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Forecasting of Electrical Energy Consumption in Aceh 2028 Using the Adaptive Neuro Fuzzy Inference System

Muzammil Jusoh[1], Christin Erniati Panjaitan[2], Vito Sentosa[3]
[1]Advance Communication Engineering (ACE) Centre of Excellence, Faculty of Electronic Engineering Technology, Universiti Malaysia Perlis, Perlis, Malaysia
[2,3]Department of Electrical Engineering, Faculty of Technology and Computer Science, University of Prima Indonesia, Medan, Indonesia

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ABSTRACT

Electricity consumption in Aceh is increasing from year to year. Factors causing increased electricity consumption in Aceh are Population Growth, and Economy. To meet the need for electricity consumption which is increasing from year to year, then it is forecast that the long-term consumption of electrical energy for 10 years is in 2028 in Aceh. To estimate the consumption of electrical energy requires a method that can approach the original results. The method is the Adaptive Neuro Fuzzy Inference System Method. The results obtained in estimating electricity consumption in 2028 in Aceh using this method amounted to 5578,02 GWh or with an increase of 2,07% every year until 2028.

Corresponding Author:

Muzammil Jusoh
Advance Communication Engineering (ACE) Centre of Excellence, Faculty of Electronic Engineering Technology, Universiti Malaysia Perlis, Perlis, Malaysia
Kampus Alam UniMAP, Pauh Putra, 02600, Arau Perlis, Malaysia
Email: muzammil@unimap.edu.my

1. INTRODUCTION

Along with increasing population growth, and economic growth, the need for electrical energy will continue to increase from year to year. This is in line with the activities of people's lives that depend on the availability of electrical energy supplies. Therefore, it is necessary to provide a sufficient and reliable supply of electrical energy at an affordable price for the needs of the community.

At this time electrical energy has become a primary need for modern human life to carry out social and economic activities to achieve a better standard of living. So that the level of use of electrical energy can also be considered as a measure of the level of income and prosperity for a country or region. Furthermore, judging from the role of electricity in the economy, the electricity industry is included in the upstream industry, so that its development can stimulate other sectors that use electrical energy as input [1].

The population has a positive relationship to electricity consumption. The impact of the population on electricity consumption is statistically significant. This indicates that, with increasing population, the consumption of electrical energy will increase [2]. Aceh's population growth from year to year has increased. With this population growth, it can affect the consumption of electrical energy in Aceh.

Economic growth has a positive relationship with electricity consumption which is statistically significant. This indicates that with increasing economic growth, it will increase the consumption of electrical

energy [2]. Economic growth in Aceh from year to year has increased. With this economic growth, it can affect the consumption of electrical energy in Aceh. This economic growth can be seen from the 2010 Gross Regional Domestic Product HK Aceh Province.

To meet these needs, we must know the need for electrical energy in the next few years. By making a demand forecast for electrical energy. Estimating the need for electrical energy is the first step in planning the growth of the electrical system. In making an estimate of the need for electrical energy, it is better to use a method that produces *output* that is closer to the results in realization, and can be accounted for. The result of an estimate that is too low (*under estimate*) will result in rotating blackouts and insufficient electricity supply for the needs of people's lives. And if the estimation results are too high (*over estimate*) it will result in too large an investment and can harm the company [3].

Therefore, the estimation of the need for electrical energy has a very important and fundamental role in formulating a plan for the development of an electricity system in an area or region. To support this, it is necessary to choose an appropriate and easy method in carrying out the calculations.

Based on the description above, in this study, research will be conducted on *"Estimated Electrical Energy Consumption in Aceh in 2028 Using the Adaptive Neuro Fuzzy Inference Method. Systems"*.

This study was conducted with the aim of analyzing the factors that affect the consumption of electrical energy, and analyzing the estimated consumption of electrical energy in Aceh in 2028.

2. METHODS

A. Basic Concepts

In some writings on forecasting, it is sometimes interpreted as forecasting or forecasting or forecasting, but actually has the same meaning, namely predicting a value in the future. Predicting the future is inherently very difficult (Nils Bohr). Forecasting electricity demand is the first step in a series of activities in making plans for the development of the electricity system which includes generation, distribution and distribution. The need for electricity is influenced by several factors, including population growth, economic growth, energy substitution, supply side capabilities, and in some countries it is also influenced by the selling price of electricity to customers, seasonal factors, changes in economic structure, and so on [3]. When viewed from the time horizon, the estimated electricity demand can be grouped into 3, namely:

a. Short term up to 2 years, ie starting daily, weekly, monthly, to yearly, is commonly used for operational planning. While the period of 1 to 2 years is usually used for budget planning (RKAP).
b. Medium term 3 to 5 years, used for corporate strategy planning, small-scale generation and distribution system master plan.
c. Long term 10 years, used for planning the development of generation, transmission and substation systems, as is RUPTL product. Long term 20 to 50 years, is used to prepare a master plan for system development

B. Adaptive Neuro Fuzzy Inference System (ANFIS)

Neuro Fuzzy System with ANFIS structure (*Adaptive Neuro Fuzzy Inference System* or commonly called *Adaptive Network based Fuzzy Inference System*) is included in the class of neural networks but based on its function is the same as the *Fuzzy Inference System*. In the Neuro Fuzzy system, the learning process is on a neural network with a number of data pairs that are useful for updating the parameters of the Fuzzy *Inference System* [4].

For example, for the Sugeno First Order fuzzy model, the general rule with two IF THEN fuzzy rules is as follows:

RULE 1 : IF x is A_1 AND y is B_1, THEN $f_1 = p_1x + q_1y + r_1$;
RULE 2 : IF x is A_2 AND y is B_2, THEN $f_2 = p_2x +$
$q_2y + r_2$;

where x and y are firm inputs at the ith node, Ai and Bi are linguistic labels (low, medium, high, etc.) expressed with the appropriate membership functions, while pi, qi, and ri are consequent parameters (i = 1 or 2) .

The data used for the learning process (training) consists of input data, ANFIS parameters, and test data that are in the ANFIS training period which is then carried out a learning process on these data so that later output in the form of prediction results is obtained [5].

Training with ANFIS uses a hybrid learning algorithm, which combines the *Least-Squares* Estimator (LSE) method to calculate the consequent value in the forward path and uses *Error Backpropagation* (EBP) and *gradient descent* in the backward path to calculate errors that occur in each layer.

ANFIS consists of five layers. The first layer consists of a fuzzification process where the input and target data are mapped in terms of their membership degrees. In the second and third layers, an inference process is carried out which is used to determine fuzzy rules using Sugeno inference where the results will be processed in the next calculation. In layer 4, the consequent value search process is carried out using LSE. At layer 5, a summary process is carried out from the two outputs at layer 4. In ANFIS, the *Fuzzy Inference System* (FIS) is located at layers 1, 2, 3 and 4 where FIS is the determinant of hidden nodes in the neural network system [5] .

After calculating the forward flow, the backward flow calculation is carried out to calculate the error value of each layer and change the input parameter values using gradient descent. The calculation process above will be repeated continuously until the error value meets the maximum error value that has been determined [6]. The process flow of an ANFIS system consisting of five layers is depicted in Fig 1.

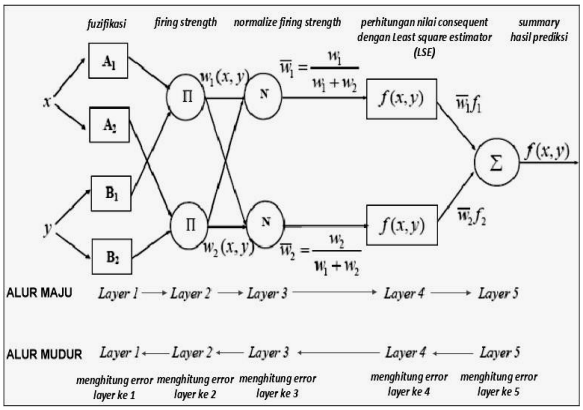

Figure 1. ANFIS Struktur Structure

After getting the final result, it will look for the error value in the final result by using the formula:

$$\text{MAPE} = \frac{\sum \frac{a-}{a}}{n} \text{ x } 100\ \% \text{.....(1)}$$

Where : a = actual data; b = Prediction data results; c = Number of estimated years.

In this study, the estimation of electrical energy consumption uses the *Adaptive Neuro Fuzzy Inference System* method. The place in this research is PT. PLN (Persero) and the Central Statistics Agency (BPS) of Aceh Province. The population in this study is the electricity consumption in North Sumatra. The sample in this study is data on population growth in Aceh in 2013-2017, data on economic growth (GRDP) in Aceh for 2013-2017, and data on electricity consumption for Aceh Province in 2013-2017.

The data collection technique in this study was carried out by means of a literature study used to find research data regarding the estimated consumption of electrical energy which includes the study of the definition of the estimation of electrical energy consumption, data collection is by collecting data on the estimated consumption of electrical energy, population growth, and economic growth.
(PDRB). Then data processing and analysis is by designing the data that has been collected and analyzing the data and testing with the data. The research procedures are as follows:

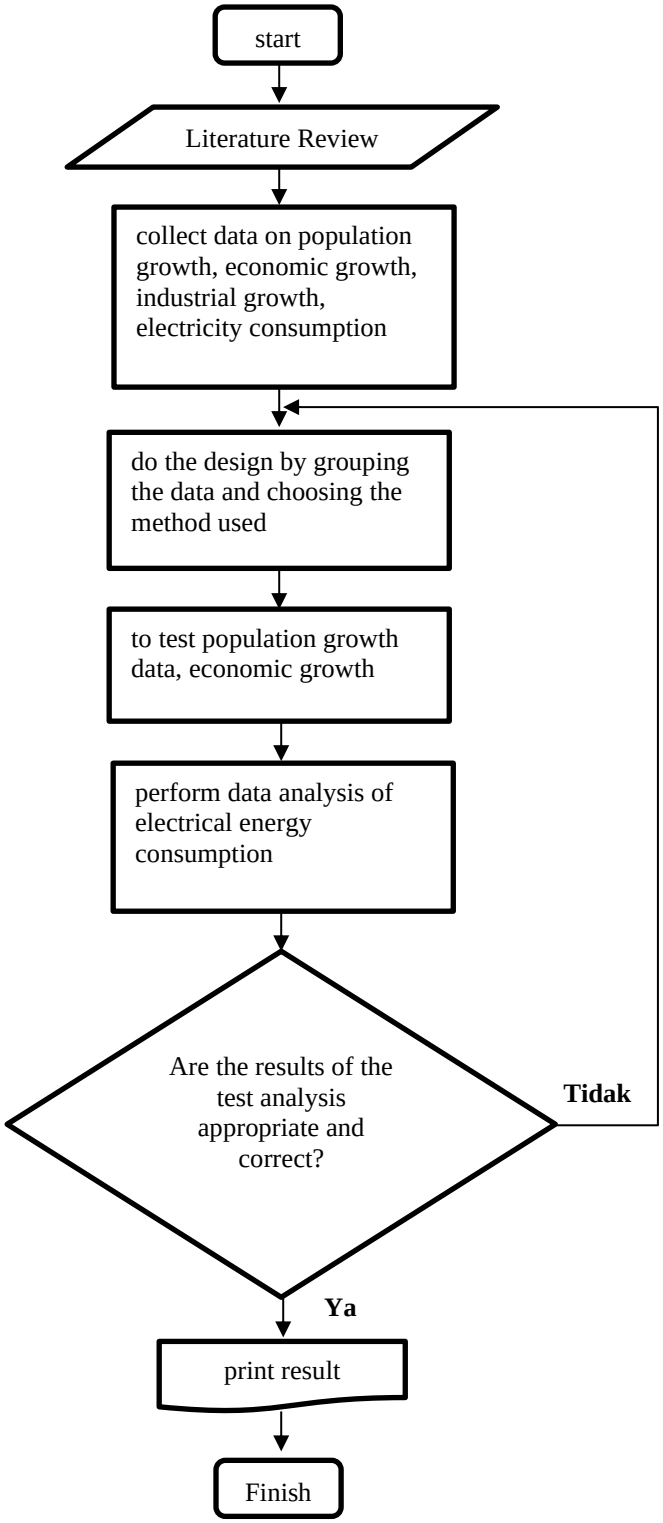

Figure 2. Research Flowchart

4. RESULTS AND DISCUSSION

A. Factors Affecting Consumption Electrical energy

The factors that affect the level of consumption of electrical energy consumption are:

1. Population Growth

In determining the estimated population growth in Aceh, data on the realization of population growth from 2013 to 2017 is needed and using the Simple E application software. The results of the calculation of the estimated population growth in 2032 obtained using the Simple E application is an average growth of 1 8%.

2. Economic Growth

In determining the estimated economic growth in Aceh, data on the realization of economic growth from 2013 to 2017 is needed and using the Simple E application software. 2,08 %.

B. Estimated Electricity Consumption in Aceh

When entering test data into ANFIS program, it will form a block diagram ANFIS. Can be seen in Figure 3.

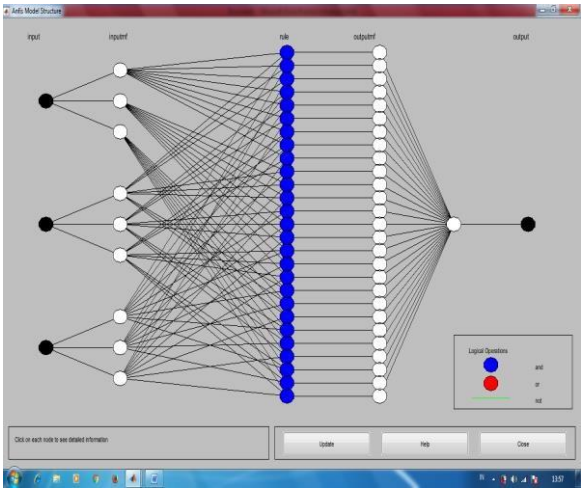

Figure 3. ANFIS Struktur

Structure In figure 3, it shows that Anfis yields 27 rules, 101 plot points, number of vertices: 78, the number of linear parameters: 27, the number of parameters nonlinearity: 27, total number of parameters: 54, sum pair of training data: 4, the number of checking data pairs: 0, and the number of fuzzy rules: 27. So, it has an error of 0.0189149%.

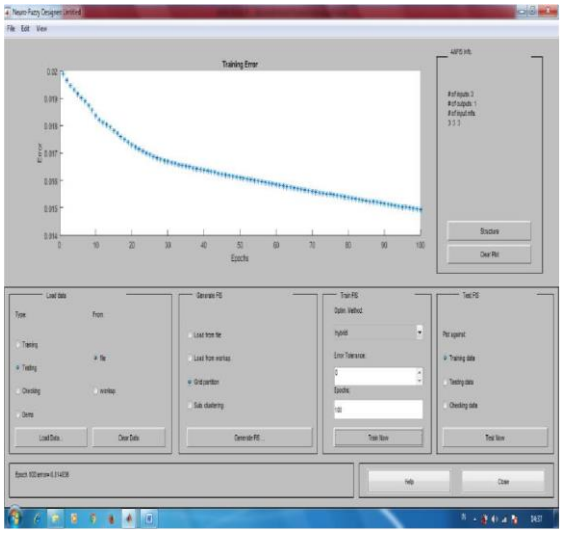

Figure 4. ANFIS Results

Based on Figure 4 above, that the comparison of the results of ANFIS forecasting has a value of Minor error with actual data. And resulted in a growth of 2.07%. So that the results of the estimation of electricity consumption in Aceh Province in 2018-2028 can be seen in Table 1.

Table 1. Results of Forecasting of Electricity Consumption In Province of Aceh on 2018-2028

Years	Results of Forecasting of Electrical Energy Consumption in Province of Aceh (GWh)
2017	2459,24
2018	2510,88
2019	2766,98
2020	3049,21
2021	3360,22
2022	3703,22
2023	4080,94
2024	4496,25
2025	4586,17
2026	4903,95
2027	5304,15
2028	5578,02

From Table 1 presented, the estimated electricity consumption in Aceh Province has been calculated using the Adaptive Neuro Fuzzy Inference System with an estimated average growth of 2.07% per year. Then the Mean Absolute Percentage Error (MAPE) value will be calculated between the ANFIS results and the actual or estimated electricity consumption data from PT. PLN (Persero) by using the equation:

$$MAPE=\frac{\left(\frac{2459,24-2409,10}{2409,10}\right)}{10} \text{ x } 100\% = \text{ } 0,002\% \text{ (2017)}$$

And from this Mean Absolute Percentage Error (MAPE) calculation, the results from ANFIS will be compared with the results of the estimated electrical energy consumption of PT. PLN (Persero) Year 2017-2032. And it can be seen in Figure 5.

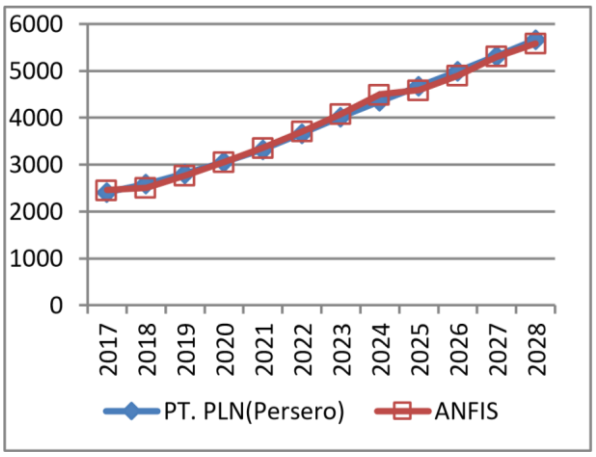

Figure 5. Comparison Graph of the Estimated Results of Aceh's Electrical Energy Consumption Using Data from PT. PLN (Persero) With ANFIS Acquisition.

4. CONCLUSION

Results Based on what was done in this study, it can be concluded that:

1. The factors that affect the level of electricity consumption are:
   a. population growth
   b. economic growth
2. Forecast of electricity consumption in Aceh in 2028 using the Adaptive Neuro Fuzzy Inference System
   method of 5578.02 GWh or an increase of about 2.07% every year until 2028.
3. This Adaptive Neuro Fuzzy Inference System method has an error rate (MAPE) of 0.002% from the realization or estimate of electricity consumption at PT. PLN (Persero). And this method is very effective for short-term to long-term forecast.

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