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Energy System Audit of Lighting and Air Conditioning in Building E and F Cilacap State Polytechnic

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ABSTRACT

The purpose of this study was to conduct a review of energy audits in the lighting systems and air conditioning of building E and F of the Cilacap State Polytechnic. The results of the calculation of energy audits in lighting can be used as a guideline to make efficiency in the use of electrical energy. The initial step taken in this study was to look for primary and secondary data. Primary data is obtained by making direct measurements in all building rooms E and F. Secondary data obtained from relevant agencies such as the Cilacap State Polytechnic building data; energy demand data from the Energy and Mineral Resources (ESDM) Office; and data on electricity consumption from the National Electricity Company (PLN). The data is then processed to obtain the value of Energy Use Intensity (IKE) and can also be used as a guide for carrying out measures in energy efficiency. Based on the calculation and processing of the data obtained, the energy consumption of buildings E and F is 3,259.82 kWh/month and 3,650.96 kWh/month. The results of the energy audit calculations performed on the building lighting systems E and F with a building area of 287 m^2 and 399 m^2 have a building IKE value of 11.37 kWh/ m^2/month and 9.16 kWh/m^2/month. Based on the IKE criteria index, it was found that building E and F of the Cilacap State Polytechnic were included in the criteria of efficiency.

Key Words: *Cilacap State Polytechnic, Energy Audit, Lighting System, Energy use Intensity.*

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1. INTRODUCTION

The increasing number of population in Indonesia every year will be directly proportional to the number of activities as well. This is evidenced by an increase in the number of electronic devices that are increasingly numerous types. The use of electronic equipment is also directly proportional to the total cost that must be paid to pay for it [1]. Substantial costs will undoubtedly affect all other types of operations. The solution to these problems is the need for energy management [2]. Energy management is a form of a systematic and integrated approach to carrying out the utilization of energy resources effectively, efficiently, and rationally without reducing the quantity and quality of the main functions of the building [3]. Energy auditing is an energy management method used to conduct energy efficiency. Qualitative analysis of energy audits in buildings is done by measuring and surveying energy use. Energy efficiency, consumption levels, energy prices, and the environmental impact of buildings can be audited, monitored, and evaluated. One of the results of the energy audit is a recommendation to conduct energy efficiency [4].

Energy efficiency is the ratio between energy output and total energy input. This ratio is always related to specific situations. Efforts can be made to determine the level of energy efficiency of a building through the energy audit process in a building. Energy audits are needed to determine the amount of electricity needed by a building. In the audit, process innovation is needed so that the calculation of electrical energy can be known quickly and can save costs. These innovations can be applied by designing software that is maintainable, dependable, and useable [5]. The Government of Indonesia has issued Presidential Regulation No. 22 of 2017 concerning the National Energy General Plan which mandates conducting energy conservation activities, especially in the field of energy-saving by implementing energy management and audit programs from the energy user side. The issuance of SNI 03-6196-2000 has also regulated energy audit standard procedures for buildings

While air conditioning will always be related to how to regulate the air condition in a particular room, air conditioning will positively always be related to the regulation of air temperature and also the regulation of humidity and movement of room air including air filtering to get air free of pollutants. In practice, air conditioning is divided into two, namely: Air conditioning based

on the level of comfort and air conditioning for the production process. In this study, the air conditioning method used is the air conditioning method based on the level of comfort that is often used in office buildings, hotels, and schools.
This research was conducted in the E and F buildings of the Cilacap State Polytechnic, Cilacap Regency, Central Java. Cilacap State Polytechnic is located in the southern coast region directly adjacent to the Indian Ocean. Cilacap State Polytechnic is a government-owned building whose activities are aimed at education and technological development. Building E and F Cilacap State Polytechnic is a building that is specialized in the field of electrical engineering so that the use of electrical appliances in this building is more dominant compared to other buildings. The use of electrical energy in this building is also quite high, and this can be proven by increasing the cost of payment of electricity consumption always increasing every month.

2. RESEARCH METHODOLOGY

2.1 Field Survey

The field survey was conducted in the area of building E and F of the Cilacap State Polytechnic by counting the number of rooms that were actively used in daily activities. The results of the field survey in Building E contained nine rooms consisting of 3 classrooms, one computer laboratory room, one tool room, one instrumentation laboratory room, one radio room, one toilet room, and a terrace. The results of the field survey in Building F contained 11 rooms consisting of 1 office room leader, one administrative room, two classrooms, 1 PLC laboratory room, one electro workshop room, one pneumatic laboratory room, 1 PLP room, one toilet room, one kitchen room, and terrace.

2.2 Collection of Tools and Materials

The primary research tool used serves for measurement, data tabulation, and research data processing. The primary research tool is a nanotip digital power meter that functions to measure electrical quantities such as voltage, current, active power, reactive power, frequency, power factor in one device. Power meter functions for measurements that are connected with current transformers. The following primary research tool is a lux meter that serves to measure the level of lighting in a room. This research material is in the form of primary data from observations and observations in the field that can be used to measure the lighting system of the E and F buildings of the Cilacap State Polytechnic. Other research materials are secondary data obtained directly from agencies including the Cilacap State Polytechnic, the State Electricity Company, and the Regional Water Supply Company.

2.3 Data Collection

This study uses a quantitative approach. The research process begins by identifying the use of electronic equipment used in office buildings, government, and education. Energy use is studied theoretically and looks at several ways to produce energy-efficient audit instruments. Data needed for this research are primary data and secondary data. The next data collection technique is observation by observation in each room in the building to see firsthand the state of the room. This technique includes reviewing secondary data to see the compatibility of secondary data with field conditions. The next collection technique is an interview by asking questions directly to the data source. This interview aims to explore data in detail that is impossible to answer with secondary data

2.4 Initial Energy Audit

This study uses the concept of an initial energy audit, the stages of which include the stages of a short audit but are complemented by momentary measurements. The results of data processing from the initial energy audit obtained the value of Energy Consumption Intensity, which is a comparison between energy consumption with the unit area of the building in a certain period. The value of energy consumption intensity is essential to be used as a benchmark of how much potential energy efficiency might be applied in the area. By comparing the intensity of energy consumption with national standards, it will be known whether the entire building is efficient. According to the Guidelines for Implementing Energy Conservation and Supervision in the Environment of the Ministry of National Education the value of Energy Consumption Intensity of a building is classified in two criteria, namely for buildings using Air Conditioners and buildings that do not use Air Conditioners. Table 2.1 shows the energy consumption intensity criteria for buildings that use Air Conditioners.

Table 2.1. Criteria for the intensity of energy consumption of buildings using air conditioners

Criteria	Information
Very Efficient (4.17 – 7.92 kWh/m^2/month)	• The building design is following the standard procedures for energy conservation technical planning. • The operation of energy equipment is carried out with the principles of energy management.
Efficient (7.93 – 12.08 kWh/m^2/month)	• Maintenance of buildings and energy equipment is carried out according to the procedure. • Efficient use of energy is still possible through the implementation of an integrated energy management system.
Quite Efficient (12.08 – 14.58	• Energy-efficient use through building maintenance and energy equipment is still possible.

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kWh/m2/month)	• The operation and maintenance of the building have not yet considered the principles of energy conservation.
Rather Wasteful (14.58 – 19.17 kWh/m^2/month)	• Energy audits need to be considered to determine possible efficiency improvements. • The building design and the maintenance and operation of the building have not yet considered energy conservation.

2.5 Data Analysis

From the results of audits conducted, an analysis will be made of energy use and energy-saving opportunities that might be possible in lighting and air conditioning systems. The analysis in this research is to use descriptive quantitative analysis techniques, which is a method of analyzing techniques by describing research results in graphical form. The final result will be in the form of recommendations for things to do to conserve energy in the E and F buildings of the Cilacap State Polytechnic.

2.6 Research Flow Chart

To facilitate the implementation of research on energy audits for energy use in buildings E and F of the Cilacap State Polytechnic a research flow chart is made as shown in Figure 2.1

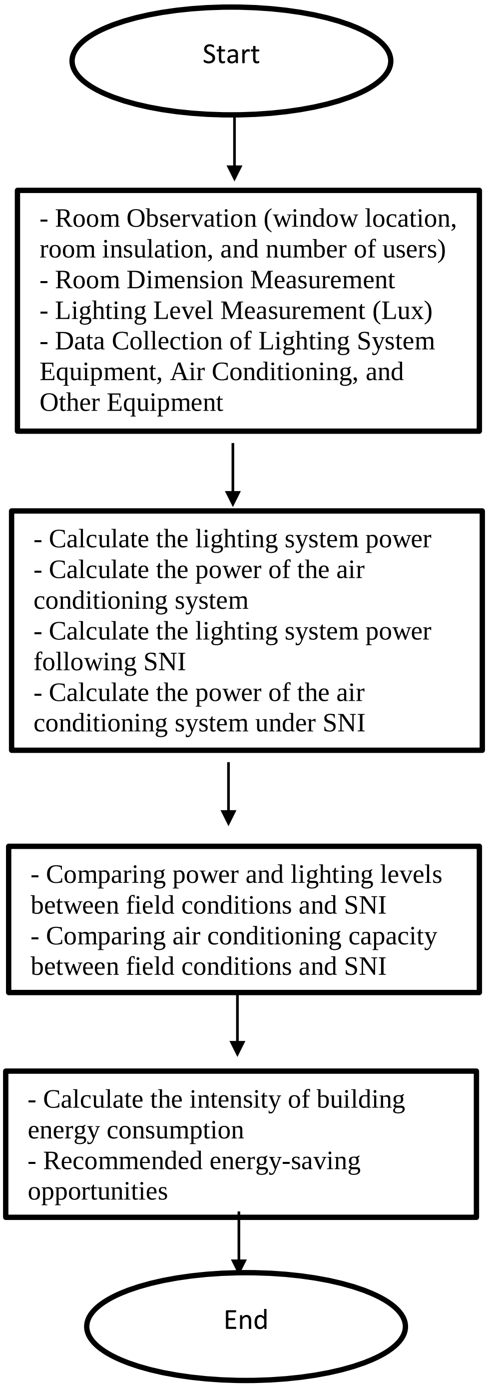

Figure 2.1: Research Flowchart

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3. RESULTS

The results of observations made in this study took place in the Cilacap State Polytechnic of Cilacap Regency by analyzing the sequential data obtained from the National Electricity Company in the form of electricity bills every month for the past two years, building electricity bill data obtained from July 2017 to June 2019. This secondary data is used to analyze the total electricity demand every month. Based on these secondary data, it is known that the building has experienced an increase in electrical energy consumption. This is evidenced by the increasing amount of electrical energy that must be paid every month. Figure 3.1 shows data on electricity usage every month at the Cilacap State Polytechnic.

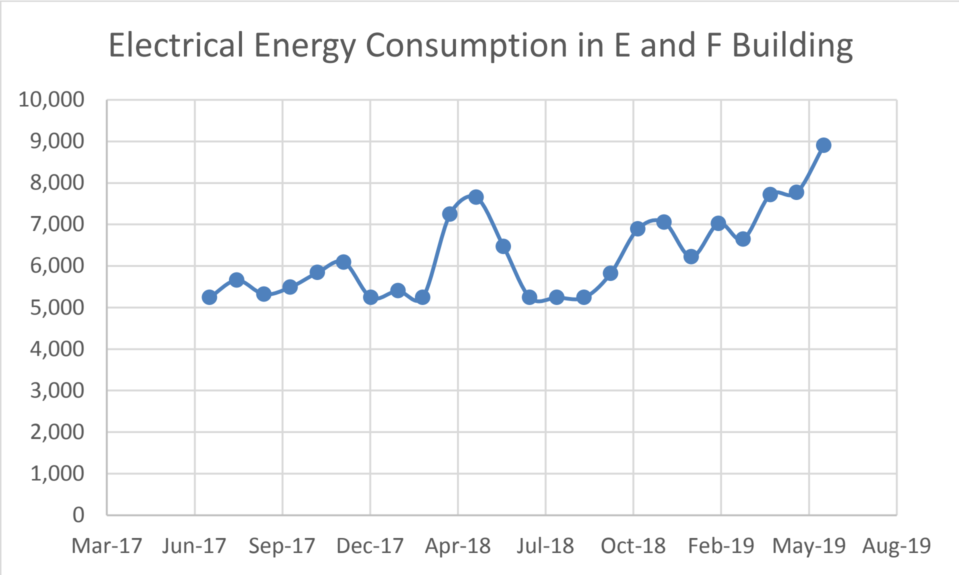

Figure 3.1: Graph of electricity consumption in building E and F of the Cilacap State Polytechnic

In this initial audit discussion, we need to calculate the Energy Consumption Intensity in Building E and F of the Cilacap State Polytechnic, to find out whether a detailed audit is necessary or not. Where to calculate the Intensity of Energy Consumption requires data that has been obtained previously, and the formula used can be seen in equation 3.1

$$\text{IEC} = \frac{\textit{Total Building Energy Consumption}}{\textit{Total Building area}} \quad \text{--------------------} \quad (3.1)$$

From the calculation of the intensity of energy consumption in one year at the Cilacap State Polytechnic building, the Energy Consumption Intensity results in building E is 12.6 kWh / m^2 / month and the Energy Consumption Intensity in Building F is 9.15 kWh / m^2 / month.

Based on Figure 3.1 shows that the increase in the amount of electrical energy consumption occurs because of the activity in the use of electronic equipment and the use of lighting systems. This is evidenced by the results of interviews with building users, most of whom are lecturers and students whose activities in the use of electronic equipment occur from morning to late at night. The percentage increase in electricity consumption in the Cilacap State Polytechnic building was 3.06% every month in the last two years. This is directly proportional to the increased activity in the use of the Cilacap State Polytechnic building and the increased use of electronic equipment and lighting systems. Based on interviews with building users that the lighting system can occur for 24 hours straight. The buildings in Cilacap State Polytechnic, starting from building A to building F have different functions. Buildings E and F are buildings that have a significant contribution to electricity consumption. This is evidenced by the results of field observations and interview results

Building E and F in Cilacap State Polytechnic is a building whose activities are related to the electronics field. This is evidenced by the results of field observations that buildings E and F have laboratories that support activities related to the electronics field. The rooms in Cilacap State Polytechnic E and F buildings also have different areas. This can be proven from the results of direct measurements and field observations. Based on the functions and area of buildings E and F, the use of lighting systems also varies. The use of electrical energy for lighting systems in each room of buildings E and F can be seen in tables 3.1, 3.2 , 3.3, and 3.4.

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Table 3.1. Primary Data and results of the calculation of the lighting system of the Cilacap State Polytechnic E building

Room Function	Area (m^2)	V (m^3)	Room Layout (B/BT)	Window Layout (N/E/S/W)	Occupancy (people)	Lighting Level (Lux/m^2)	Power (watt)	Duration (hour)
Classroom A	36,68	152,62	18	20	25	93	154	8
Classroom B	36,68	152,62	18	20	25	159	72	8
Computer Laboratory	55,26	229,90	18	20	25	143	144	8
Device Room	36,68	152,62	18	20	25	142	72	8
Instrumentation Laboratory	55,26	229,90	18	20	25	111	144	8
Classroom C	36,68	152,62	18	20	25	140	72	8
Radio Room	14,47	66,74	18	18	2	111	18	4
Toilet	14,89	66,29	18	18	2	237	40	12

Table 3.2. Primary Data and results of the calculation of air conditioning system of the Cilacap State Polytechnic E building

Room Function	Area (m^2)	V (m^3)	Room Layout (B/BT)	Window Layout (N/E/S/W)	Occupancy (people)	Air Conditioning System	Observation (PK)	Duration (hour)
Classroom A	36,68	152,62	18	20	25	Above SNI	2	8
Classroom B	36,68	152,62	18	20	25	Under SNI	2	8
Computer Laboratory	55,26	229,90	18	20	25	Under SNI	2	8
Device Room	36,68	152,62	18	20	25	Under SNI	1.5	8
Instrumentation Laboratory	55,26	229,90	18	20	25	Under SNI	4	8
Classroom C	36,68	152,62	18	20	25	Under SNI	2	8
Radio Room	14,47	66,74	18	18	2	Under SNI	1	4
Toilet	14,89	66,29	18	18	2	Under SNI	0	0

Table 3.1 shows the results of the primary data measurement and the calculation results of the lighting system of the Cilacap State Polytechnic Building E. Based on table 3.1, the relationship between the power and duration of use of the available lighting system is directly proportional to the electricity consumption per hour. The computer laboratory and instrumentation laboratory have the same room area with 229.90 m^2. The power needed in the room is 144 watts, each with a usage time of 8 hours. The total electrical energy consumption of the lighting system in the room is 20.84 wh / m^2. Three classrooms and tool rooms have the same room area of 152.62 m^2. The power needed in this room is 154 watts each for class A rooms and 72 watts for other rooms with extended usage of 8 hours. The total electrical energy consumption of the lighting system in the room is 33.58 wh / m^2 for class A and 15.70 wh / m^2 for other classrooms. The power needed in class A is different from class B and C. This is evidenced by the measurement of the electronic equipment used is also different. Based on the results of field observations, class A is used as a theoretical classroom, so there are projectors for the teaching process. The radio and toilet rooms each have 14.47 m^2 and 14.89 m^2. The power needed in the room is 18 watts and 40 watts respectively, with extended usage of 4 hours and 12 hours. The total electrical energy consumption of the lighting system in the room is 4.97 wh / m^2 and 32.21 wh / m^2. The results of the calculation of the building lighting system power E are different from building F. The following are the results of the primary data and the results of the calculation of the power system of the Cilacap State Polytechnic, as shown in table 3.3 and 3.4.

Table 3.3. Primary Data and results of the calculation of the lighting system of the Cilacap State Polytechnic F building

Room Function	Area (m^2)	V (m^3)	Room Layout (B/BT)	Window Layout (N/E/S/W)	Occupancy (People)	Lighting Level (Lux/m^2)	Power (watt)	Duration (hour)
Head Office	21,30	97,98	18	20	2	100	72	8
Administration Room	33,37	153,50	18	17	6	119	72	8
Classroom A	37,13	170,79	18	20	25	125	72	8
PLC Laboratory	54,67	251,48	18	20	25	123	144	8
Classroom B	35,88	165,04	18	20	25	120	72	8

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Electrical workshop	63,99	294,35	18	20	25	125	144	8
Pneumatic Laboratory	21,28	97,88	18	17	10	168	36	8
PLP Room	20,72	95,31	18	10	2	50	40	8
Toilet	14,44	66,42	18	18	3	110	51	12
Kitchen	14,44	66,42	18	20	4	105	18	8
Terrace	81,40	374,44	18	20	100	105	18	12

Table 3.4. Primary Data and results of the calculation of air conditioning system of the Cilacap State Polytechnic F building

Room Function	Area (m^2)	V (m^3)	Room Layout (B/BT)	Window Layout (N/E/S/W)	Occupancy (People)	Air Conditioning System	Observation (PK)	Duration (hour)
Head Office	21,30	97,98	18	20	2	Under SNI	2	8
Administration Room	33,37	153,50	18	17	6	Under SNI	2	8
Classroom A	37,13	170,79	18	20	25	Under SNI	2	8
PLC Laboratory	54,67	251,48	18	20	25	Under SNI	2	8
Classroom B	35,88	165,04	18	20	25	Under SNI	2	8
Electrical workshop	63,99	294,35	18	20	25	Under SNI	2	8
Pneumatic Laboratory	21,28	97,88	18	17	10	Under SNI	0	0
PLP Room	20,72	95,31	18	10	2	Above SNI	2	8
Toilet	14,44	66,42	18	18	3	Under SNI	0	12
Kitchen	14,44	66,42	18	20	4	Under SNI	0	0
Terrace	81,40	374,44	18	20	100	Under SNI	0	12

Table 3.3 and 3.4 show the results of the primary data measurement and the calculation results of the lighting system of the Cilacap State Polytechnic F building. Based on table 3.2 for the Head Office space, administration and two classrooms have a room area of 21.30 m^2, 33.37 m^2, 37.13 m^2, and 35.8 m^2. The power needed in the room is 72 watts, each with a length of 8 hours. The total electrical energy consumption of the indoor lighting system is 27.04 wh / m^2, 17.26 wh / m^2, 15.51 wh / m^2 and 16.05 wh / m^2. The PLC laboratory and electrical workshop have a room area of 54.67 m^2 and 63.99 m^2. The power needed in the room is 144 watts, with a length of 8 hours. The total electrical energy consumption of the lighting system in the room is 21.07 wh / m^2 and 18.01 wh / m^2. The Pneumatic Laboratory and PLP room have a room area of 21.28 m^2 and 20.72 m^2. The power needed in the room is 36 watts and 40 watts, with a long usage of 8 hours. The total electrical energy consumption of the lighting system in the room is 13.53 wh / m^2 and 15.44 wh / m^2. Toilets, kitchens, and terraces have a room area of 14.44 m^2, 14.44 m^2 and 81.40 m^2. The power needed in the room is 51 watts, 18 watts, and 18 watts with the use of 12 hours, 8 hours, and 12 hours. The total electrical energy consumption of the indoor lighting system is 42.38 wh / m2, 9.97 wh / m^2, and 2.65 wh / m^2. Based on table 3.2, the biggest use of electrical energy is in the toilet, and therefore to be more efficient in the use of electrical energy, it is recommended that the lamp power used to be reduced from the previous power.

The following is a graphic image of the difference in energy consumption per day for one week from observations made from 1 July 2019 to 7 July 2019.

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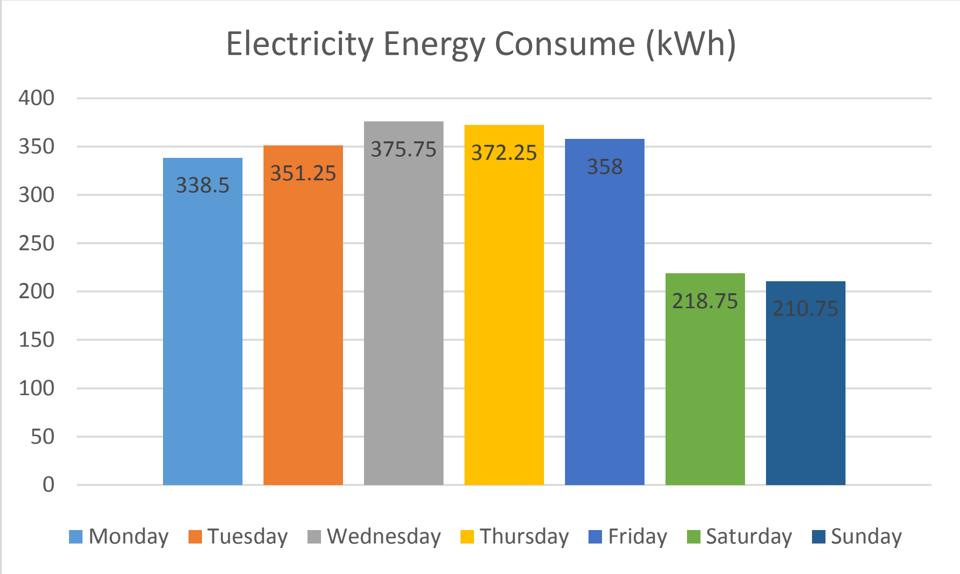

Figure 3.2 Energy Consumption for one week Cilacap State Polytechnic

4. ENERGY SAVING OPPORTUNITY RECOMMENDATIONS

Energy savings in educational buildings and government institutions can be done by saving energy through lighting systems, air conditioning systems, and supporting equipment. Energy savings through lighting systems can be done by using energy-saving lamps in accordance with their objectives, reducing the use of decorative lighting accessories, using electronic ballasts on TL lamps, adjusting your maximum electric power for lighting in accordance with SNI 03-6197-2011 which can be seen in table 2.1 , using a reflector lamp housing that has high light reflection, adjust the switch based on the group of areas so that it is in accordance with the use of space, use an automatic switch using a timer.

Saving air conditioning systems can be done by using energy-efficient air conditioners and using hydrocarbon coolers, placing the compressor unit in a location that is not exposed to direct sunlight, turning off the air conditioner when not in use, installing a room thermometer to monitor room temperature, ensuring there is no outside air entering air-conditioned rooms that cause a reduced cooling effect, use certain types of glass that can reduce the heat of the sun entering the room but not reduce natural lighting.

Energy savings on supporting equipment can be done by operating the elevator by stopping every two floors, using speed regulators and motion sensors on the escalator, turning off the computer if it will leave the workspace for more than 30 minutes, turning off the printer when not in use and only turning on just before printing, using copiers that have a standby mode with low electricity consumption, looking for energy diversification such as the use of solar and wind energy.

5. CONCLUSION

The calculation result of Energy Consumption Intensity in building E Cilacap State Polytechnic obtained the value of the total building consumption of 3,259.82 kWh / month with a total building area of 286.65 m2, then the Energy Consumption E of building E is 11.37 kWh / m2 / month. Based on the results of this calculation, building E is included in the category of efficient use of electrical energy in the lighting system at the Cilacap State Polytechnic Building. The calculation result of Energy Consumption Intensity in Building F of the Cilacap State Polytechnic obtained total building consumption value of 3,650.97 kWh / month with a total building area of 398.62 m2, then Energy F Energy Consumption of Building F obtained at 9.16 kWh / m2 / month. Based on the results of this calculation, Building F is included in the efficient category in the use of electrical energy in the lighting system at the Cilacap State Polytechnic Building.

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REFERENCES

1. Mehulkumar, J. P. Ved Vyas, D. Rajendra, A. 2014. The Case study of Energy Conservation & Audit in Industry Sector. *International Journal Of Engineering And Computer Science*, 3 (4), 5298-5303.
2. Denis, Denis, Ahmad Agus Setiawan, and Ahmad Sarwadi. "SKENARIO MANAJEMEN ENERGI RENDAH EMISI SEKTOR RUMAH TANGGA UNTUK MENGURANGI EMISI GAS CO2 DI KOTA SEMARANG." *Transmisi* 18.1: 1-7.
3. Awanish, K. Shashi, R. Bharath Kuma, S. M. Priyanka, K. Ramesh, L. 2015. Electrical Energy Audit in Residential House. *SMART GRID Technologies*, 21, 625–630.
4. Deepak, R. Ranjana, K. Asutosh, K.P. 2013. Electrical Energy Audit (A Case a study of Tobbaco Industry). Rishiraj Institute of Technology. Indore India. *International Journal of Engineering and Applied Sciences. www.eaas-jour*.
5. Charlier, D. 2015. Energy efficiency investments in the context of split incentives among French households. *Energy Policy* 87, 465–479.
6. Sommerville. Ian. 2011. *Software Engineering Ninth Edition*. Pearson Education. Inc.: United States of America.
7. Rafel, P.Z. Julio, C.M.S. Fernadno, S. S. Paulo, S.S. 2018. Energy audit model based on a performance evaluation system. *Energy*, 154, 544–552.
8. Lobão, J.A. Devezas, T. Catalão, J.P.S. 2015. Energy efficiency of lighting installations: Software application and experimental validation. *Energy Reports*, 1, 110–115.
9. SNI 6196:2011 tentang Prosedur Audit Energi pada Bangunan Gedung.
10. SNI 6197: 2011 tentang Konservasi Energi pada Sistem Pencahayaan.
11. SNI 6390:2011 tentang Konservasi Energi Sistem Tata Udara Bangunan Gedung.

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