Lighting System Energy Conservation Simulation at Faculty of Engineering Diponegoro University Library Using Ecotect

by Jaka Windarta

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Lighting System Energy Conservation Simulation at Faculty of Engineering Diponegoro University Library Using Ecotect

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Abstract. Global warming is becoming a severe concern day by day. Indonesia still uses a large portion of fossil fuels in electricity generation; this made matters even worse due to carbon emissions. Government through PP No. 70 of 2009 issued an energy conservation policy stating that used energy must be carried out economically and efficiently. The objective of this policy for all sectors of life, one of sector is the academic environment. The library spends a lot of energy consumption for supporting activities, especially in the lighting system. Observations and measurements were performed to see the illuminance of the library when categorized as visually very bright. The results are then compared with the standard, whether it meets the minimum threshold or not or even exceed, and how the savings opportunities that can be done. The method that used in this research is data collection, measurement of illuminance, and search for savings opportunities through simulations. Based on methods, a savings opportunity is obtained by reducing the number of lamps used. If this step is applied, then obtained savings of up to 514 kWh/year, equivalent to the electricity bill amounting to IDR 462.672, - from the lighting system.

1. Introduction

Energy conservation is a policy issued by the government to maintain domestic energy security. PP No. 70 of 2009 states that energy conservation is systematic, planned, and integrated to conserve resources and improve the efficiency of energy utilization. In the sphere of energy utilization, energy conservation activities include the use of energy-saving and efficient [1].

Energy conservation needs to be carried out considering that energy demand continues to increase day by day, while the national energy reserves are mainly dependent on fossil fuels dwindling. Also, the threat of global warming due to carbon emissions from burning fossil fuels has increased. Therefore, various policies have been issued by the government to implement savings in all sectors of life including education sector.

The library is a public facility that has functions to provide services and places for discussion for every community [2]. The library is used daily for reading and writing activities, and of course, requires adequate lighting. The savings in this room can be done by maximize natural lighting [3][4]. The use of sunlight allows a significant reduction in the overall number of watts on the lights installed, then followed by a decrease in electricity consumption due to reduced reliance on artificial lighting

[5]. In addition, natural lighting can improve the indoor environmental quality and positive impact on occupants [6][7]. With light use, on average 7 hours a day, it would require the participation of librarians to familiarize the behaviour of energy saving by turning off lights when not in use.

This research is motivating the visual condition of the library room that looks very bright. An observation method used to collect data from the library, then the lighting intensity measurement was conducted to see the existing lighting system meets the standards or not or even exceeded. If it exceeds the standard, the next step is to find savings opportunities using software simulations.

2. Methods

The object of this research is the library room at the Faculty of Engineering, Diponegoro University, Semarang. This library is an L-shaped room with an area of 464 m^2. There are windows on the northeast and southeast sides facing outside of the room. The library operates from Monday to Friday at 08.00 - 16.00 with breaks at 12.00 - 13.00, so assuming that the library serves 7 hours a day.

Figure 1. Library room

The main problems that exist in the picture is a lot of light points that make the room appear very bright. Therefore, it needs to be seen whether the existing lighting is following the standards set or not and how the savings opportunities.

The research was preceded by observing and collecting field data such as room documentation, window location, operating hours, and the number of lights used. The next step is to measure lighting intensity using a lux meter. Measurements were performed three times at 09:00, 13:00, and 15:00. Determination of measurement points based on the SNI 16-7062-2004, which if room area reached 464 m^2, then the measuring points are divided every 6 m [8]. The measurement results are then compared to the SNI 6197: 2011 [9]. The next step is to modelling using the software.

3. Result and discussion

3.1. *Observation's results*

Based on the observations that have been made, The number of lights in library has been obtained. If the room operates for 7 hours from Monday to Friday and subscribes to 197 kVA power from PLN [10], then the energy consumption of the lighting system can be calculated as in table 1.

Table 1. Energy consumption on existing condition

Lamp Type	Watt (W)	Number of Lights	Energy Consumption (Wh)
CFL	18	29	3.654
TL	18	28	3.528
Energy consumption per year (Wh / year)			1.723.680
Cost of energy consumption per year (IDR / year)			1.551.312

Energy consumption in lighting systems is calculated by multiplying the power lamp, the lamp usage time, and the number of lights used in this period [15]. Table 1 shows that for one year, the library room cost up to IDR 1.551.312,- just for the lighting system.

3.2. Measurement's result

The lighting intensity measurement is done to see how high the level of natural and artificial lighting in the library. Then a comparison is made with SNI 6197: 2011 whether or not it meets the requirements. Data from the measurement of the intensity of natural and artificial lighting is shown in table 2.

Table 2. Measurement's results

Time	Measurement Point	Natural Lighting (lux)	Artificial Lighting (lux)
9:00	A1	156	470
	A2	86	220
	A3	158	499
	A4	145	333
	A5	7	45
	A6	109	250
	A7	46	244
	A8	42	327
	A9	39	514
	A10	71	554
	A11	24	146
	A12	30	133
	A13	25	247
	A14	24	231
13:00	A1	154	456
	A2	66	134
	A3	62	465
	A4	77	276
	A5	4	44
	A6	116	228
	A7	44	264
	A8	28	443
	A9	32	440
	A10	61	536
	A11	24	125
	A12	24	131
	A13	28	283
	A14	33	263
15:00	A1	79	422
	A2	41	143
	A3	44	434
	A4	60	320
	A5	3	43
	A6	113	220
	A7	40	255
	A8	26	421
	A9	21	402
	A10	42	532
	A11	20	142

Time	Measurement Point	Natural Lighting (lux)	Artificial Lighting (lux)
	A12	18	115
	A13	24	260
	A14	21	250

Note: those that are coloured yellow are by Indonesia National Standart (*SNI*)

From the measurement results obtained information that several points meet the standards of measurement that is equal to 300 lux and some have not. The table also shows that by using natural lighting alone is not enough to meet the standards that have been set because its value is still far below the standards. While the measurement of artificial lighting intensity, there are several points which far exceed the standards set. Opportunities for energy consumption savings can be made on these points.

3.3. Simulation

The simulation is carried out using Autodesk Ecotect where this software is an environmental analysis tool that allows the designer to simulate the building's performance precisely in the conceptual phase [11][12]. ECOTECT was developed by Dr.Andrew Marsh and Square One Research Ltd., which was later acquired by Autodesk Ecotect provides thermal, lighting and acoustic analysis tools, including hourly thermal comfort, natural and artificial lighting levels, acoustic reflections, echo time, project costs and environmental impact [14].

The simulation is done by modelling the condition of the library room to find savings opportunities. Modelling was performed using Autodesk Ecotect software, where windows are close to actual conditions (see in figure 2).

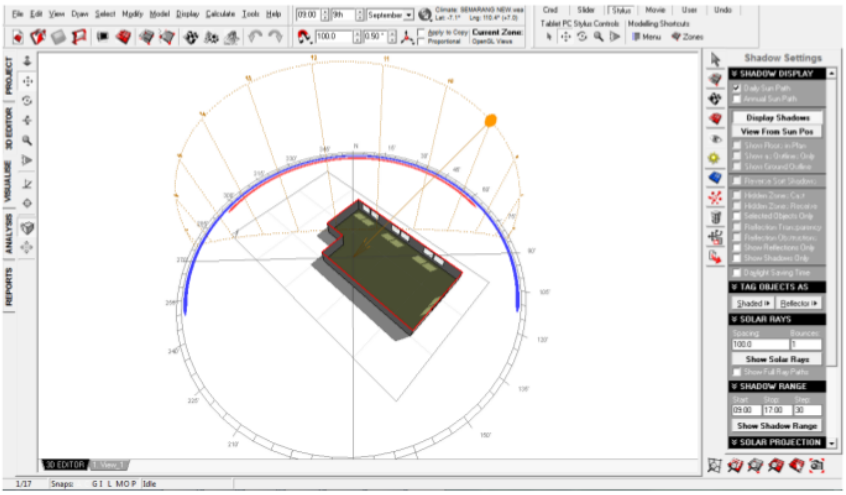

Figure 2. Library room model

After the room model is formed, the next step is to enter climate and location data. Initial simulation is used to view the condition of natural lighting in the library room.

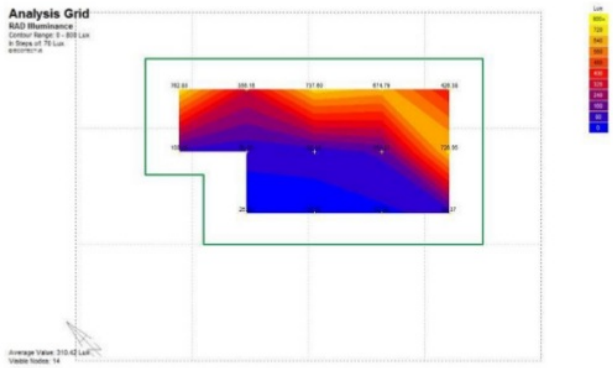

Figure 3. Natural lighting simulation

Figure 3 is the result of a simulation of natural lighting intensity at 09:00 WIB with a display that has been adjusted to the measurement points. From the picture, we can see that some measurement points located near the window have a higher lux value than locations that are far away from the window. Therefore, natural lighting is less able to support library activities that require adequate lighting throughout the room.

The next simulation is done to see the condition of the room that gets artificial lighting. On models that have been made previously, added lamp with a height of 2.5 meters from the floor and increasing the number of light-adapted to the existing conditions.

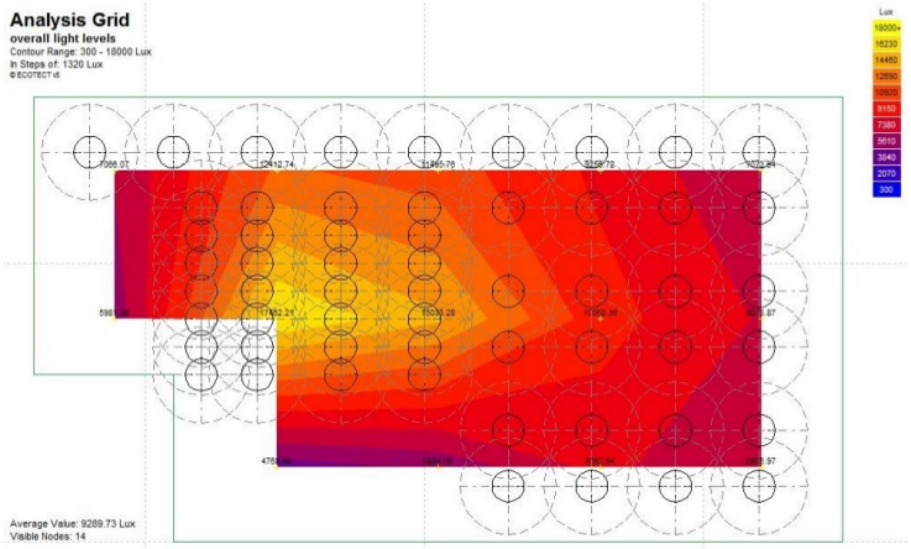

Figure 4. Simulation of artificial lighting in existing conditions

The figure above shows that by using artificial lighting, the light obtained to support the activities within the library room more evenly distributed. From the simulation results obtained an average of 9289.73 lux, this shows that the condition of the room is very bright. The savings recommendation can

be made by reducing the number of lamps used. In the next simulation, the author tries to reduce some of the light points as shown in Figure 5.

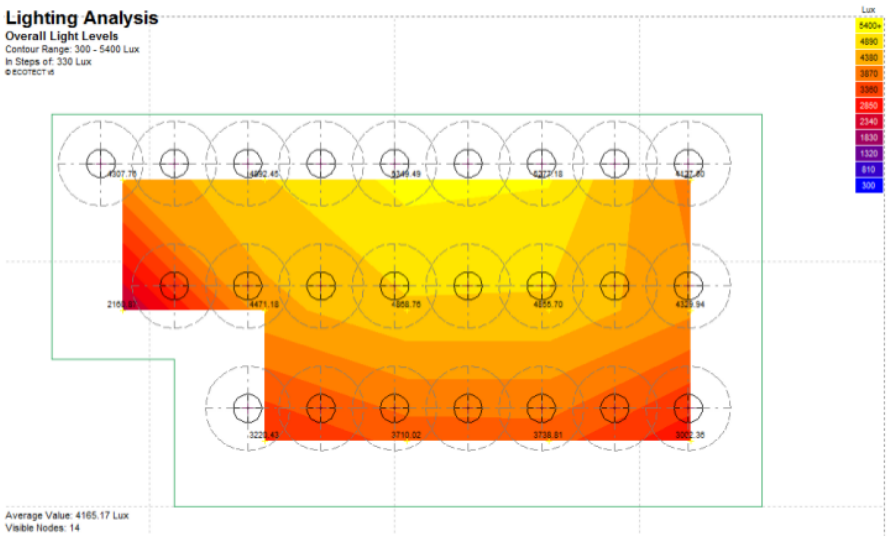

Figure 5. Simulation of artificial lighting by reducing the number of lights

From the simulations obtained, an average lighting intensity reached 4165.17 lux, it shows that reducing the amount of light in the library room, the lighting intensity in the room still meet the standards set. If the simulation results are compared with the measurement results, then we can make savings by reducing the number of lamps used so that the following savings are obtained.

Table 3. Comparison of energy consumption

existing energy consumption (Wh/year)	energy consumption after lamp reduction (Wh / year)
1.723.680	1.209.600

The table shows that by reducing 9 CFL lamps and 8 TL lamps, savings can reach up to 514 kWh / year or equivalent to an electricity bill of IDR 462.672,-.

4. Conclusion

Based on observations and measurements that have been made in the library room, it can be concluded that the intensity of the lighting from artificial lighting in the library room at some points still exceeds the existing standards. As for the intensity of natural light were below standard. So, the natural lighting in the room is not capable of supporting the needs of adequate lighting in the room and less able to play a role in the use of lights. Therefore, the savings recommendation obtained from modelling the condition of the library room is to reduce the number of lamps used. The results of these recommendations obtained savings of up to 514 kWh / year.

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