Study of Electrical Energy Saving Opportunities Faculty of Economy and Business Tanjungpura University

Muhammad Fathurrahman Hasma, Zainal Abidin, Junaidi

1 Undergraduate Program Electrical Engineering, Faculty of Engineering, Universitas Tanjungpura, Pontianak, Indonesia
2 Department of Electrical Engineering, Faculty of Engineering, Tanjungpura University, Pontianak, Indonesia

ABSTRACT
The energy audit at the Faculty of Economics and Business, Tanjungpura University, aims to save energy use and achieve efficient use of electrical energy without affecting the system function and usability. The bills at FEB UNTAN are high compared to other faculties in UNTAN, even though the total building area at FEB UNTAN is smaller than other faculties. In order to minimize the use of electrical energy in FEB UNTAN which aims to avoid cost overruns in the use of electrical energy, it is necessary to know the amount of electrical energy consumption. After the value of electrical energy consumption is obtained, then look for energy saving opportunities, especially in the FEB UNTAN environment. This energy audit uses a detailed energy audit method for lighting and air conditioning systems. The research results from the Energy Saving Opportunities (PHE) carried out have three steps, No Cost, Low Cost and High Cost. The first stage is done by reducing the power-on time, reducing the number of lights used in the lighting system, reducing the power-on time and the number of air conditioners in the air conditioning system, the second stage is done by installing infrared sensors, and the last stage is by replacing lower power lamps, replacing AC units with lower power consumption. The IKE value obtained is categorized as very efficient. The IKE value for three kWh meters before PHE was 7.24 kWh/m²/month, 12.290 kWh/m²/month, 7.679 kWh/m²/month. After PHE No Cost the IKE value becomes 5.299 kWh/m²/month, 7.89 kWh/m²/month, 5.439 kWh/m²/month. IKE value after PHE Low Cost is 7.226 kWh/m²/month, 12.18 kWh/m²/month, 7.669 kWh/m²/month.

1. INTRODUCTION
Electrical energy is a fundamental in running various operational activities, the industrial level, in companies, and in educational institutions such as the Faculty of Economics and Business (FEB) at Tanjungpura University (UNTAN). Dependence on electrical energy is significant, especially in supporting daily activities. However, attention needs to be paid to the type of energy source used, with most of electronic energy producers in Indonesia relying on fossil fuels, such as coal and petroleum. This trend is a concern because fossil energy is non-renewable and leads to the depletion of energy reserves.

UNTAN's Faculty of Economics and Business (FEB), as an educational entity established in 1959, has an important role in using of energy. Data on the number of rooms, land area, and installed power in FEB provide a concrete picture of the scale of energy consumption in the environment. Through the information on electrical energy usage from January 2019 to December 2022 and the amount of the bill, it can be seen electrical energy usage has reached a significant level. Awareness of the importance of energy efficiency in FEB UNTAN is a strategic step to manage energy consumption and prevent uncontrolled cost increases. The bills in FEB UNTAN are high compared to other faculties in UNTAN, even though the total building area in FEB UNTAN is smaller than other faculties. In order to minimize the use of electrical energy in FEB UNTAN which aims to avoid cost overruns in the use of electrical energy, it is necessary to know the amount of electrical energy consumption. After the value of electrical energy consumption is obtained, then look for energy saving opportunities, especially in the FEB UNTAN environment.
To achieve energy efficiency goals, concrete steps are needed that can be implemented at FEB UNTAN. Measurement of electrical energy consumption has been identified as the first step in assessing the extent to which energy efficiency can be improved. By knowing the specific energy consumption pattern, FEB UNTAN can design a more targeted energy saving strategy. In addition, adoption green technologies and sustainable practices in using electrical energy can be a valuable alternative to reduce environmental impact and keep long-term energy costs down. By taking these proactive steps, FEB UNTAN can not only optimize the efficiency of electrical energy use but also positively contribute to facing global challenges related to limited energy resources and the impact of climate change.

2. LITERATURE REVIEW

Several similar research journals existed before the material was used to prepare research. Research conducted by Immanuel Manurung “Analysis of opportunities to save electrical energy on Air Conditioner (Ac) Gelanggang Mahasiswa University of North Sumatra”. In this study, researchers examined the opportunity to save electrical energy on the air conditioner of the University of North Sumatra Gelanggang [1]. Research conducted by Ahmad Taufik Yunanto entitled "Study of Opportunities for Efficiency of Electric Energy Consumption at Pt. Sai Apparel Semarang". In this study, researchers found that the electrical energy consumption of PT SAI Apparel during 2016 was 8,309,763 kWh which was consumed by PES loads and non-PES loads. PES loads consist of motor loads (52%), lighting (12%), compressors (10%) and air conditioners (6%) [2]. Research by Andi Ramdani H. entitled "Audit of Electrical Energy Use in Campus Buildings of the Faculty of Engineering, Hasanuddin University Gowa" conducted detailed measurements in several buildings to assess the IKE value, and the results were considered efficient. Rizal Fariz Mustaram in his research entitled "Energy Audit of Campus Data Center for Energy Efficiency Based on Digital Twin” uses the digital twin technique to create a digital representation of the energy and thermal systems through real-time data on ICT and HVAC infrastructure in data centers [3]. Research conducted by Ismi Dina Solikha entitled "Evaluation of the Quality of the Diponegoro University ICT Building Lighting System". The lighting system in the ICT Building of Diponegoro University has an artificial lighting system that does not meet the standards set out in SNI 03-6575-2001 [4]. Research conducted by Chrisna Radityatama entitled “Analysis of Energy Consumption Intensity and Electric Power Quality at UNDIP Campus”. Researchers obtained the results of electrical energy consumption at the Undip Campus, and there was an increase in electricity bills for the last 5 years [5]. Research conducted by Andri Pengestu Purba entitled "Lighting System Audit and Lighting Source Replacement Study in Office Space". In this study, researchers obtained audit results in the form of an average lighting level that was not in accordance with SNI 03-6576-2001 and a lighting replacement design was needed [6]. Research conducted by Dimas Dwi Prayoga entitled "Electrical Energy Audit to Achieve Energy Efficiency in the Graha Building Pt. Inka (Railway Industry) Madiun". This study aims to determine the electrical energy consumption of various electronic equipment used in the Graha Building of PT INKA (Railway Industry) Madiun [7]. What distinguishes this research, from previous research is that this study calculates the IKE value per kWh meter for lighting and air conditioning systems. The calculation of IKE FEB UNTAN used data for four years, from 2019 to 2022 by calculating the efficiency index of the air conditioning system EER (Energy Efficiency Ratio) and COP (Coefficient of Performance), then analyzing energy saving opportunities.

3. METHOD

3.1 Electrical Power

In the context of electricity and physics, electrical power refers to a quantity that measures the rate of use or production of electrical energy [10]. Electrical power is the amount of electrical effort that can be done by a voltage source every second.

3.2 Electrical Load

Electrical load is the total amount of electrical power used by all electrical equipment, devices, or systems in a given environment or system. Calculate the electrical load, by summing or combining the electrical power of all equipment and devices connected to the system. So, electrical load is the total electrical power used in a system or environment at any given moment [10].

3.3 Electrical Energy

Energy is a quantity that is conceptually associated with transformations, processes or changes that occur. This quantity is often associated with transferring a force or a temperature change. Energy is the ability to do work that can be in the form of heat, light, mechanics, chemistry, and electromagnetics [11].

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3.4 Electricity Conservation

Energy Conservation is a systematic, planned, and integrated effort to conserve domestic energy resources and improve their utilisation efficiency. Energy conservation aims to minimize energy consumption by reducing wasteful use of energy that is not needed. We must first conduct an energy audit to find out which systems can be saved [12].

3.5 Energy Management

Energy Management is an integrated activity to control energy consumption in order to achieve effective and efficient energy utilization to produce maximum output through technical actions in a structured and economical manner to minimize energy utilization including energy for production processes and minimize consumption of raw materials and supporting materials. [13].

3.6 Energy Audit

An energy audit is a method to find ways to reduce energy consumption per unit of production and operating costs. The results of an energy audit can reveal potential energy savings through efficiency improvements. For buildings that are already in operation, it is important to assess the efficiency of the building. Energy audits are used to identify energy waste and plan retrofitting. Energy audit activities involve [14]:

1. Identify energy use, including energy types, components, systems, and costs.
2. Observe the level of energy use according to building conditions and usage.
3. Determine the greatest potential for improving energy use efficiency.
4. Develop measures to improve that efficiency.
5. An audit is defined as evaluating a building's energy use and identifying opportunities to reduce consumption.

There are 3 stages of energy audit procedures in a building, namely [14]:

a. Walk Through Audit
b. Preliminary Audit
c. Detailed Energy Audit

3.7 Lighting System

The building's lighting system is crucial in supporting activities or tasks, ensuring their efficient and safe operation. Energy audits conducted on lighting systems aim to assess the adequacy of lighting levels within a room, determining whether they align with the room's intended function or not. The lighting system is categorized into two distinct components, as indicated by references [12] and [13].

1. Natural lighting system

Natural lighting systems utilize light from natural sources, such as sunlight. Incorporating natural lighting not only harnesses sustainable energy but also minimizes reliance on electrical energy. Therefore, maximizing the utilization of natural lighting is essential to reduce overall energy consumption.

2. Artificial lighting system

Artificial lighting systems encompass man-made light sources such as lamps or luminaires. The utilization of artificial lighting should be prudent and optimized for efficiency to prevent unnecessary wastage of electrical energy [15].

The types of artificial lighting systems are as follows:

b. Compact Fluorescent Lamp (CFL).
c. LED lights.
d. Downlights.

3.8 Air Conditioning System

Artificial lighting systems are lighting systems that come from artificial light sources such as lamps or lighting equipment. The use of artificial lighting should be as reasonable and effective as possible to avoid wasting electrical energy.

1. Natural Air Conditioning System
Natural air conditioning is based solely on space planning and airflow around the building. Rooms without air conditioning should have a minimum of 15% floor area with cross-ventilated fan openings for air circulation. These natural air conditioners are windows, doors, and vents.

2. Artificial Air Conditioning System

Artificial air conditioning regulates the thermal conditions, quality and circulation of air indoors to meet the thermal comfort requirements of building use [8].

\[ AC\ PK = \text{Room Size} \times \text{BTU constant} \] (1)

To calculate the COP, using equation 2:

\[ COP = \frac{Qe \ (kW)}{W \ (kW)} \] (2)

Description:
COP = Coefficient of Performance
Qe = Cooling Capacity (kW)
W = Compressor Input Power (kW)

EER is an indicator of energy efficiency expressed as the ratio of BTU/hour produced by AC power to Watts of electricity consumed. To calculate the EER, using equation 3:

\[ EER = \frac{T \ (\text{Btu/h})}{W \ (\text{kWh})} \] (3)

Description:
EER = Energy Efficiency Ratio
T = AC Cooling Capacity (Btu/h)
W = Electrical Energy (kWh)

Based on the type, 4 types of air conditioners are commonly used as follows:

a. Window AC
b. Split AC
c. Cassette AC
d. Central AC
e. Standing AC

3.9 Variables or Data

The data collected in this study are as follows:

1. Primary Data

Primary data was obtained directly from each building in FEB UNTAN in the form of electricity account payment data every month from January 2019 to December 2022, lighting power data for each room, air conditioning system (AC) power data for each room, and floor plan of FEB UNTAN.

2. Secondary Data

Secondary data is obtained from various references in the form of books, journals, reports, and other scientific sources related to this research.

3.10 Research procedure

The research procedure contains a description of the research steps. The description of the research steps is explained as follows.

1. Preparation

The preparation stage is in the form of collecting and studying literature and collecting scientific documents related to energy audits.

2. Implementation

Data collection and field observations were carried out by collecting primary data directly from FEB UNTAN in the form of electricity payment account data every month from January 2019 to December 2022, room area, power and number of lights throughout the room, power and number of air conditioners throughout the room.

3. Calculation
3.11 Calculation of Energy Saving Intensity (IKE)

Electricity Energy Consumption Intensity (IKE) is a term used to determine how much energy is used in buildings. The energy in question is electrical energy. Energy Consumption Intensity is obtained by dividing the result between total energy consumption during a certain period (one year) and the total building area. The unit of IKE is kWh/per year. The use of IKE has been determined in various ASEAN and APEC countries. To get the IKE value, using equation 4 [16]:

\[
IKE = \frac{\text{Total Energy Consumption (kWh)}}{\text{Building Area (m}^2\text{)}}
\]  

\[\text{(4)}\]

![Figure 1. Research Flow Chart](image)

This research was conducted FEB UNTAN from January 2019 to December 2022. The research method used in this research is a literature study that aims to find references to theories related to energy audits, namely the calculation of IKE values and PHE analysis. Field observations were carried out by taking field data in the form of data on the area of each building, data on lighting systems and air conditioning systems at FEB UNTAN. The descriptive method describes or provides insight into the subject under study through data or samples collected and compares electrical energy consumption before and after energy-saving opportunities. The research flow begins with collecting data, calculating IKE values based on electricity payment account data, calculating IKE COP and EER values, calculating energy saving opportunities and recommending energy saving measures. The research flow chart is shown in Figure.
Secondary data is obtained from various references in books, journals, reports, and other scientific sources related to this research.

4. RESULTS AND DISCUSSION

4.1 Calculation of IKE for Electricity

In an energy audit, finding the IKE value is important as it helps evaluate the energy efficiency of a system or process. The IKE value gives an idea of how well energy is being utilized. By knowing the IKE value, energy auditors can identify areas where energy efficiency can be improved or where energy is wasted. It also allows comparison of energy performance between different systems or buildings for the choice of more efficient solutions.

To obtain the IKE value of electricity, a calculation is made based on energy consumption data every month for the last year. For example, namely January 2019 to December 2019 divided by the total area each electricity meter of FEB UNTAN of 4010 m².

So, to calculate IKE per month as follows:

\[ \text{IKE} = \frac{17.003 \text{ (kW/h)}}{4010 \text{ (m}^2\text{/month)}} \]

To calculate IKE per year as follows:

\[ \text{IKE} = \frac{243.109 \text{ (kW/h)}}{4010 \text{ (m}^2\text{/year)}} = 60,6257 \text{ (kW/m}^2\text{/year)} \]

The results of the IKE calculation from August 2022 to July 2023 are presented in Table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Year</th>
<th>Month</th>
<th>Building Area</th>
<th>Power (kWh)</th>
<th>IKE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2019</td>
<td>January</td>
<td>4010</td>
<td>17.003</td>
<td>4,2401</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>February</td>
<td>4010</td>
<td>18.539</td>
<td>4,6232</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>March</td>
<td>4010</td>
<td>18.302</td>
<td>4,5641</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>April</td>
<td>4010</td>
<td>21.102</td>
<td>5,2623</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>May</td>
<td>4010</td>
<td>19.580</td>
<td>4,8828</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>June</td>
<td>4010</td>
<td>20.505</td>
<td>5,1135</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>July</td>
<td>4010</td>
<td>15.731</td>
<td>3,9229</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>August</td>
<td>4010</td>
<td>22.397</td>
<td>5,5853</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>September</td>
<td>4010</td>
<td>22.056</td>
<td>5,5002</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>October</td>
<td>4010</td>
<td>21.845</td>
<td>5,4476</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>November</td>
<td>4010</td>
<td>22.881</td>
<td>5,7060</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>December</td>
<td>4010</td>
<td>23.168</td>
<td>5,7776</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>4010</td>
<td>243.109</td>
<td>60,6257</td>
<td>Highly Efficient</td>
</tr>
</tbody>
</table>

4.2 Lighting System

The use of electrical energy in the lighting system depends on the duration of ignition and the amount of power of each lamp; the longer the ignition time is, and the greater the lamp power, the greater the use of electrical energy.

- Calculation of the energy consumption of the classroom B31 at the library building lighting system as follows:

In the classroom B31:

LED lights with 18 watts of power as many as 5 with 10 hours of ignition.

\[ W = \frac{P \times t}{1000} \]

\[ = \frac{(18 \times 5) \times 10}{1000} = 0.9 \text{ kwh/day} \]

The total electrical energy consumption of the lighting system is 157,572 kWh per day.

4.3 Air Conditioning System

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The use of AC depends on the service schedule or office administrative activities in each room, the amount of PK or AC power must be adjusted to the size of the room, so that its use is efficient.

- Calculation of air conditioning consumption in the classroom B31 at library building

In the classroom B31:
2 pk split air conditioner with a power of 1470 W as many as 2 units, 10 hours start-up time.

\[ W = \frac{P \times t}{1000} = \frac{1470 \times 2 \times 10}{1000} = 29.4 \text{ kWh/day} \]

The total electrical energy consumption of the entire air conditioning system FEB UNTAN is 1.986,98 kWh/day.

In the energy audit process, the air conditioning system’s efficiency is considered. The efficiency of an air conditioning system is expressed as COP or EER.

- Calculation of COP in the classroom B01

In classroom B01, it is known AC 2 PK as many as 2 units with a power of 1470 W and Qe 5,27528. Then the COP value:

\[ \text{COP} = \frac{e'(\text{kW})}{W(\text{kW})} = \frac{5,27528}{1,47 \text{ kW}} = 3,58862449 \]

- EER calculation in classroom B01

Classroom B01, is known as; AC 2 PK as many as 2 units with power 1470 W and T 18000 Btu/h. Then the EER value:

\[ \text{EER} = \frac{T(\text{Btu/h})}{W(\text{kW})} \times \text{unit ac} = \frac{18000}{1470 \text{ W}} \times 2 = 24.4898 \]

It is known that the COP value is included in the good category where the average COP is 3.5 and the good COP criteria have a value range of 3.0-4.0. The EER value obtained is included in the excellent category where the average EER value is 16.06 and the excellent EER criteria have a value range of 14-20.

4.4 Energy Saving Opportunities
4.4.1 No Cost

1. Lighting System

PHE: No Cost in the lighting system are done by reducing the ignition time of the lighting system, and reducing the number of lights in a room. Reduction of lights by adjusting the needs according to the size of the area of each room.

- Calculation of the energy consumption of the classroom B31 at the library building lighting system by reducing the ignition time of the lighting system as follows:

In the classroom B31:
LED lights with 18 watts of power as many as 5 with 10 hours of ignition.

\[ W = \frac{P \times t}{1000} = \frac{18 \times 5 \times 9 \times 24}{1000} = 19,44 \text{ kWh/month} \]

Energy consumption before savings 3785,616 kWh and after savings to 3478,032 kWh. Then the monthly energy savings can be calculated as follows:

Monthly Saving = 3785,616 kWh - 3478,032 kWh = 307,584 kWh

The value of savings per year is:

Annual savings = 307,584 kWh x 12 month = 3691,008 kWh

- Calculation of the energy consumption of the conf laboratory lighting system by reducing the number of lights in a room as follows:

Determine the lighting needs of Conf lab:
Length of room = 12 m; Width of room = 12 m; Height of light source to work plane = 2 m; E = 500 lux; 18-watt LED with 1600 lumens

Then:

\[ R_k = \frac{12 \times 12}{2 (12 + 12)} = \frac{144}{2 (24)} = 3 \]
In Conf Lab there are 69 lamps, while the need for 18 watt lamps is 54 pieces, so a reduction in the number of lamps is made by 16 pieces. So that the energy consumption per month after reducing the lights is:

\[ W = \frac{P \times t}{1000} = \frac{18 \times 54 \times (24 \times 24)}{1000} = 93,312 \text{ kWh/month} \]

Energy consumption before savings 3785,616 kWh and after savings to 3481,272 kWh. Then the monthly energy savings can be calculated as follows:

Monthly Saving = 3785,616 kWh - 3481,272 kWh = 304,344 kWh

The value of savings per year is:
Annual savings = 304,344 kWh x 12 month = 3652,128 kWh

2. Air Conditioning System

PHE No Cost in the air conditioning system, savings are made by reducing the usage time and the number of air conditioning units used.

- Calculation of the energy consumption of the classroom B31 at the library building air conditioning system by reducing the usage time as follows:

In the classroom B31:
Classroom B31 has 2 PK Split ACs with a power of 1470 as many as 2 pieces with a power-up time of 9 hours, then:

\[ W = \frac{P \times t}{1000} = \frac{1470 \times 2 \times (9 \times 24)}{1000} = 793.8 \text{ kWh/month} \]

Energy consumption before savings 58.179,48 kWh and after savings to 42.281,28 kWh. Then the monthly energy savings can be calculated as follows:

Monthly Saving = 58.179,48 kWh – 42.281,28 kWh = 15.898,2 kWh

The value of savings per year is:
Annual savings = 15.898,2 kWh x 12 months = 190,778,4 kWh

- Calculation of the energy consumption of the Prof. Syamsuddin's room air conditioning system by reducing the number of air conditioning units used:
In the Prof. Syamsuddin's room:
Prof. Syamsuddin's room has 3 PK Standing AC with 2270 watts of power as many as 2 pieces with a power-up time of 4 hours, then:

\[ W = \frac{P \times t}{1000} = \frac{2270 \times 2 \times (4 \times 24)}{1000} = 435.84 \text{ kWh/month} \]

Energy consumption before savings 58.179 kWh and after savings to 42.339 kWh. Then the monthly energy savings can be calculated as follows:

Monthly Saving = 58.179 kWh – 42.339 kWh = 15.840,456 kWh

The value of savings per year is:
Annual savings = 15.840,456 kWh x 12 months = 190,085,472 kWh

4.4.2 Low Cost

1. Lighting System

PHE Low-Cost lighting system can be done by installing infrared sensors.

- Calculation of the energy consumption of toilet at the library building lighting system by installing infrared sensors as follows:
In the restroom:
The restroom in the library building has 3 9-watt LED lights, with a power-on time of 24 hours, after the sensor is installed, it becomes 12 hours per day.
Then:
\[
W = \frac{\rho \times t}{1000} = \frac{(9 \times 3) \times (12 \times 24)}{1000} = 7,776 \text{ kWh/month}
\]

Energy consumption before savings 3785,616 kWh and after savings to 3675,456 kWh. Then the monthly energy savings can be calculated as follows:
- Monthly Saving = 3785,616 kWh − 3675,456 kWh
= 110,16 kWh

The value of savings per year is:
- Annual savings = 110,16 kWh x 12 months
= 1321.92 kWh

The total investment cost for replacing the lamp type is Rp.2.513.000. Then the Payback Period can be determined as follows:
\[
Payback Period = \frac{\text{Rp.2.513.000}}{\text{Rp.102.060}} = 25.34 = 25 \text{ months}
\]

2. Air Conditioning System

PHE Low Cost in the air conditioning system is done by replacing the air conditioning system unit with a lower power.

- Calculation of the energy consumption of Prof. Syamsuddin's room air conditioning system replacing the air conditioning system unit with a lower power

In the Prof. Syamsuddin's room:

Prof. Syamsuddin's room has 3 PK Standing AC with 1080 watts of power as many as 2 pieces and 2 PK Split AC with 1470 watts of power as many as 1 piece with a power-up time of 11 hours.

Then:
\[
W = \frac{\rho \times t}{1000} = \frac{(2270 \times 2) + (1470 \times 1) \times (11 \times 24)}{1000} = 576,96 \text{ kWh}
\]

Energy consumption before savings 57.888,42 kWh and after savings to 53.551,56 kWh. Then the monthly energy savings can be calculated as follows:
- Monthly Saving = 57.888,42 kWh − 53.551,56 kWh
= 4336,86 kWh

The value of savings per year is:
- Annual savings = 4336,86 kWh x 12 months
= 52.042,32 kWh

The total investment cost for replacing the lamp type is Rp.70.200.511. Then the Payback Period can be determined as follows:
\[
Payback Period = \frac{\text{Rp.70.200.511}}{\text{Rp.3.903.174}} = 17.985 = 18 \text{ months}
\]

4.5 Energy Saving Opportunities

Recommendations that can be made from all PHEs obtained are written in the Table 2

<table>
<thead>
<tr>
<th>PHE Type</th>
<th>Activities Conducted</th>
<th>Energy Consumption Savings per Year (kWh)</th>
<th>Cost Savings per Year</th>
<th>Investment cost</th>
<th>Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Cost</td>
<td>Lighting System Usage</td>
<td>3691,008</td>
<td>Rp3.321.907,20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Time Reduction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduction of Unit Light Usage</td>
<td>3652,128</td>
<td>Rp3.286.915,20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reduction of Air Conditioning System Time and Usage</td>
<td>190778,4</td>
<td>Rp171.700.560,00</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reduction in the number of AC units used</td>
<td>190085,47</td>
<td>Rp171.076.924,80</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>237422,88</td>
<td>Rp213.680.592,00</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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4.6 Calculating Final IKE

4.6.1 kWh Meter 1

After determining the energy saving opportunities that can be done at FEB UNTAN, the IKE value can be found as follows:

<table>
<thead>
<tr>
<th>PHE Type</th>
<th>Activities Conducted</th>
<th>Energy Consumption Savings per Year (kWh)</th>
<th>Cost Savings per Year</th>
<th>Investment cost</th>
<th>Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Cost</td>
<td>Sensor Installation on Lighting System</td>
<td>1321.92</td>
<td>Rp1.189.728.00</td>
<td>Rp2.513.000.00</td>
<td>25 months</td>
</tr>
<tr>
<td></td>
<td>Replacement of Air Conditioning System Unit with Lower Power</td>
<td>53418.24</td>
<td>Rp48.076.416.00</td>
<td>Rp70.200.511.00</td>
<td>18 months</td>
</tr>
</tbody>
</table>

Table 3. Comparison of IKE Value kWh meter 1

<table>
<thead>
<tr>
<th>NO</th>
<th>PHE</th>
<th>Building Area</th>
<th>Power (kWh)</th>
<th>IKE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Before</td>
<td>4010.0</td>
<td>29033.232</td>
<td>7.2403</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>2</td>
<td>No Cost</td>
<td>4010.0</td>
<td>21249.72</td>
<td>5.2992</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>3</td>
<td>Low Cost</td>
<td>4010.0</td>
<td>28978.8</td>
<td>7.2267</td>
<td>Highly Efficient</td>
</tr>
</tbody>
</table>

4.6.2 kWh Meter 2

<table>
<thead>
<tr>
<th>PHE Type</th>
<th>Activities Conducted</th>
<th>Energy Consumption Savings per Year (kWh)</th>
<th>Cost Savings per Year</th>
<th>Investment cost</th>
<th>Payback Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Cost</td>
<td>Sensor Installation on Lighting System</td>
<td>1321.92</td>
<td>Rp1.189.728.00</td>
<td>Rp2.513.000.00</td>
<td>25 months</td>
</tr>
<tr>
<td></td>
<td>Replacement of Air Conditioning System Unit with Lower Power</td>
<td>53418.24</td>
<td>Rp48.076.416.00</td>
<td>Rp70.200.511.00</td>
<td>18 months</td>
</tr>
</tbody>
</table>

Table 3. Comparison of IKE Value kWh meter 1

<table>
<thead>
<tr>
<th>NO</th>
<th>PHE</th>
<th>Building Area</th>
<th>Power (kWh)</th>
<th>IKE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Before</td>
<td>4010.0</td>
<td>29033.232</td>
<td>7.2403</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>2</td>
<td>No Cost</td>
<td>4010.0</td>
<td>21249.72</td>
<td>5.2992</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>3</td>
<td>Low Cost</td>
<td>4010.0</td>
<td>28978.8</td>
<td>7.2267</td>
<td>Highly Efficient</td>
</tr>
</tbody>
</table>

Table 4. Comparison of IKE Value kWh meter 2

<table>
<thead>
<tr>
<th>NO</th>
<th>PHE</th>
<th>Building Area</th>
<th>Power (kWh)</th>
<th>IKE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Before</td>
<td>535.9</td>
<td>6586.88</td>
<td>12.2908</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>2</td>
<td>No Cost</td>
<td>536.9</td>
<td>4236.77</td>
<td>7.8909</td>
<td>Highly Efficient</td>
</tr>
<tr>
<td>3</td>
<td>Low Cost</td>
<td>537.9</td>
<td>6551.89</td>
<td>12.1800</td>
<td>Highly Efficient</td>
</tr>
</tbody>
</table>
4.6.3 kWh Meter 3

Total energy consumption of kWh meter 3 before PHE = 26,344.98 kWh
Total energy consumption of kWh meter 3 PHE No Cost = 18,666.58 kWh
Total energy consumption of kWh meter 3 PHE Low Cost = 26,324.24 kWh
Energy savings of kWh meter 3 PHE No Cost = 9283.284 kWh
Energy savings of kWh meter 3 PHE Low Cost = 9157.076 kWh

The building area of kWh meter 3 is 3430.4 m², then the final IKE calculation is as follows:

\[
IKE = \frac{26,344.98 \text{ (kWh)}}{3430.4 \text{ (m}^2\text{)}} = 7.6798 \text{ (kWh/(m}^2\text{/month})}
\]

IKE calculation after PHE:

\[
IKE = \frac{18,666.58 \text{ (kWh)}}{3430.4 \text{ (m}^2\text{)}} = 5.439 \text{ (kWh/(m}^2\text{/month})}
\]

5. CONCLUSION

IKE values for kWh meters 1, 2, and 3 show very good efficiency. Recommendations for the lighting system are to do PHE No Cost by reducing the time and number of lights used, and PHE Low Cost by installing infrared sensors in rooms that are rarely used. For the air conditioning system, recommendations include PHE No Cost by reducing the time and amount of AC usage, and PHE Low Cost by replacing the AC with a lower power.

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REFERENCES

Muhammad Fathurrahman Hasma

Muhammad Fathurrahman Hasma, born in Nanga Pinoh, April 1, 2001, completed elementary school education from 2007 to 2013 at SD Negeri 01 Putussibau, continued junior high school from 2013 to 2016 at SMP Negeri 01 Putussibau, then continued high school from 2016 to 2019 at SMA Negeri 01 Nanga Pinoh, and continued his Electrical Engineering education at Tanjungpura University from 2019.

Zainal Abidin

Zainal Abidin, born in Pontianak on 07 May 1986, pursued his undergraduate education at Tanjungpura University Pontianak and received a Bachelor of Engineering degree in 2009, then continued his education at Gadjah Mada University and received a master of engineering degree in 2015. Started actively teaching as a lecturer at the Faculty of Engineering, Tanjungpura University since 2019 until now. He is a member of the Electric Power System and Distribution expertise group at the Tanjungpura University Pontianak electrical engineering study program. Research topics on power system, energy, and smart grid.

Ir. Junaidi M.Sc, IPM

Ir. Junaidi M.Sc, IPM, was born in Pontianak, Indonesia, in 1959. He received B.S and M.S. degrees from the Institut Teknologi Bandung (ITB) in 1985 and 1992, respectively. Since 1985, he has been with Departament of Electrical Engineering, Tanjungpura University, Pontianak, Indonesia. Currently, he is a senior lecturer in Electrical Engineering. His major research topics include power system operation and economics