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Energy Audit of Office Building PT. PJB UP Paiton

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Abstract:

An energy audit for the office building of PT. PJB UP Paiton has been conducted. This audit is conducted to show the efficiency of energy usage in PT. PJB UP Paiton. The area that audited are building lightning system, building insulation system and total electrical usage in the entire building. Building lighting system is analyzed by measuring the illuminance level and electrical energy usage for lightning in each floor. PT. PJB UP Paiton building insulation system also analyzed by measuring the overall thermal transmittance value of the building. This measurement are based on building material detailed profile and orientation. In the other hand, total electrical energy in the entire building is measured based on two method. First, electrical energy consumption and active hour of each equipment in each floor is gathered. Then, electrical energy used for lightning system, thermal conditioning, lift and other tools are measured through main distributed panel. Through this measurement, electrical energy usage for the entire building and the energy usage intensity can be calculated. The result shows that the energy used for lightning system on floor level 1, 2, 3 and 4 are 5.8, 6, 9.9 and 9.6 W/m^2 respectively. The overall thermal transmittance value for the entire building is 34.49 W/m^2. The electrical energy usage for the entire building is 779.163 kWh per year. And the energy usage intensity of PT. PJB UP Paiton entire building is 223.962 kWh/m^2. According to SNI 03-6197-2000, SNI 03-6575-2001 and ASEAN-USAID 1992 standards can be concluded that PT. PJB UP Paiton office building is energy efficient.

Keywords — **Energy audit, Lightning system, Building insulation system, Energy usage intensity, Energy efficient**

1. INTRODUCTION

The importance of energy has been emerge through human history, most people would find it hard to live without it. Growing prices of energy combined with rapid economic development lead to an increasing understanding for the need of energy audit [1]. Energy audit is essential for business owner who want to upgrade their facilities to be more energy efficient [2].

Energy audit has conducted around the world. For example, energy improvement of office buildings was conducted in Southern Europe to increase the use of renewable energy resources [3]. In China, energy audit also conducted to evaluate the energy and thermal performance of office buildings envelope [4].

This aim of this paper is to describe about the efficiency of energy usage in PT. PJB UP Paiton limited companies through energy audit.

2. REVIEW

2.1 Lightning System

Lighting system plays an important role in building energy management. Total energy required for lighting system in a building is proportional to the usage of artificial light used that building. Artificial light became important when there is not enough light inside the building. In order to efficiently determine how much artificial light should be used, some measurement and calculation are needed.

There are several measurements that usually conducted to define how well the light from any sources illuminate the entire room or building and how efficient they are. These measurements are luminous flux measurement, luminous efficacy measurement, luminous intensity measurement, illuminance measurement and luminance measurement.

In this work, illuminance measurement is conducted to evaluate the building lightning system. While the standard used in the evaluation is based on National Standardization Institution of Indonesia manual SNI 03-6197-2000 about energy conservation of lightning system as shown in Table 1 [5].

Table -1: Recommended illuminance level

Room	Illumincance level
Director's Room	350
Workspace	350
Computer Room	350
Meeting Room	300
Drawing Room	750
Archive Room	150
Library	300
Lobby	100

Based on its function, light can be categorized as four basic function. These are light for safety or security, light for people movement and task oriented, light for visual interest and light for merchandise lighting.

2.2 Building insulation

Cooling load used for conditioning in a building consist of internal load and external load. Internal load is load that came from lamp, computer, any other tools that produce heat and human. In the other hand, external load mostly caused by the sun radiation and heat conduction through the building insulation. To limit the external load, building insulation and the design of the roof should be chosen wisely. Different type of insulation can directly impact the energy usage of the building.

Some criterions based on energy usage and the looks of building exterior are considered to design the building insulation system. In this work, these criterions are based on National Standardization Institution of Indonesia that defined as Overall Thermal Transfer Value (OTTV) that should be under 45 Watt/m^2. The equation to calculate the OTTV can be seen below [6].

$$OTTV = \alpha[(U_w \times (1 - WWR)] \times TD_{EK} + (SC \times WWR \times SF) + (U_f \times WWR \times \Delta T) \quad (1)$$

Where:

OTTV : Overall Thermal Transfer Value (W/m^2)
α : Sun radiation absorption
U_w : Non-transparent wall thermal transmittance
WWR : Total window area to total area ratio under same orientation
TD_{EK} : Equivalent temperature different
SF : Sun radiation factor
SC : Fenestration system shading coefficient
U_f : Fenestration thermal transmittance
ΔT : Design temperature different

2.3 Electrical Energy Usage Analysis

Electrical energy status per floor level measured by total amount of electrical energy used by lightning system, thermal conditioning and other tools in each floor. To evaluate electrical energy profile for each floor, two method is applied.

First, electrical energy usage per room is calculated by summing the total amount of electrical energy needed by each tools and their active hour. Second, electrical energy usage is measured through power panel on each floor.

3. METHODOLOGY

3.1 Lightning System Analysis

Lighting system analysis cover about natural lighting analysis, artificial lightning analysis and lighting system optimization. Data used for this analysis are taken using lux-meter on several point that that represent the overall illuminance level of the room. While the natural lightning measurement are based on SNI 03-6575-2001 measurement standard.

3.2 Building Insulation Analysis

Building insulation analysis is based on OTTV calculation. First, detailed profile and dimension of materials are calculated. Then, OTTV for each orientation are calculated. Finally, Total OTTV is calculated and analyzed.

4. RESULT AND DISCUSSION

4.1 Lightning System Analysis

As described before, illuminance level for each room are measured to evaluate the lightning system in PT. PJB UP Paiton. The result for floor level 1, 2, 3 and 4 in PT. PJB UP Paiton can be seen below.

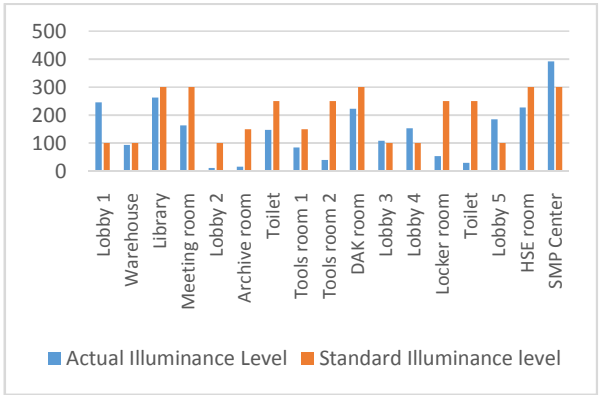

Chart -1: Illuminance level at building floor 1

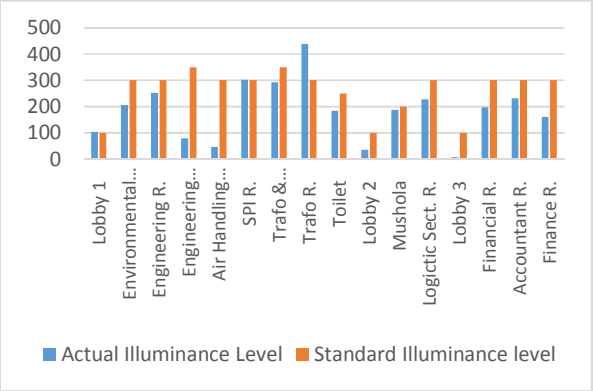

Chart -2: Illuminance level at building floor 2

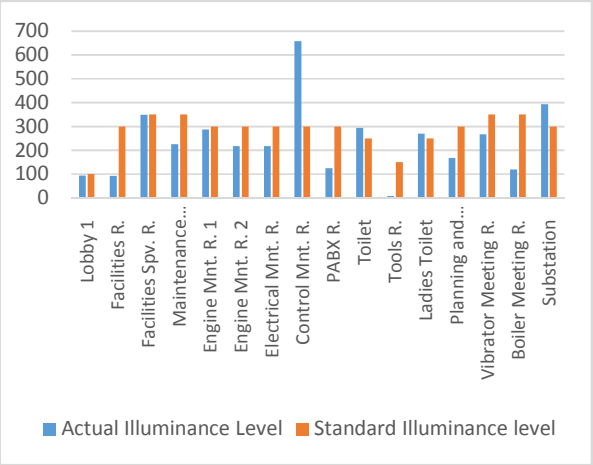

Chart -3: Illuminance level at building floor 3

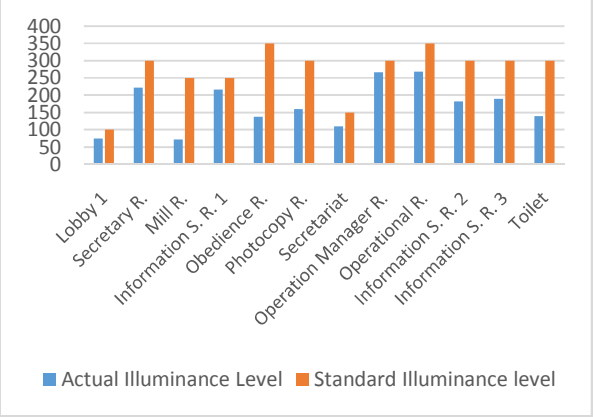

Chart -4: Illuminance level at building floor 4a

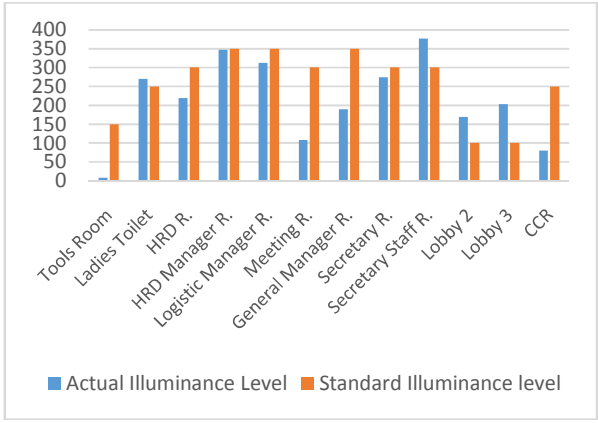

Chart -5: Illuminance level at building floor 4b

As an addition, outdoor illuminance level also measured. The illuminance level for motorcycle parking area and car parking area at night are 75.2 and 222.4 respectively, with standard illuminance level of 100. Based on these chart, most of the rooms in PT. PJB UP Paiton are sufficiently illuminated. Some rooms that are not sufficiently illuminated mostly caused by the absence natural lighting. To evaluate lightning system efficiency, average electrical value for each level are calculated. The results are 5.8, 6, 9.9 and 9.6 W/m^2 for floor level 1, 2, 3 and 4 respectively. This result shows that the lightning system in PT. PJB UP Paiton building is efficient because all the electrical power value still 15 W/m^2, which is the maximum electrical power per area for office building based on SNI 03-6197-2000 standard.

4.2 Building Insulation Analysis

Building insulation evaluation is performed by calculation the OTTV. As mentioned before, the calculation of OTTV required materials detailed profile and dimension. These profile are shown below.

- Absortion (α) = 0.885
- Brick wall transmittance (U_{wall}) = 3.24 W/m^{2}K
- Glass transmittance (U_{glass}) = 2.89 W/m^{2}K
- Brick wall area (A_{north}, A_{west}) = 504 m^2
- Brick wall area (A_{south}, A_{east}) = 630 m^2
- Window to wall ratio (WWR_{north}) = 0.2031
- Window to wall ratio (WWR_{south}) = 0.2031
- Window to wall ratio (WWR_{west}) = 0.0508
- Window to wall ratio (WWR_{east}) = 0.2222
- Equivalent temperature difference (ΔT_{EK}) = 11 ^{o}K
- Shading coefficient = 0.64

OTTV for each orientation then calculated. The result can be seen below.

Table -3: OTTV for each orientation

Orientation	OTTV (W/m^2)
North	42.69
South	38.40
West	35.85
East	41.44

Based on these OTTVs, building OTTV can be easy calculated. OTTV for the entire building averaging those OTTVs according to their area, the result is 34.49 W/m^2. This value shows that building OTTV is lower than SNI 03-6389-2000 standard, which is 45 W/m^2.

4.3 Electrical Energy Usage Analysis

In order to evaluate the electrical energy consumption on each floor, data about electrical energy consumption and active hour of every tools in the room is gathered. After data gathering, electrical energy usage per year is calculated as the secondary data. The result can be seen in Table 3.

Table -3: Secondary Electrical Energy Usage

Floor level	Electrical Energy Usage per year (kWh)
1	44671.2
2	72015.0
3	87342.0
4	192340.5

Then, electrical energy usage for each floor and other equipment are also measured. First, electrical energy used for lightning system, thermal conditioning, lift and other tools are measured through main distributed panel. The result can be seen below.

Table -3: Primary Electrical Energy Usage

Floor level and Other Equipment	Electrical Energy Usage per day (kWh)
1	45,4483
2	81,2108
3	107,4370
4	113,3970
Lift	16,8755
Compressor/Chiller	1493,7613
AC Central	306,2170

Based on these data, total electrical energy usage per year can be easily calculated. Total electrical energy usage per year in PT. PJB UP Paiton is 779.163 kWh. Since total area of the building is 3479 m^2, then the energy usage intensity of the entire building is 223,962 kWh/m^2. This value shows that PT. PJB UP Paiton building meet the standard energy usage intensity for office building. This standard is based on ASEAN-USAID 1992 that shows that maximum energy usage intensity for office building is 240 kWh/m^2 [7].

5. CONCLUSIONS

This paper describe about energy efficiency of office building in PT. PJB UP Paiton limited companies through energy audit. PT. PJB UP Paiton office building electrical power usage for lightning system in each floor are still under 15 W/m^2. While the OTTV for entire building is only 34.49 W/m^2 and for overall electrical energy usage for the entire building is only 223.962 kWh/m^2. This result shows that PT. PJB UP Paiton office building is efficient in lightning system, building insulation system and electrical energy usage.

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BIOGRAPHIES

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