Analysis of Energy Consumption and Energy Efficiency in Government Office Buildings of Bengkulu, Indonesia

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Abstract: This article aimed to analyze the energy consumption and energy efficiency in government office buildings of Bengkulu, Indonesia. This research was conducted using a quantitative descriptive method. The research step begins by observing the initial conditions of Energy Consumption Intensity (ECI) to determine the category of buildings that are efficient or not in terms of energy use, then collecting data on the profile of the use of the building and its rooms, recapitulation of the use of energy sources (both electrical energy and other chemical energy), a list of equipment that consumes electrical energy (lighting, air conditioning, and others). Furthermore, measuring the performance of systems and equipment that consumes energy and conducting efficiency analysis to then make recommendations with operating settings, to replace inefficient equipment with more efficient equipment. The final step is to draw conclusions about the final Energy Consumption Intensity (ECI) obtained based on the results of the analysis and recommendations obtained on the previous Energy Consumption Intensity (ECI) value. It can be concluded that the final Energy Consumption Intensity (ECI) of government office buildings of Bengkulu based on the results of the analysis and recommendations such as performing preventive maintenance on air conditioners, the temperature of the air conditioner is set to always be at 24°C, replacing the type of lamp in the artificial lighting system that still uses TLD lamps with LED lamps, and efforts in organizing energy management systems will decrease around 13 percent from the previous Energy Consumption Intensity (ECI) or down from 40.9 kWh/m²/year to be 35.6 kWh/m²/year.

Keywords: Energy, Consumption, Efficiency, Government Office Building

1. Introduction

Along with economic growth and population increase energy consumption. The high level of energy consumption which is inversely proportional to energy availability requires every energy user to make electrical energy efficient to reduce electrical energy consumption [1-3]. This is because the available
energy sources are very limited. This limitation will certainly be a problem if it is not addressed with appropriate actions.

Energy efficiency measures begin with conducting an energy audit [4] and evaluating the use of electrical energy [5]. Energy audit of actual energy use performance is used to assess the intensity of energy consumption. The value of the actual energy consumption intensity is compared with the standard to assess the actual energy use performance accompanied by recommendations for energy saving follow-up to achieve the planned energy use. Several energy efficiency follow-ups were carried out by managing building operations [6-7], implementing the installation of occupational sensors, replacing magnetic ballasts with electronics, and installing dimmers [8], turning off loads outside of working hours, setting the level lighting, setting the thermostat temperature regulator [9], to energy management [10-11] and implementation of government policies [12]. Energy efficiency follow-up can certainly be done by adjusting the conditions. However, in terms of energy efficiency, it should not interfere with the comfort of use [13-14]. This is because convenience is related to productivity [15].

The importance of analyzing energy consumption and energy efficiency in government office buildings of Bengkulu is felt to be important for research.

2. Method
To analyze energy consumption and energy efficiency in government office buildings of Bengkulu, it can be explained using a quantitative descriptive method according to the steps described in the research method flowchart in Figure 1 below.

![Figure 1. Research Method Flowchart](image-url)
In Figure 1, observing the initial conditions of Energy Consumption Intensity (ECI) is the first step of research in determining the category of energy efficient or not in buildings, then collecting data on the profile of the use of the building and its rooms, recapitulation of the use of energy sources (both electrical energy and other chemical energy), a list of equipment that consumes electrical energy (lighting, air conditioning, and others). Furthermore, measuring the performance of systems and equipment that consumes energy and conducting efficiency analysis to then make recommendations with operating settings, to replace inefficient equipment with more efficient equipment. The final step is to draw conclusions about the final Energy Consumption Intensity (ECI) obtained based on the results of the analysis and recommendations obtained on the previous Energy Consumption Intensity (ECI) value.

3. Results and Discussion

3.1. Results

The Energy Consumption Intensity (ECI) in government office buildings of Bengkulu is 40.9 kWh/m²/year or 3.7 kWh/m²/month. This value is obtained based on the total value of energy consumption per year (37,348 kWh) divided by the building area (37.348 m²) or the average value of energy consumption per month (3,395 kWh) divided by the building area (37.348 m²). The value of ECI in government office buildings of Bengkulu is pretty good. The results of total energy consumption in government office buildings of Bengkulu are shown in Table 1.

| Month      | Energy (kWh) |
|------------|--------------|
| November   | 3,840        |
| December   | 3,198        |
| January    | 3,600        |
| February   | 3,343        |
| March      | 3,585        |
| April      | 3,496        |
| May        | 3,310        |
| June       | 3,608        |
| July       | 3,263        |
| August     | 3,198        |
| September  | 2,907        |
| **Total**  | **37,348**   |
| **Average**| **3,395**    |
| **Minimum**| **2,907**    |
| **Maximum**| **3,840**    |

Referring to Table 1, the average energy consumption in government office buildings of Bengkulu was 3.395 kWh, the lowest energy consumption in government office buildings of Bengkulu was 2.907 kWh in September, and the highest energy consumption in government office buildings of Bengkulu was in November.

Potentials recommendations of energy efficiency in the government office buildings of Bengkulu are among others.

1. Performing preventive maintenance on air conditioners
2. The temperature of the air conditioner is set to always be at 24°C.
3. Replacing the type of lamp in the artificial lighting system that still uses TLD lamps with LED lamps.
4. Efforts in organizing energy management systems
3.2. Discussion
In the discussion will discuss the calculation of energy efficiency for electric equipments. Table 2 shows the results of energy efficiency calculations by replacing TLD lamps with LED lamps.

| No. | Item                                      | LED 10 W | TLD 18 W |
|-----|-------------------------------------------|----------|----------|
| I.  | Qty lampu                                 | 32,00    | 32,00    |
| II. | General Data                              |          |          |
|     | Lighting running hour/day (hour)           | 12,00    | 12,00    |
|     | Actual Power consumption (watt)            | 10,20    | 27,67    |
|     | Unit Price of lighting (Rp)                | 200,000,00 | 20,000,00 |
|     | Tarif/kwh (Rp)                            | 800,00   | 800,00   |
| III.| Lighting Replacement                      |          |          |
|     | Lighting running hour/year (hour)          | 4.380,00 | 4.380,00 |
|     | Lifetime (Year)                           | 9,13     | 0,46     |
| IV. | Lighting Cost/lamp                        |          |          |
|     | Energy used / lamp-year (kwh)              | 44,69    | 121,29   |
|     | Energy cost / lamp-year (Rp)               | 35.755,10 | 97.033,85 |
| V.  | Pay back period/lamp (year)                |          |          |
|     | Cost of lamp replacement/year (Rp)         | 21.900,00 | 43.800,00 |
|     | Cost of energy/year                       | 35.755,92 | 97.033,85 |
|     | Total running cost/lamp-year               | 57.655,12 | 140.833,85 |
|     | Saving/lamp-year                          | 83.178,74 |          |
|     | Pay back period/lamp (year)                | 2,40     |          |
| VI. | Lighting Cost Total                       |          |          |
|     | Energy used total lamp-year (kwh)          | 1.430,20  | 3.881,35  |
|     | Energy cost total lamp-year(Rp)            | 1.144.163,27 | 3.105.083,08  |
| VII.| Pay back period Total lamp (year)          |          |          |
|     | Cost of lamp replacement total year (Rp)   | 700.800,00 | 1.401.600,00 |
|     | Cost of energy total year                  | 1.144.163,27 | 3.105.083,08 |
|     | Total running cost total lamp-year         | 1.844.963,27 | 4.505.683,08 |
|     | Saving total lamp-year                     | 2.661.719,81 |          |
|     | Pay back period total lamp (year)          | 2,40     |          |

Referring to Table 2, the replacement 32 unit lamps of 18 W TLD lamp with 10 W LED lamp will affect the efficiency of 2.451,15 kWh/year or 6.6% of total energy consumption energy consumption in government office buildings of Bengkulu.

The results of potentials recommendations of energy efficiency in government office buildings of Bengkulu are shown in table 3.
Table 3. Potentials Recommendations of Energy Efficiency in Government Office Buildings of Bengkulu

| No | Potentials recommendations of energy efficiency | Energy Efficiency (kWh/ year) | Percentage of Energy Efficiency (%) | Cost Saving (Rp/ year) |
|----|-----------------------------------------------|-----------------------------|-----------------------------------|------------------------|
| 1  | The temperature of the air conditioner is set to always be at 24°C | 327                          | 0.88                              | 309.430                |
| 2  | Performing preventive maintenance on air conditioners | 327                          | 0.88                              | 309.430                |
| 3  | Replacing TLD lamps of 18 watts with LED lamps of 10 watts | 2.451                        | 6.56                              | 1.960.920              |
| 4  | Efforts in organizing energy management systems | 1.867                        | 5.00                              | 1.618.456              |
|    | **Total**                                        | **4.972**                    | **13**                            | **4.198.236**          |

Referring to Table 3, the total percentage of energy efficiency was found to be 13% of total energy consumption in government office buildings of Bengkulu or energy efficiency of 4.972 kWh/year with the annual cost savings of Rp 4,198,236,-.

The final Energy Consumption Intensity (ECI) in government buildings of Bengkulu by applying potential energy efficiency recommendations will decrease around 13 percent from the previous Energy Consumption Intensity (ECI) or down from 40.9 kWh/m²/year to be 35.6 kWh/m²/year.

4. Conclusion
The results of potentials recommendations of energy efficiency in government office buildings of Bengkulu are performing preventive maintenance on air conditioners, the temperature of the air conditioner is set to always be at 24°C, replacing the type of lamp in the artificial lighting system that still uses TLD lamps with LED lamps, and efforts in organizing energy management systems with total energy efficiency of 4.972 kWh/year.

The final Energy Consumption Intensity (ECI) in government buildings of Bengkulu by applying potential energy efficiency recommendations will decrease around 13 percent from the previous Energy Consumption Intensity (ECI) or down from 40.9 kWh/m²/year to be 35.6 kWh/m²/year.

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