

## Comparative Analysis of Fuzzy Mamdani Method and Fuzzy Sugeno Method in Predicting Household Electricity Consumption Costs

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### Abstract

Electricity has become an essential part of our daily lives. As technology has rapidly developed, many modern activities and devices have become highly dependent on electricity. The more electricity that is used, the higher the monthly cost. This cost is influenced by usage patterns and various uncertain factors. Fuzzy logic is one approach that can be used in decision support systems in the face of uncertainty like this. This study aims to apply the Mamdani and Sugeno fuzzy methods based on house building area, number of electronic devices, number of family members, and income to determine which method more accurately predicts household electricity consumption costs based on the mean absolute percentage error (MAPE) value. Data for this study were obtained through questionnaires and interviews with residents of Margorejo Village. Data processing yielded a MAPE value of 12.3% for the Mamdani method and a MAPE value of 9.9% for the Sugeno method. Based on these results, the MAPE value for the Sugeno method is smaller than that for the Mamdani method. Therefore, it can be concluded that the Sugeno method is more accurate for predicting household electricity consumption costs in Margorejo Village.

**Keywords:** Mamdani method; Sugeno method; MAPE.

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## 1. INTRODUCTION

Electricity is a major necessity in people's lives, used by businesses, institutions, and the general public to carry out various activities. Almost all equipment, from households to transportation, depends on electrical energy, so its availability is very important every day [1]. Electricity demand increases with population and economic growth, affecting the amount of electricity that must be produced to meet demand [2]. Kabupaten Pati, located in the eastern part of Central Java, has an area of 150,368 hectares. Based on topographic data, most of the area is in the lowlands with an altitude of 0-100 meters above sea level, covering approximately 100,769 hectares [3]. Pati Regency is experiencing rapid economic growth that has a positive impact on the industrial and electricity sectors. PT PLN UP3 Kudus recorded a 5.76% increase in electricity sales in this region, a figure that is relatively high compared to other districts in Central Java.

The cost of electricity consumption is influenced by several factors, such as house size, electrical power, number of electronic devices, family members, and income level. By understanding these factors, a mathematical approach can be used to estimate monthly electricity costs more accurately. Mathematics is a method of logical thinking with various branches, such as statistics, algebra, and analysis. One important concept in mathematical logic is fuzzy logic, which is used to address ambiguity and uncertainty in real systems. This concept is very relevant in everyday life because many problems involve uncertainty [4].

Household electricity cost prediction is a fuzzy problem because it involves uncertainty and nonlinear relationships between various factors, such as house size, number of electronic devices,

number of family members, and income. For example, a large house generally requires more electricity, but a small house may consume more electricity depending on its efficiency. Differences in power and usage patterns of electronic devices, electricity needs of each family member, and lifestyle based on income also add to the complexity. Each factor affects electricity consumption [5].

Fuzzy logic, which is based on fuzzy set theory, has various applications in everyday life such as prediction of scholarship candidates, optimization of drug demand, and scheduling of lectures. One of its applications is as a decision support system to predict electricity usage costs. In its calculation, fuzzy logic can use several methods, including the Mamdani, Sugeno, and Tsukamoto methods, each of which has a different approach and calculation results. tion differently, creating uncertainty in the calculation [6]. The Mamdani fuzzy method, introduced by Ebrahim Mamdani in 1975, is popular for its ability to handle uncertainty and is easy to understand. This method consists of four main processes to produce the output and is often completed using Matlab software, which provides various tools for the Mamdani method. Meanwhile, the Sugeno fuzzy method, introduced by Takagi-Sugeno Kang in 1985, has many similarities with Mamdani but differs in the form of output. The Sugeno method produces output in the form of constants or linear equations, while Mamdani produces output in the form of fuzzy sets. Matlab also provides special tools for the application of the Sugeno method.

There have been many studies conducted related to efforts to predict electricity usage, including by Aenun [2], Santosa [7], and Haryanto [8]. In addition, research using the Mamdani method fuzzy logic has been carried out by Yudhistira et al., [9], Tundo & Mahyuzar [10], Nurhayati et al., [11]. Research using fuzzy logic Sugeno method has also been widely done, including by Pasaribu & Rozy [12], Simanjuntak [13], Hafiz & Sriani [14]. Based on research conducted by Aenun and Mashuri [2] using the Mamdani fuzzy method with 4 input variables, namely house area, electrical power, electronic devices, and economic income, and the help of Matlab software, the results show that the Mamdani method is well used to predict electricity usage costs. Then, based on Santosa's research [7] using the Sugeno fuzzy method with 1 input variable, namely power usage, the results show that the Sugeno fuzzy method allows the calculation of electricity tariffs with a better level of smoothness and provides results that are considered fairer by consumers.

Based on the description above, the researcher intends to conduct research on the comparison between the Mamdani fuzzy method and the Sugeno fuzzy method in predicting electricity consumption costs with the title "Comparative Analysis of the Mamdani Fuzzy Method and the Sugeno Fuzzy Method in Predicting Household Electricity Consumption Costs."

## 2. METHODS

This research method includes literature study, problem formulation and solving, and conclusion drawing. Prior to problem solving, data was collected through questionnaires and interviews in RT 002, Margorejo Village. The number of samples taken for this study was 50 respondents, where 10 respondents were obtained through interviews and 40 respondents were obtained through questionnaires. The respondents interviewed came from communities with different occupational segments, and therefore had varying levels of income. In addition, the respondents also had varying household characteristics, including house size, number of electronic devices, and number of family members, which were relevant to the research objectives. The data collected included building area (m<sup>2</sup>), number of electronic devices (unit), number of family members (person), income (Rupiah), and monthly electricity consumption costs (Rupiah).

This research uses four variables input, namely the input of building area, number of electronic devices, number of family members, and income and the output of electricity consumption costs. The cost prediction is done using Mamdani and Sugeno fuzzy methods with the help of Matlab R2014a software.

### 2.1. Mamdani Method

In this research, the method applied is the Mamdani method, which was introduced by Ebrahim Mamdani in 1975 and is also known as the Max-Min method. To obtain the output of this method, there are 4 stages of the process that must be completed, namely:

1. Fuzzification is the process of transforming input from a firm set (crisp) into a fuzzy set [15]. This stage determines the fuzzy set of each input and output variable using a membership function.
2. Implication Function Application. In the Mamdani method, the implication function used is min. The basic rules formed are 81 rules based on each input variable.
3. Rule Composition, in the Mamdani fuzzy method the inference process is carried out using the max method.
4. Defuzzification, in the Mamdani method using the centroid method, with the following formula

$$z^* = \frac{\int_z \mu(z) z \, dz}{\int_z \mu(z) \, dz} \quad (1)$$

where  $z$  is represents the  $i$ -th domain value,  $\mu(z)$  is indicates the degree of membership at that point and  $z^*$  is the result of defuzzification.

### 2.2. Sugeno Method

This research uses the zero-order Sugeno method with the help of Matlab R2014a software with the following stages:

1. Fuzzification. This stage determines the fuzzy set of each input and output variable using the membership function.
2. Implication function application. Fuzzy rules in the Sugeno fuzzy method are the same as the Mamdani method which is formed by 81 rules.
3. Rule Composition, in the Sugeno fuzzy method the inference process is carried out using the max method.
4. Defuzzification, the Sugeno method uses the weighted average method.

After the calculations are carried out using the Mamdani and Sugeno fuzzy methods manually and with the help of Matlab R2014a software, the next step is to calculate the mean absolute percentage error (MAPE) value. The use of mean absolute percentage error (MAPE) in evaluating forecasting results can see the level of accuracy of forecasting figures and realization figures [16]. The MAPE value can be calculated using the following formula:

$$MAPE = \frac{\sum_{i=1}^n \left| \frac{X_i - F_i}{X_i} \right|}{n} \times 100\% \quad (2)$$

with:

$X_i$  = the original data value of the  $i$ -th observation

$F_i$  = the forecast value of the  $i$ -th observation

$n$  = the amount of data

The accuracy level of the forecasting results can be categorized based on the MAPE value which can be seen in more detail in the following Table 1.

**Table 1.** MAPE value evaluation

MAPE (%)	Interpretation
<10	Very accurate prediction
10 – 20	Good prediction
20 – 50	Reasonable prediction
>50	Inaccurate prediction

The final step of the research is to draw conclusions based on the lowest MAPE value to determine the most accurate method.

### 3. RESULTS AND DISCUSSION

In this study, the input variables used are the size of the house, the number of electronic devices, the number of family members, and income, with the output being the cost of electricity consumption. Fuzzy sets have a domain of values in the universe of discourse. Generally, this domain is determined using an expert system, which is a system that stores and applies expert knowledge to provide solutions. However, in this study, the determination of the domain of each fuzzy set was carried out directly by the researcher [17]. The fuzzy set of each variable is formed based on the data obtained as shown in Table 2.

**Table 2.** Fuzzy set of research variable

Function	Variable Name	Fuzzy Set	Universe of Discourse	Domain
Input	House Building Area	STANDARD	[42, 330]	[42, 100]
		MEDIUM		[80, 180]
		LARGE		[150, 330]
	Number of Electronic Devices	FEW	[1, 21]	[1, 8]
		NORMAL		[6, 15]
		MANY		[13, 21]
	Number of Family	FEW	[2, 8]	[2, 4]
		NORMAL		[3, 6]
		MANY		[5, 8]
	Income	LOW	[2, 10]	[2, 5]
		MEDIUM		[4, 8]
		HIGH		[7, 10]
Output	Electricity Cost	LOW	[40, 1000]	[40, 300]
		MEDIUM		[250, 700]
		HIGH		[600, 1000]

#### 3.1. Application of Mamdani Fuzzy Method

The calculation will use data from the 14th respondent with a house building area of  $104 m^2$ , the number of electronic devices used is 12 units, with a family of 2 people, and a monthly income of Rp9,000,000.

##### 1) Fuzzification

- a. The variable Area of House Building, with a universe of speech [42, 330] is divided into three fuzzy sets, namely STANDARD, MEDIUM, and LARGE. Membership functions are represented with linear and triangular curves (presented in Figure 1) and are formulated as follows:

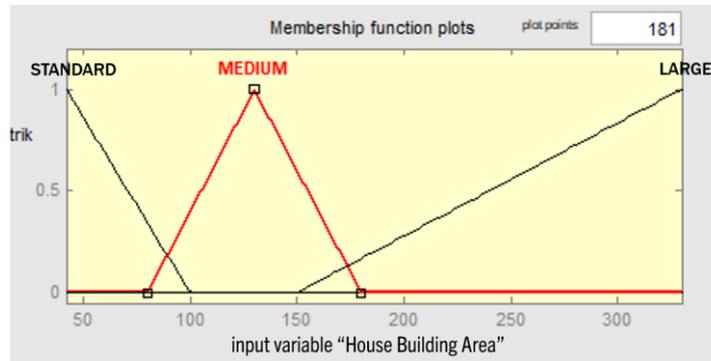


Figure 1. Membership function of house building area

$$\mu_{lbrSTANDARD}(a) = \begin{cases} 1, & a \leq 42 \\ \frac{100 - a}{100 - 42}, & 42 \leq a \leq 100 \\ 0, & a \geq 100 \end{cases}$$

$$\mu_{lbrMEDIUM}(a) = \begin{cases} 0, & a \leq 80 \text{ or } a \geq 180 \\ \frac{a - 80}{130 - 80}, & 80 \leq a \leq 130 \\ \frac{180 - a}{180 - 130}, & 130 \leq a \leq 180 \end{cases}$$

$$\mu_{lbrLARGE}(a) = \begin{cases} 0, & a \leq 150 \\ \frac{a - 150}{330 - 150}, & 150 \leq a \leq 330 \\ 1, & a \geq 330 \end{cases}$$

Because the house building area of 104 m<sup>2</sup> is located in the MEDIUM category, the following membership values are obtained:

$$\mu_{MEDIUM}(104) = \frac{a - 80}{130 - 80} = \frac{104 - 80}{50} = \frac{24}{50} = 0.48$$

- b. The variable Number of Electronic Devices, with a universe of speech [1, 21] is divided into three fuzzy sets namely FEW, NORMAL, and MANY. The membership functions are represented with linear and triangular curves (presented in Figure 2) and are formulated as follows:

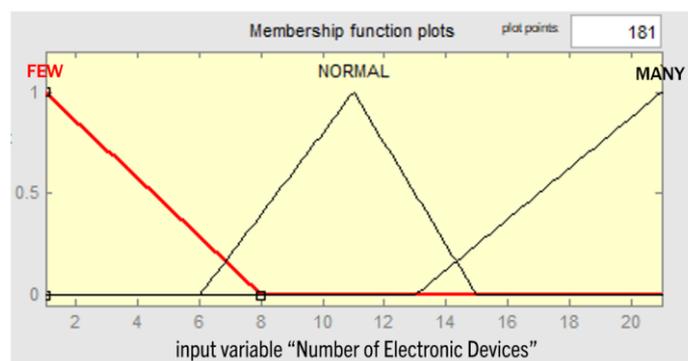


Figure 2. Membership function number of electronic devices

$$\mu_{jpeFEW}(b) = \begin{cases} 1, & b \leq 1 \\ \frac{8 - b}{8 - 1}, & 1 \leq b \leq 8 \\ 0, & b \geq 8 \end{cases}$$

$$\mu_{jpeNORMAL}(b) = \begin{cases} 0, & b \leq 6 \text{ atau } b \geq 15 \\ \frac{b-6}{11-6}, & 6 \leq b \leq 11 \\ \frac{15-b}{15-11}, & 11 \leq b \leq 15 \end{cases}$$

$$\mu_{jpeMANY}(b) = \begin{cases} 0, & b \leq 13 \\ \frac{b-13}{21-13}, & 13 \leq b \leq 21 \\ 1, & b \geq 21 \end{cases}$$

Because the number of electronic devices owned is 12 units, it is located in the NORMAL category, so the membership value is obtained as follows:

$$\mu_{NORMAL}(12) = \frac{15-b}{15-11} = \frac{15-12}{4} = \frac{3}{4} = 0.75$$

- c. The variable Number of Family Members, with a universe of speech [2, 8] is divided into three fuzzy sets namely LITTLE, NORMAL, and LOTS. Membership functions are represented with linear and triangular curves (presented in Figure 3) and are formulated as follows:

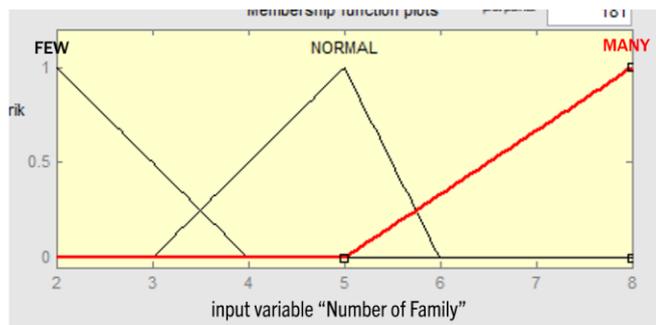


Figure 3. Membership function number of family

$$\mu_{jakFEW}(c) = \begin{cases} 1, & c \leq 2 \\ \frac{4-c}{4-2}, & 2 \leq c \leq 4 \\ 0, & c \geq 4 \end{cases}$$

$$\mu_{jakNORMAL}(c) = \begin{cases} 0, & c \leq 3 \text{ or } c \geq 6 \\ \frac{c-3}{4-3}, & 3 \leq c \leq 4 \\ \frac{6-c}{6-4}, & 4 \leq c \leq 6 \end{cases}$$

$$\mu_{jakMANY}(c) = \begin{cases} 0, & c \leq 5 \\ \frac{c-5}{8-5}, & 5 \leq c \leq 8 \\ 1, & c \geq 8 \end{cases}$$

Because the number of family members is 2 people, it is located in the FEW category, so the membership value is obtained as follows:

$$\mu_{FEW}(2) = \frac{4-c}{4-2} = \frac{4-2}{2} = \frac{2}{2} = 1$$

- d. The income variable with the universe of speech [2, 10] is divided into three fuzzy sets, namely LOW, MEDIUM, and HIGH. The following is the membership function for the income variable which is formulated as follows and presented in Figure 4.

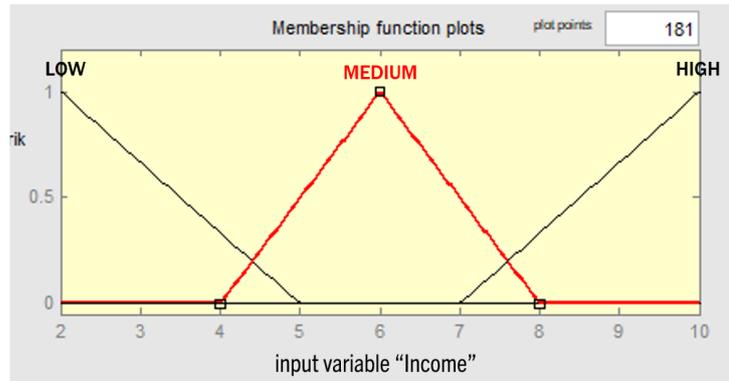


Figure 4. Membership function income

$$\mu_{pLOW}(d) = \begin{cases} 1, & d \leq 2 \\ \frac{5-d}{5-2}, & 2 \leq d \leq 5 \\ 0, & d \geq 5 \end{cases} \quad \mu_{pMEDIUM}(d) = \begin{cases} 0, & d \leq 4 \text{ or } d \geq 8 \\ \frac{d-4}{6-4}, & 4 \leq d \leq 6 \\ \frac{8-d}{8-6}, & 6 \leq d \leq 8 \end{cases}$$

$$\mu_{pHIGH}(d) = \begin{cases} 0, & d \leq 7 \\ \frac{d-7}{10-7}, & 7 \leq d \leq 10 \\ 1, & d \geq 10 \end{cases}$$

Because his monthly income is Rp9,000,000, it is located in the HIGH category, so the membership value is obtained as follows:

$$\mu_{HIGH}(9) = \frac{d-7}{10-7} = \frac{9-7}{3} = \frac{2}{3} = 0.67$$

- e. Electricity consumption cost variable  
 In the electricity consumption cost variable with the universe of speech [40, 1000], it is divided into three fuzzy sets, namely LOW, MEDIUM, and HIGH. The following is the membership function for the variable cost of electricity consumption which is formulated as follows and presented in Figure 5.

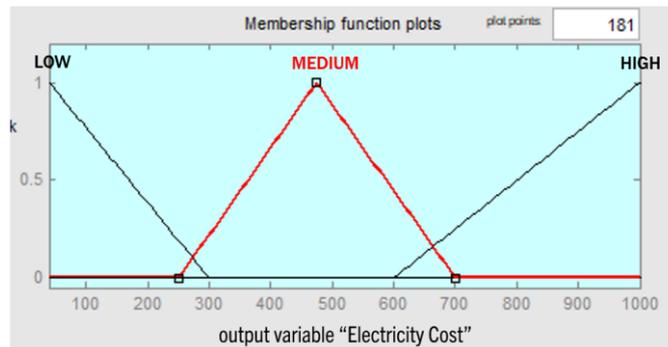


Figure 5. Membership function of electricity consumption cost

$$\mu_{bklLOW}(e) = \begin{cases} 1, e \leq 40 \\ \frac{300 - e}{300 - 40}, 40 \leq e \leq 300, \\ 0, e \geq 300 \end{cases}, \quad \mu_{bklMEDIUM}(e) = \begin{cases} 0, e \leq 250 \text{ or } e \geq 700 \\ \frac{e - 250}{475 - 250}, 250 \leq e \leq 475 \\ \frac{700 - e}{700 - 475}, 475 \leq e \leq 700 \end{cases}$$

$$\mu_{bklHIGH}(e) = \begin{cases} 0, e \leq 600 \\ \frac{e - 600}{1000 - 600}, 600 \leq e \leq 1000 \\ 1, e \geq 1000 \end{cases}$$

2) Application of Implication Function

Based on the fuzzy set of each input variable, 81 fuzzy rules are formed, as shown in Table 3.

**Table 3.** Rules fuzzy

Rules <i>Fuzzy</i>	House Building Area	Number of Electronic Devices	Number of Family	Income	Electricity Cost
[R1]	STANDARD	FEW	FEW	LOW	LOW
[R2]	STANDARD	FEW	FEW	MEDIUM	LOW
[R3]	STANDARD	FEW	FEW	TINGGI	LOW
[R4]	STANDARD	FEW	NORMAL	LOW	LOW
[R5]	STANDARD	FEW	NORMAL	MEDIUM	LOW
[R6]	STANDARD	FEW	NORMAL	HIGH	MEDIUM
[R7]	STANDARD	FEW	MANY	LOW	LOW
[R8]	STANDARD	FEW	MANY	MEDIUM	MEDIUM
[R9]	STANDARD	FEW	MANY	HIGH	MEDIUM

Based on all the rules that have been established, there is one matching rule:

[R39] If the house area is MEDIUM and the number of electronic devices is NORMAL and the number of family members is FEW and the income is HIGH, then the electricity consumption cost is MEDIUM.

$$\begin{aligned} \mu_{R[39]} &= \mu_{lbrMEDIUM}[x] \cap \mu_{jpeNORMAL}[x] \cap \mu_{jakFEW}[x] \cap \mu_{pHIGH}[x] \\ &= \min(\mu_{lbrMEDIUM}[104], \mu_{jpeNORMAL}[12], \mu_{jakFEW}[2], \mu_{pHIGH}[9]) \\ &= \min(0.48; 0.75; 1; 0.67) = 0.48 \end{aligned}$$

3) Rule Composition

At the rule composition stage using the MAX method to combine the results of rule composition. Next, determine the cut-off point of the rule when  $\mu_{bklMEDIUM} = 0.48$  as follows:

a. Intersection point 1

$$\begin{aligned} \frac{t_1 - 250}{475 - 250} &= 0.48 \\ \Leftrightarrow t_1 - 250 &= 0.48(225) \\ \Leftrightarrow t_1 - 250 &= 108 \\ \Leftrightarrow t_1 &= 108 + 250 \\ \Leftrightarrow t_1 &= 358 \end{aligned}$$

b. Intersection point 2

$$\begin{aligned} \frac{700 - t_2}{700 - 475} &= 0.48 \\ \Leftrightarrow 700 - t_2 &= 0.48(225) \\ \Leftrightarrow 700 - t_2 &= 108 \\ \Leftrightarrow 700 - 108 &= t_2 \\ \Leftrightarrow 592 &= t_2 \end{aligned}$$

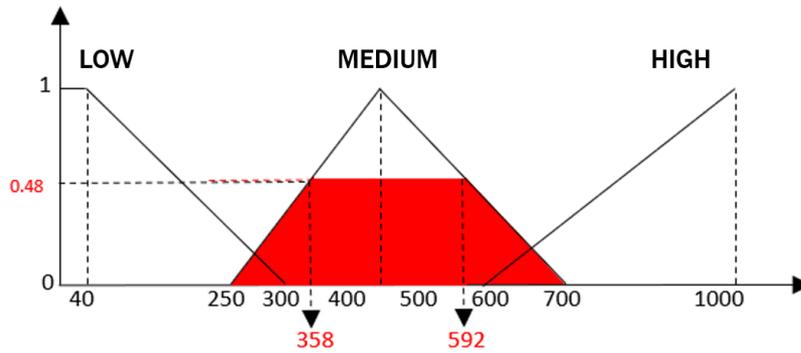


Figure 6. The result of rule composition

So that the new fuzzy solution region is obtained as shown in Figure 6 with its new membership function as follows:

$$\mu_{bkl}[z] = \begin{cases} \frac{z - 250}{475 - 250}; & 250 \leq z \leq 358 \\ 0.48; & 358 \leq z \leq 592 \\ \frac{700 - z}{700 - 475}; & 592 \leq z \leq 700 \end{cases}$$

4) Defuzzification

Determine the moment value:

$$M_1 = \int_{250}^{358} \frac{z-250}{475-250} z dz = 8346.24$$

$$M_2 = \int_{358}^{592} (0.48) z dz = 53352$$

$$M_3 = \int_{592}^{700} \frac{700-z}{700-475} z dz = 16277.76$$

Determine the area:

$$A_1 = \int_{250}^{358} \frac{z-250}{475-250} dz = 25.92$$

$$A_2 = \int_{358}^{592} (0.48) dz = 112.32$$

$$A_3 = \int_{592}^{700} \frac{700-z}{700-475} dz = 25.92$$

Thus, the center point of the fuzzy region is obtained as follows:

$$z = \frac{\int_z \mu(z) z dz}{\int_z \mu(z) dz} = \frac{M_1 + M_2 + M_3}{A_1 + A_2 + A_3} = \frac{8346.24 + 53352 + 16277.76}{25.92 + 112.32 + 25.92} = 475$$

Through manual calculations using the Mamdani method, the predicted cost of electricity consumption that must be paid is Rp475,000.

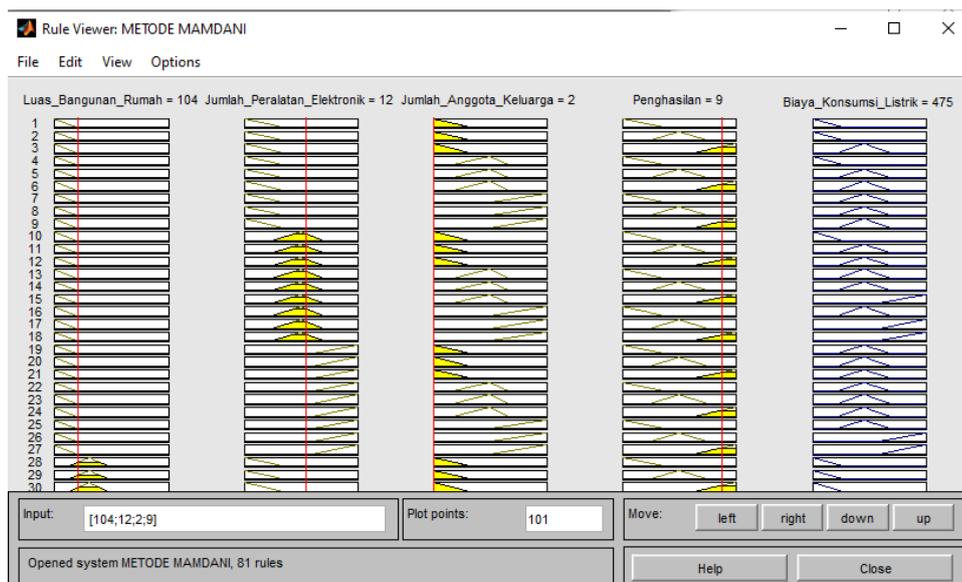


Figure 7. The result of defuzzification mamdani method

Meanwhile, using the help of fuzzy Matlab software calculation of the Mamadani method (presented in Figure 7), the predicted cost of electricity consumption that must be paid is Rp475,000.

### 3.2. Application of Sugeno Fuzzy Method

#### 1) Fuzzification

While the Sugeno method is generally similar to the Mamdani method, the difference lies in the output. In Sugeno method, the output is a constant without complex defuzzification process. Based on Figure 8, electricity consumption costs are categorized into LOW (148), MEDIUM (470), and HIGH (850) which are obtained based on the average output value of each category.

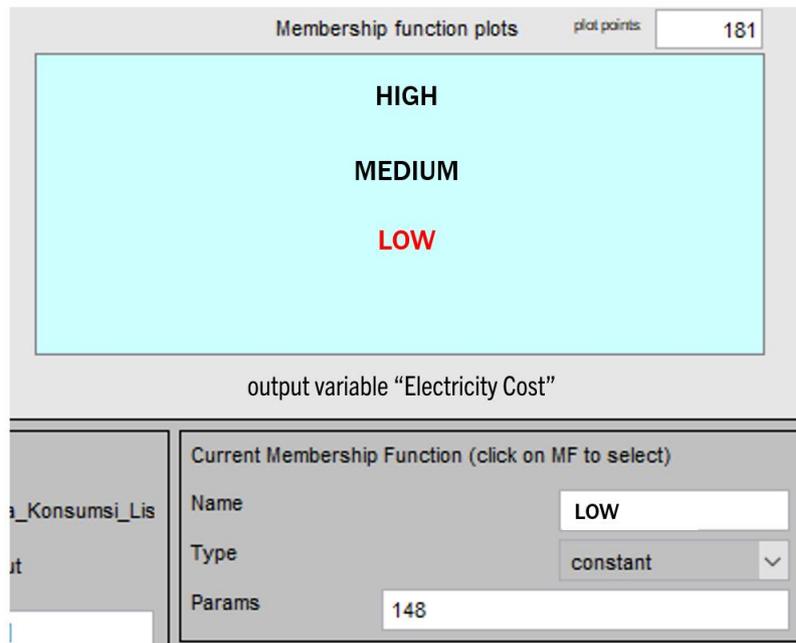


Figure 8. Membership function of electricity consumption cost sugeno method

2) Application of Implication Function, the Sugeno method uses the same basic fuzzy rules as the Mamdani method. The rules used are presented in Table 3.

#### 3) Rule Composition

[R39] If the house area is MEDIUM and the number of electronic devices is NORMAL and the number of family members is FEW and the income is HIGH, then the electricity consumption cost is MEDIUM.

$$\begin{aligned} \mu_{R[39]} &= \mu_{lbrMEDIUM}[x] \cap \mu_{jpeNORMAL}[x] \cap \mu_{jakFEW}[x] \cap \mu_{pHIGH}[x] \\ &= \min(\mu_{lbrMEDIUM}[104], \mu_{jpeNORMAL}[12], \mu_{jakFEW}[2], \mu_{pHIGH}[9]) \\ &= \min(0.48; 0.75; 1; 0.67) = 0.48 \end{aligned}$$

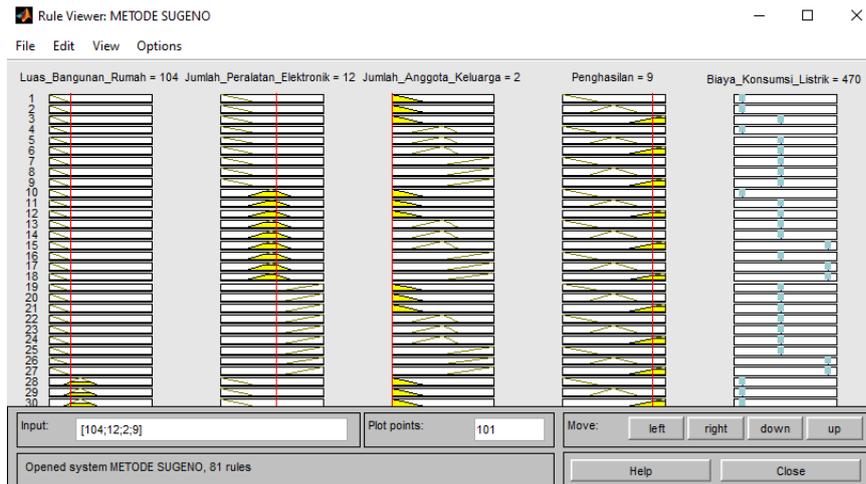
Value  $z_{39} = 470$  (obtained from the average output value in the MEDIUM category)

#### 4) Defuzzification

Defuzzification, the Sugeno method used is the weighted average method, which can be obtained as follows:

$$z = \frac{(\alpha - pred39 * z_{39})}{\alpha - pred39} = \frac{0.48 \times 470}{0.48} = 470$$

Through manual calculations using the Sugeno method, the predicted cost of electricity consumption that must be paid is Rp470,000.



**Figure 9.** The result of defuzzification mamdani method

Meanwhile, using the help of fuzzy Matlab software calculation of the Sugeno method (presented in Figure 9), the predicted cost of electricity consumption that must be paid is Rp470,000.

### 3.3. Comparison of MAPE Values

MAPE calculation using the Mamdani method.

$$\begin{aligned}
 MAPE &= \frac{\sum_{i=1}^{50} \left| \frac{X_i - F_i}{X_i} \right|}{50} \times 100\% \\
 &= \frac{615.2868347}{50} \times 100\% \\
 &= 12.306\% \approx 12.3\%
 \end{aligned}$$

MAPE calculation using the Sugeno method.

$$\begin{aligned}
 MAPE &= \frac{\sum_{i=1}^{50} \left| \frac{X_i - F_i}{X_i} \right|}{50} \times 100\% \\
 &= \frac{494.7964708}{50} \times 100\% \\
 &= 9.895\% \approx 9.9\%
 \end{aligned}$$

Based on the results of the calculations that have been carried out, the MAPE value of each method is obtained. In the Mamdani method, the MAPE value is 12.3%, which means that the accuracy level is 87.7%. This shows that the Mamdani method is well used to predict electricity consumption costs. Meanwhile, the Sugeno method obtained a MAPE value of 9.9% which means a accuracy level of 90.1% is obtained. Thus, the Sugeno method is proven to provide more accurate prediction results than the Mamdani method. The accuracy results are presented in the following Table 4.

**Table 4.** MAPE value accuracy result

Calculation Method	MAPE Result	Interpretation
Mamdani Method	12.3%	Good forecasting
Sugeno Method	9.9%	Highly accurate forecasting

### 3.4. Comparison of Results

Comparison of the results of the Mamdani method with the Sugeno method is presented in Table 5.

**Table 5.** Comparison of MAPE results

Respondent To-	Actual Data (Rupiah)	Mamdani Method Calculation (Rupiah)	Sugeno Method Calculation (Rupiah)
1	147,000	155,000	148,000
2	465,000	438,000	470,000
3	150,000	155,000	148,000
4	350,000	384,000	341,000
5	455,000	475,000	470,000
6	600,000	582,000	597,000
7	185,000	142,000	148,000
8	465,000	475,000	470,000
9	600,000	582,000	597,000
10	460,000	475,000	470,000
⋮	⋮	⋮	⋮
46	850,000	826,000	850,000
47	135,000	155,000	148,000
48	40,000	151,000	148,000
49	465,000	475,000	470,000
50	470,000	475,000	470,000

## 4. CONCLUSION

Based on the results of research on the application of fuzzy logic Mamdani and Sugeno methods in predicting electricity consumption costs in Margorejo Village, Pati Regency, it is concluded that both methods can be used effectively with inputs in the form of house building area, number of electronic devices, number of family members, and income. The Mamdani method involves the fuzzification process, implication function application using the min operator, rule composition with the max method, and defuzzification using the centroid method, resulting in 81 fuzzy rules. Meanwhile, the Sugeno method uses a zero-order model with the output being a constant, defuzzification is done through weighted average. The accuracy comparison results indicate that the Sugeno method achieves a lower MAPE value of 9.9% compared to the Mamdani method, which records a MAPE of 12.3%, suggesting that the Sugeno method provides better predictive performance within the scope of this study. Therefore, the Sugeno method provides more accurate predictions. However, this study has several limitations: (1) the dataset is limited to a single village, which may affect the generalizability of the results; (2) the number of input variables is restricted and does not account for factors such as electricity tariff classes or usage behavior; and (3) the Sugeno model used is limited to a zero-order structure. The suggestions for further research are to add other relevant input variables, try other fuzzy methods as a comparison, and develop a prediction system in the form of mobile or web applications for ease of use.

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