Dynamic Energy Conservation Based On Room Characteristics at Polytechnic State of Pontianak

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Dynamic Energy Conservation Based On Room Characteristics at Polytechnic State of Pontianak

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Abstract

Generally, energy conservation are carried out on a building as a whole, but in this research the energy conservation are carried out dynamically based on the characteristics and the user of the room. In this research, the lux measurement has been taken at certain times. Based on the characteristics of the existing room at Polytechnic State of Pontianak, the lux measurements were taken at one of the electronics laboratory, one technician room, Electrical engineering department library, one classroom for Information Technology students and one academic staff office. These rooms divided into three size: small, medium, and large. The data that has been taken will be compared with the standard of room lighting according to the Indonesian National Standard SNI-03-6917-2000. Analysis in determining lux can be used with fuzzy logic based on room size, number of lights and electrical power. Lux can be obtained by 3 values, namely Lemah, Sedang, and Kuat. With fuzzy it is obtained that the value of output membership for Lux Kuat for library = 0.11, Technician room = 0.10, and Classroom IT 7 = 0.31 with the scale of 0 – 1. With 0 is the value of the minimum and 1 is the maximum value of the fuzzy membership. It can be seen between the 3 rooms that classroom It 7 is the room with better lighting, hence better lux value.

Keywords—Energy Conservation; Polytechnic State of Pontianak; Fuzzy Logic; Rooms Characteristics; SNI-03-6917-2000.

1. Introduction

The Pontianak State Polytechnic has several departments in the field of engineering such as Electrical Engineering, Machine Engineering, Civil Engineering, and Architect Engineering and non-engineering, such as Administration Business, Accounting, Marine and Fisheries Science. Vocational education at the Pontianak State Polytechnic has a theoretical and practical percentage of 30 : 70 so that the electricity usage in the Pontianak State Polytechnic is big at the workshop and engineering laboratory.

Having observed that a large amount of electricity has been consumed in the Pontianak State Polytechnic, an initial energy audit was then conducted to find out the level of efficiency of electricity usage this institution. The audit has resulted that the obtained data on the calculation of energy consumption intensity (IKE) of electricity for each gross area of the Pontianak State Polytechnic building complex, based on secondary data on energy consumption from electricity payment bills in the years of 2014, 2015 and 2016 which respectively amounted to 63.37 kWh / m2 per year (with an average IKE value per month of 5.28 kWh / m2), 62.30 kWh / m2 per year (with an average IKE value per month of 5.19 kWh / m2) and 44.79 kWh / m2 per year (with an average IKE value of 3.73 kWh / m2) per month. The ASEAN-USAID Research in 1992 has shown that the IKE Standard for Electricity consumption for an office building was 240 kWh / m2 / year leaving that the value of IKE at the Pontianak State Polytechnic was still below the standard value. In addition to that, according to the IKE standard of the Republic of Indonesia National Department, the air-conditioned rooms under a Highly Efficient criterion should have an IKE value between 4.17 to 7.92 kWh / m2 / month. Taking that criterion into account, it is learned that the IKE value in the Pontianak State Polytechnic falls in the Very Efficient criterion.

In general, energy savings are carried out on a building as a whole and based on the reasons contained in the preceding paragraph, this study focuses on dynamic energy conservation on the basis of room functions in the Pontianak State Polytechnic. Room lighting in each room is different depending on its respective function. Considering that the Pontianak State Polytechnic has various room types, a study was made to determine the energy conservation with regard to the light requirements in each room. By developing a fuzzy logic algorithm, the lux for each room based on its characteristics could then be obtained. This study aims at determining the optimal level of energy conservation to be applied to the Pontianak State Polytechnic.

This research focuses on the search for lighting levels that commensurate with the function of the rooms that it could be expected, by regulating the lighting in each room, a maximum energy savings could be obtained. Based on previous research, not all cases could be completely resolved neither by means of fuzzy logic method nor by other artificial intelligence method. To find out the success rate of case resolution, further research needs to be carried out so that the results of this study can be recommended for resolution of similar cases.

2. Method and materials

Fuzzy Logic

Fuzzy logic is a form of logic that has many values where variable truth value can be a real number between 0 and 1. This logic is used to handle the concept of partial truth, where truth values can range between completely true and completely wrong. In contrast to Boolean logic, variable truth values can only be in the values of 0 and 1. Fuzzy logic has been applied to many fields, ranging from control theory to artificial intelligence.

Classical logic only allows true or false conclusions. However, there are also propositions with variable answers that might be found when asking a group of people to identify colors. In such a case, truth arises as a result of reasoning from inappropriate or partial knowledge where the sample answers are mapped on the spectrum.

Both levels of truth in classical and fuzzy logic and their probabilities range between 0 and 1 that may appear similar at first, but fuzzy logic uses the degree of truth as a mathematical model of obscurity while probability is a mathematical model of ignorance.

The basic application of fuzzy logic is characterized by a sub-range of continuous variables. For example, a temperature measurement for an anti-lock brake may have several split member functions that determine the specific temperature range needed to properly control the brakes. Each function maps the same temperature values to truth values in the range of 0 to 1. These truth values can then be used to determine how the brakes should be controlled.

The processes that exist in fuzzy logic are:

a. Converting all input values into fuzzy membership functions.
b. Running all the rules that apply in the base rule to calculate the fuzzy output function.
c. Re-converting the fuzzy output function to get the actual output value.

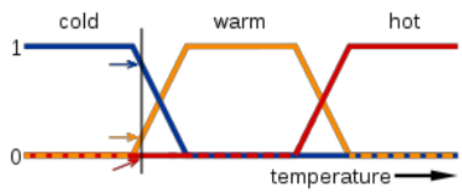

Figure 1. Fuzzy's logic for temperature

In Figure 2.1 above, the meaning of cold, warm and hot expressions is represented by a temperature scale mapping function. One point on the temperature scale has three truth values - one for each of the three functions. The vertical line in the image represents a certain temperature measured by the three arrows. Because the red arrow points to zero, this temperature can be interpreted as "not hot". The orange arrow (pointing at 0.2) can be described as "slightly warm" and the blue arrow (pointing 0.8) "cool enough".

[14].

SNI 03-6917-2000

A standardization of lighting energy conservation is needed prior to determining dynamic energy savings based on the characteristics and functions of the room in order that energy savings carried out still maintains the comfort of the users of the room. According to the SNI 03-6917-2000, the lighting standard is adjusted in accordance with the function of the room itself. The lighting that is much more widely used in buildings and rooms at the Pontianak State Polytechnic is an artificial one where the artificial lighting must meet the minimum lighting level as shown in table 1 below (adjustment is made with regard to the rooms at the Pontianak State Polytechnic).

Table 1. Recommended average lighting levels, rendering and color temperature.

Room Function	Lighting Level (Lux)	Color Rendering Group	Color Temperature		
			Warm white <3300 K	Cool white 3300K – 5300K	Daylight >5300K
Classroom	250	1 or 2		✓	✓
Library	300	1 or 2		✓	✓
Laboratory	500	1		✓	✓
Drawing Room	750	1		✓	✓
Cafeteria	200	1	✓	✓	
Director Room	350	1 or 2		✓	✓
Working Room	350	1 atau 2		✓	✓

3. Results

In Polnep, there are 5 engineering department and 3 non engineerng department, with the total of 21 program study. The engineering department was proved to used more electrical power rather than the engineering department as shown in the table 2 below.

Table 2. Load data of lighting buildings at Polnep

No	Location	Power (watt)
1	Administration Business Department Laboratory	1008
2	Plantation Processing Techniques Department	2406
3	Marine and Fischeries Science	1244
4	Electrical Engineering Laboratory	3664
5	Machine Engineering Workshop	11366

Therefore, in this research the data measurements were taken at one of the engineering department in Polnep, which is Electrical Engineering Department. In order to determine the dynamic energy conservation, there are some parameters to defined. The parameters are listed in the sub chapter below.

Room Specification and Characteristics

This research was conducted by taking 3 sample rooms, which are Electrical Engineering Library Department, Technician room of Electronic Laboratory, and Classroom 7 at IT Laboratory. The specification of the rooms are listed in the table 3 below.

Table 3. Characteristics of room sample

No.	Room Function	Room's size (m^2)	Number of lights
1	Electrical Engineering Library Department,	91	8
2	Technician room of Electronic Laboratory, and	91	8
3	Classroom 7 at IT Laboratory	60	13

Light Intensity Measurements

The measurements were taken in the sunny condition by applying 3 conditions of artificial lights. By applying this scenarios, the measurements were taken and the results is shown in the table 4 below:

Table 4. Light intensity measurements result

No	Room specification	Light condition	Light intensities (lux)
1	Electrical Engineering Library Department,	Sunny and the lights are turn off	32
		Sunny and the lights are partly turn off	63,5
		Sunny and the lights are all turn on	121,78
2	Technician room of Electronic Laboratory, and	Sunny and the lights are turn off	7
		Sunny and the lights are partly turn off	23,5
		Sunny and the lights are all turn on	90
3	Classroom 7 at IT Laboratory	Sunny and the lights are turn off	273
		Sunny and the lights are partly turn off	245
		Sunny and the lights are all turn on	557

The measurements above will be taken into account as the comparison of the simulation results of the fuzzy logic which will be explained in the section 4.

Fuzzy Logic Process

In order to process the data in fuzzy logic method, the steps to be taken are as follows:
- Determining membership value of Input variable and output variable
- Determining Crisp value
- Input value fuzzification
- Integrating fuzzy and servqual using Mamdani Method
- Defuzzification using Centroid method.

4. Discussion

Based on the room specification, the membership will be defined below.

Membership Input

The membership input of fuzzy logic in this research was obtained based on the linguistic variable and numeric variable used. In this article the membership function was determined by the room sizes, the amount of lights used, and electricity power used. The membership function are as follows:

- Room characteristics divided in 3 sets of variable which are Kecil with the size of room 0 – 10 m^2, Sedang with size of room 10 – 100 m^2, and Besar with the size of room > 100 m^2.
- The amount of lights used divided in 3 sets of variable which are Sedikit with 1 – 6 lights, Sedang with 6 – 10 lights, and Banyak with more than 10 lights.
- Elextricity power used divided in 2 sets of variable which are Kecil with electricity power range from 900 kWh – 2300 kWh and Besar with electricity power more than 2300 kWh.

The function of the variable sets to all three membership can be seen as follows:

1) Membership function set Kecil, Sedang, and Besar of room variable

$$\mu LuasKecil[x] = \begin{cases} 1 & ; x < 10 \\ \frac{(100-x)}{(90)} & ; 10 \le x \le 100 \\ 0 & ; x > 100 \end{cases}$$

$$\mu Luas\ Sedang[x] = \begin{cases} 0 & ; x \le 10\ atau\ x \ge 100 \\ \frac{(x)}{(50)} & ; 0 < x \le 50 \\ \frac{(100-x)}{(50)} & ; 50 \le x < 100 \end{cases}$$

$$\mu LuasBesar[x] \begin{cases} 0 & ; x \le 0 \\ \frac{(x)}{(100)} & ; 0 < x < 100 \\ 1 & ; x \ge 100 \end{cases}$$

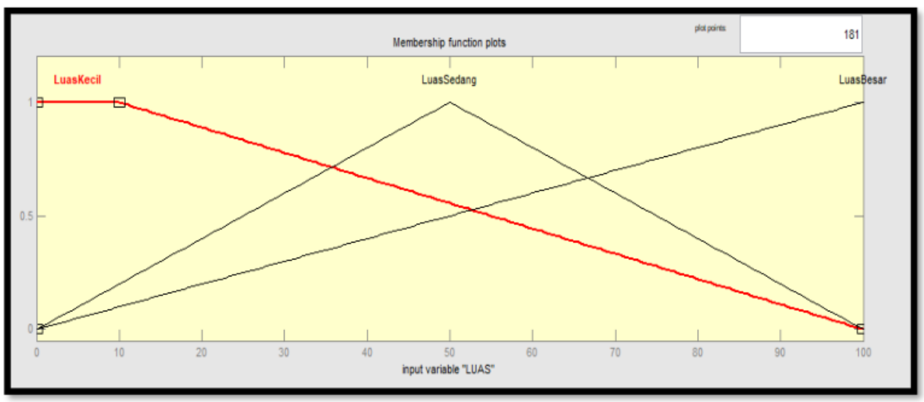

Figure 2. Membership function of room size

2) Membership function set Sedikit, Sedang, and Banyak of number of lights variable

$$\mu LampuSedikit[x] = \begin{cases} 1 & ; x < 6 \\ \frac{(6-x)}{(5)} & ; 1 \le x \le 6 \\ 0 & ; x > 6 \end{cases}$$

$$\mu LampuSedang[x] = \begin{cases} 0 & ; x \le 1\ atau\ x \ge 10 \\ \frac{(x-1)}{(5)} & ; 1 < x \le 6 \\ \frac{(10-x)}{(4)} & ; 6 \le x < 10 \end{cases}$$

$$\mu LampuBanyak[x]\begin{cases} 0 & ; x \leq 1 \\ \frac{(x)}{(10)} & ; 1 < x < 10 \\ 1 & ; x \geq 10 \end{cases}$$

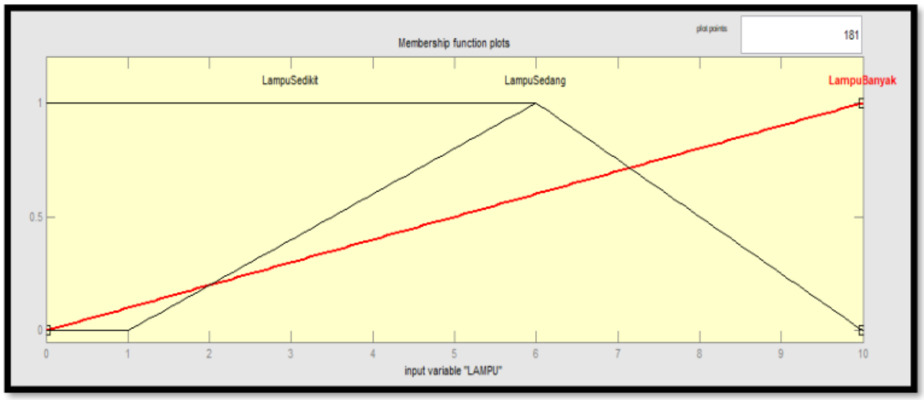

Fig. 3. Membership function of number of lights

3) Membership function set Kecil, and Besar of power variable.

$$\mu DayaKecil[x] = \begin{cases} 1 & ; x < 900 \\ \frac{(2300 - x)}{(1400)} & ; 900 \leq x \leq 2300 \\ 0 & ; x > 2300 \end{cases}$$

$$\mu DayaBesar[x]\begin{cases} 0 & ; x < 900 \\ \frac{(x)}{(1400)} & ; 900 < x < 2300 \\ 1 & ; x > 2300 \end{cases}$$

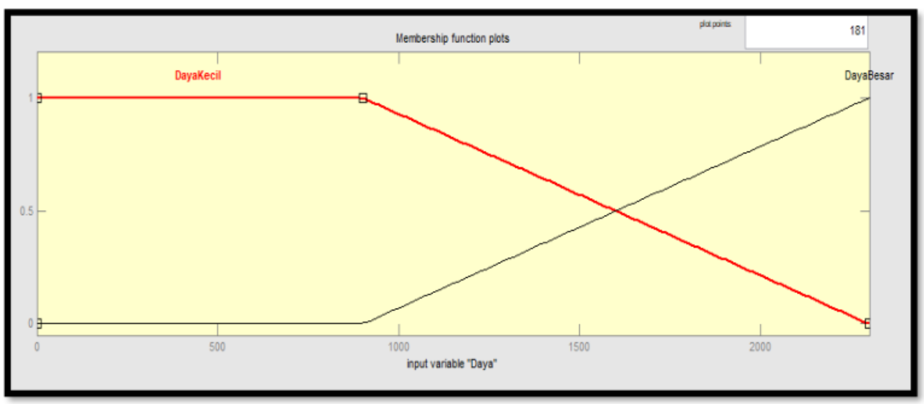

Fig. 4. Membership function of Power

Output Fuzzy Membership Function

The output fuzzy membership function is Lemah, Sedang, dan, Kuat of the variable LUX. Whereas Lemah is lux value below 250, Sedang is lux value from 250 to 500, while Kuat is lux value more than 500. This lux value were obtained from the data measurements taken in the three room samples as shown in table 4.

$$\mu LuxLemah[y] = \begin{cases} 1 & ; 0 \leq y \leq 250 \\ \frac{(500 - y)}{(250)} & ; 250 \leq y \leq 500 \\ 0 & ; y > 500 \end{cases}$$

$$\mu LuxSedang[y] = \begin{cases} 0 & ; y \leq 0 \; atau \; y \geq 500 \\ \frac{(y - 250)}{(250)} & ; 0 < y < 250 \\ \frac{(500 - y)}{(250)} & ; 250 < y < 500 \end{cases}$$

$$\mu LuxKuat[y] \begin{cases} 0 & ; y \leq 250 \\ \frac{(y - 250)}{(250)} & ; 250 < y < 500 \\ 1 & ; y \geq 500 \end{cases}$$

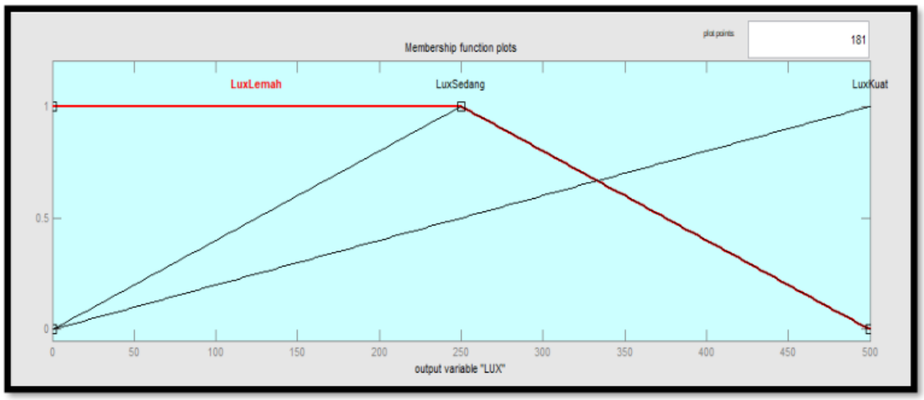

Fig. 5. Output membership function of LUX

Fuzzy Inference System

After determining the membership function of Input and Output, then the rules for the inference system was set. The inference that has been made can be seen in the table 5 below.

Table 5. Inference Fuzzy System

No.	Size	Lights	Power	LUX
1	Kecil	Banyak	Kecil	Kuat
2	Kecil	Banyak	Besar	Kuat
3	Kecil	Sedang	Kecil	Sedang
4	Kecil	Sedang	Besar	Sedang
5	Kecil	Sedikit	Kecil	Lemah
6	Kecil	Sedikit	Besar	Lemah
7	Besar	Banyak	Kecil	Kuat
8	Besar	Banyak	Besar	Kuat
9	Sedang	Banyak	Kecil	Kuat
10	Sedang	Banyak	Besar	Kuat
11	Sedang	Sedang	Kecil	Sedang
12	Sedang	Sedang	Besar	Sedang
13	Besar	Sedikit	Kecil	Lemah

14	Besar	Sedikit	Besar	Lemah
15	Besar	Sedang	Kecil	Sedang
16	Besar	Sedang	Besar	Sedang
17	Sedang	Sedikit	Kecil	Lemah
18	Sedang	Sedikit	Besar	Lemah

With the complete display of the FIS editor on Fuzzy Logic as shown in the figure 6 below.

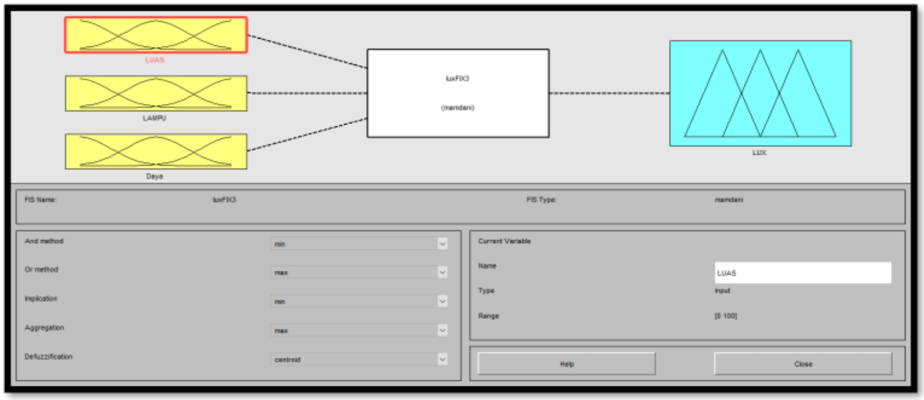

Fig. 6. Complete Fuzzy Inference System editor on fuzzy logic

Defuzzification

In this research, the defuzzification method that was used is Centroid method by taken the value of fuzzy domain. With the input of room size = 62 m^2, number of lights = 9, and Power = 900 watt, then the output of lux is = 309.

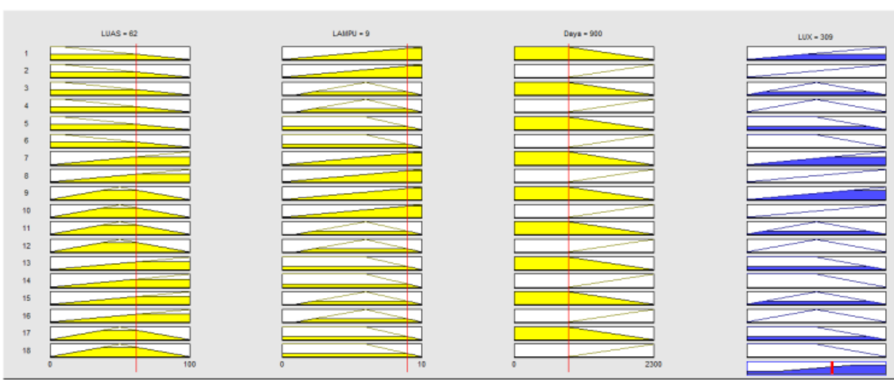

Fig. 7. Defuzzification example

Simulation results

By using matlab the simulation results were obtained which is shown in the table 6 below.

Table 6. Simulation result with Lux output

No.	Room Name	LUX	LUX Measurements result	Lux Standardization

1	Electrical Engineering Department Library	278	121	300
2	Electronic Laboratory Technician Room	277	90	350
3	Classroom 7 IT Laboratory	328	557	250

Analysis

Based on the measurement data and the Energy conservation standard on lux we obtain:

- Library : Lux = 278 → $\frac{278-250}{250} = 0.11$
- Technician room : Lux = 277 → $\frac{277-250}{250} = 0.10$
- Classroom IT 7 : Lux = 328 → $\frac{328-250}{250} = 0.31$

With fuzzy it is obtained that the value of output membership for Lux Kuat for library = 0.11, Technician room = 0.10, and Classroom IT 7 = 0.31 with the scale of 0 – 1. With 0 is the value of the minimum and 1 is the maximum value of the fuzzy membership. It can be seen between the 3 rooms that classroom It 7 is the room with better lighting, hence better lux value.

5. Conclusion

Analysis in determining lux can be used with fuzzy logic based on room size, number of lights and electrical power. Lux can be obtained by 3 values, namely Lemah, Sedang, and Kuat. With these 3 values, the value of fuzzy membership can be seen. From the test results it is known that the lux value obtained for the library is 278. As for the technician room, the lux value of the test result is 277, and the TI-7 lab classroom has a lux value of 328.

6. Acknowledgments

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