.276,33	30.552,67	45.829	63.373.563
October	16.315,33	32.630,67	48.946	67.683.834
November	17.670,67	35.341,33	53.012	73.306.407
December	17.543,33	35.086,67	52.630	72.778.167
January	19.080,33	38.160,67	57.241	79.154.381
February	17.437,33	34.874,67	52.312	72.338.429
March	15.497	30.994	46.491	64.288.995
April	7.370	14.740	22.110	30.574.298

May	5.331	10.662	15.993	22.115.547
June	8.542,333	17.084,67	25.627	35.437.699
July	9.702	19.404	29.106	40.248.553
August	10.193	20.386	30.579	42.285.457
Maximum	19.080,33	38.160,67	57.241	79.154.381
Minimum	5.331	10.662	15.993	22.115.547
Total	15.9958,7	319.917,3	479.876	663.585.329
Average	13.329,89	26.659,78	39.98967	55.298.777

From the data above, the energy consumption of Hotel Asri over one year, from September 2019 to August 2020, totals 479,876 kWh. The total electricity usage cost is 663,585,329

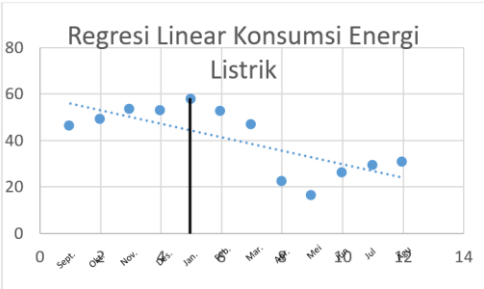

Figure IV. Trend Graph of Electricity Energy Consumption

Figure IV shows the trend of electricity energy consumption at Hotel Asri from September 2019 to August 2020. Based on the results of the graph, it can be concluded that the electricity energy consumption at Hotel Asri has a decreasing linear relationship each month. The linearity of electricity energy consumption at Hotel Asri follows the function: $y = -2.9105x + 58.908$.

E. Performance of Electricity Energy Usage on Energy Efficiency

1) Calculation of IKE

a) Calculation of Overall IKE

The calculation of IKE for air-conditioned rooms is obtained from the total energy consumption in rooms with air conditioning (AC) and rooms without AC. The IKE calculation uses equation 2.2.

From the energy consumption calculation for air-conditioned rooms, the IKE value for electricity at Hotel Asri per unit area is 139.225 kWh/m² year. Therefore, the overall IKE of Hotel Asri falls under the very efficient category.

b) Calculation of IKE for Air-Conditioned Rooms

The calculation of the IKE for energy consumption in air-conditioned rooms gives the IKE value for electricity at Hotel Asri per unit area as 7.8 kWh/m² month. Therefore, the IKE for air-conditioned rooms at Hotel Asri falls under the very efficient category.

c) Calculation of IKE for Non-Air-Conditioned Rooms

The calculation of the IKE for non-air-conditioned rooms gives the IKE value for electricity at Hotel Asri per unit area as 1.19 kWh/m² month. Therefore, the IKE for non-air-conditioned rooms at Hotel Asri falls under the very efficient category.

F. Optimization of Electricity Energy

1) Percentage Comparison of Light Intensity Measurement (Lux) Results with SNI 03-6197-2000

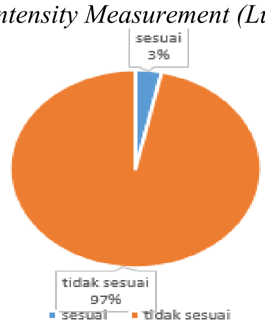

Figure V. Percentage Comparison of the Measurement Results at Hotel Asri

From Figure V, it can be seen that only 3% of Hotel Asri Tasikmalaya meets the light intensity (Lux) value, while the rest of the lighting at Hotel Asri does not meet the SNI 03-6197-2000 standard.

2) Air Conditioning Calculation

a) Cooling Load Calculation

To calculate the cooling load, several variables must first be determined, including occupancy, building sensible load (BSB), sensible load of people (BSO), latent load of people (BLO), sensible load of lighting (BSL), infiltration load (CFM_1), and ventilation load (CFM_2).

Based on the calculation of electricity consumption at Hotel Asri, the highest energy consumption is from air conditioning, accounting for 67%. Therefore, the use of air conditioning at Hotel Asri needs to be re-planned.

V. CONCLUSION

1) The electricity load profile of Hotel Asri has an average daily power consumption of 50,970 Wh, with a minimum power of 33,080 Wh per day and a maximum power of 60,250 Wh. The total energy consumption in one year is 479,876 kWh, with an average annual electricity consumption of 39,989.67 kWh.

2) Electricity consumption at Hotel Asri is influenced by the hotel's guests or occupancy rate. The highest electricity consumption at Hotel Asri occurred in January 2020, while the lowest consumption was in April 2020.

3) After conducting light intensity measurements and calculating the installed load and cooling load for the building, the results for Hotel Asri Tasikmalaya show that the IKE calculation for the air-conditioned building is 7.8 kWh/m² month, which falls into the very efficient category. The IKE for the non-air-conditioned building is 1.19 kWh/m² month, also falling into the very efficient category. Furthermore, the overall IKE for Hotel Asri is 139.225 kWh/m² year, which is below the target IKE for hotels.

4) Although Hotel Asri's IKE is in the very efficient category according to the building energy efficiency standards in Indonesia, the lighting measurement results showed that many of the readings did not meet the Indonesian National Standard for artificial lighting (SNI 03-2496-2001).

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