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Implementation of Backpropagation Artificial Neural Network for Electricity Load Forecasting in Jember District

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Abstract

The increase in population and various kinds of human activities in the world has made it possible for changes to increase the need for electrical power with demand that is not the same at any time. Based on this description, this research will propose research on the theme of electricity load forecasting as a preventive measure to determine future electricity load needs. Research was assisted using MATLAB data processing software to process research data. Three forecasting models were carried out, namely day, night and day-night conditions. From these three forecasting models, parameters such as epoch, number of input layers, number of hidden layers, activation function, and etc. The data is divided into two parts, training data and test data with a ratio of 70: 30. Test results using the backpropagation artificial neural network method show the highest MSE values for the three forecasting models, day, night, and day-night, are, 0.0039, 0.0041, and 0.002 while the lowest MSE values were in the three models are, 6.77E-04, 0.001, and 0.0011.

Keywords

Electricity Load Forecasting, Backpropagation Neural Network, MSE

INTRODUCTION

The purpose of establishing a company is to provide products or services that customers need while also making a profit from the business. In addition to making money, companies hope to support the government in reducing the unemployment rate by creating jobs and maintaining and increasing the level of survival in the long run. In order for all of this to be realized, business executives need to set appropriate policies in running their business. Company managers always try to accurately estimate decisions when making decisions. occur in the future. Effective planning is beneficial in the long term or short term, depending on how well the organization forecasts the demand for its products.

The term "forecasting" refers to the process of determining or estimating future events. Since organizations need to set goals to achieve, it is necessary to forecast what will happen in the future. Forecasting serves as a tool for decision-making. Forecasting is an important process in the world of economics and business, including energy management. In line with this sentence, "forecasting methods will assist in conducting an analytical approach to the behavior or pattern of past data, so as to provide a way of thinking, and provide a greater level of confidence in the accuracy of the forecast results made" [1].

Backpropagation artificial neural networks are among the many methods available for forecasting electricity loads. Backpropagation, or error propagation, is a common method of artificial neural network learning to accomplish a given task. It is a supervised learning process and is an implementation of the delta rule [2]. As a reference, researchers took some previous research on electricity load forecasting with artificial neural network methods. Short-term electricity load forecasting using artificial neural networks was carried out with daily electricity load data on the power system in Egypt obtained an average error of 0.493% with a standard deviation of 2.923% [3].

Electrical circuits have several components, one of which is the electrical load. Electrical loads are electrical components (machines or devices) that consume electrical energy (power) and convert it into other forms of energy. Generally, the electrical load is connected to the output terminal of the voltage source. In essence, an electrical load is anything that consumes electrical energy. Electric load forecasting methods vary according to their needs and functions. This research aims to determine the accuracy of electricity load forecasting in Arjasa repeater using the backpropagation artificial neural network method. The JST method has the ability to predict well and accurately, but its use requires quite complicated software, for example MATLAB.

METHOD

A. Time and Place of Research

The first stage in this research is data collection which will be useful for this research process. The data obtained

is the PLN electricity load data on the Arjasa repeater in Jember Regency. The process of taking electricity load data by sending an official letter from the campus to PT PLN (Persero) UP3 Jember Jalan Gajah Mada No. 198, Kec. Kaliwates, Jember Regency. The research time period for data collection at PLN (Persero) UP3 Jember was carried out in September 2023 with the repeater load data obtained was data in the period January 2022 to August 2023.

B. Literature Study

Literature study is carried out by taking material from several books, journal titles, papers and theses that have existed before, used as references and research references to be further developed to conduct research.

C. Research Phase

In making a simulation of electric power load forecasting, a clear flow is needed to facilitate its implementation. Problem identification is the beginning of the process of a flow chart that can perform electricity load forecasting according to the required target. Then data collection is carried out to generate and fulfill the required data, namely in the form of historical data on the Arjasa electricity load from January 2022 to August 2023 in the form of daily electricity load. Next is to preprocess the data which aims to prepare and process the electric load and temperature data in order to process the artificial neural network model. The stages are data correction and data normalization (changing the data value into a certain range or range of values, with the aim of simplifying the calculation process). Next is the separation of data into input and target according to the JST model developed.

Then an artificial neural network model design is made with the backpropagation neural network method or commonly referred to as back propagation. The training function used is trainlm. The next step is to change or initialize the learning rate and the number of neurons in the hidden layer by trial and error (there is no official reference) in order to get convergent results so as to get the best (smallest) error and MSE values. Then what is done is training input data with training data and training target data with training target data. This is done so that the artificial neural network (JST) undergoes a process in the form of learning from the input training data that has been given. so that it is expected to learn historical data.

Furthermore, the resulting MSE is seen. if it is still too large, it is necessary to do training again. Training is done by trial method. If the MSE obtained is appropriate, what is done next is testing the input data with the test data and testing the target data with the test target data. This is done so that the artificial neural network (JST) experiences a process in the form of testing from the input test data that has been given, so that it can get accurate results compared to the value of the real load). The smaller the MSE value produced, the better the electricity load forecasting results. Then if the MSE of the testing results is good, then look for the value of electricity load forecasting (X) using the equation.

$$X' = \left(\left(\frac{x - min_{data}}{max_{data} - min_{data}} \right) \cdot 0.8 \right) + 0.1 \quad (1)$$

The process of making simulations can be seen in the flow chart in Figure 1. While the design of the Backpropagation Neural Network can be seen in Figure 2.

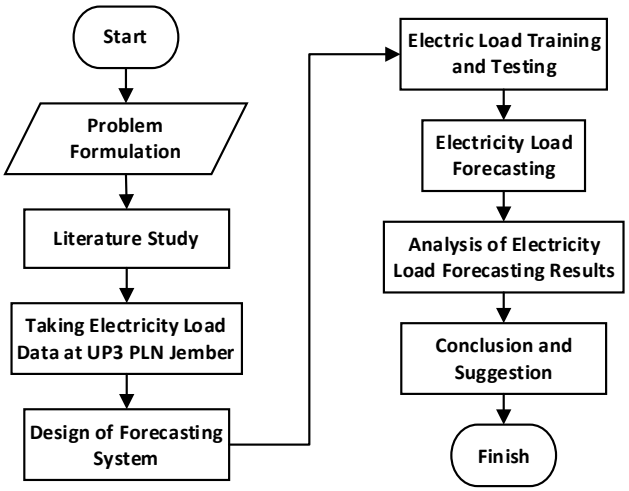

Figure 1. Research Stage

ISSN: 2720-9598

D. Design of Backpropagation Design

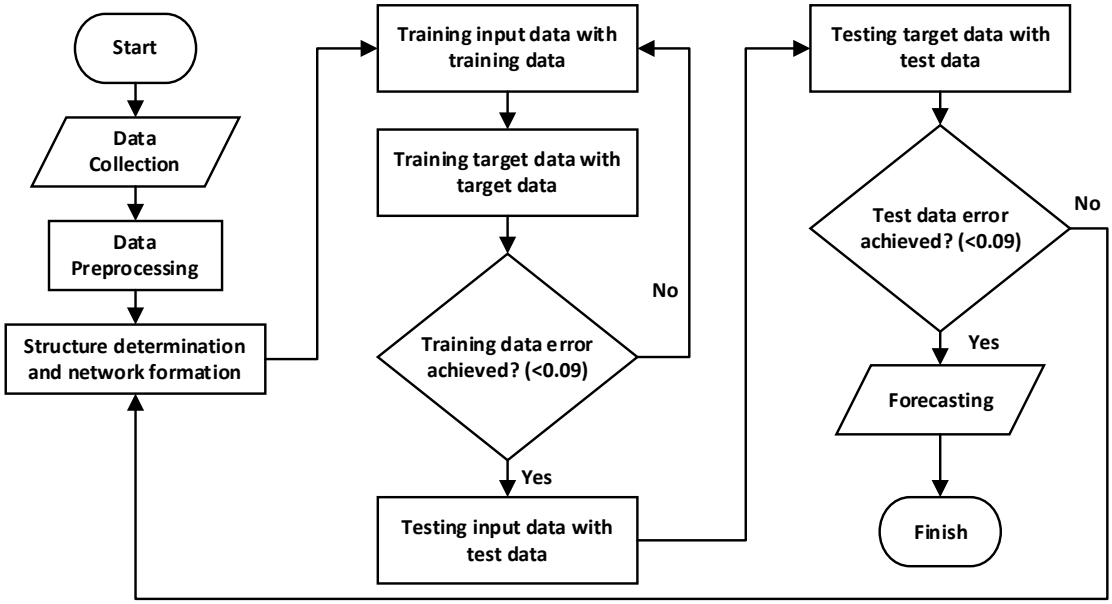

Figure 2. Flowchart of Backpropagation Neural Network

RESULTS

The purpose of this research is to create a short-term electricity load forecasting model in Arjasa repeater with the backpropagation neural network method. It aims to determine the accuracy and accuracy of this method itself. It is expected that the method used can fulfill the index for forecasting the electricity load in Arjasa repeater.

The function of electricity load forecasting is to know if there is an increase in electricity demand in Arjasa District directly proportional to the increase in terms of economic activity and community welfare. Increased demand for electricity requires proper planning of the electric power system. Good planning can be done through proper forecasting for electricity load requirements. Forecasting in the field of electric power aims to estimate the need for electrical loads in the future. Forecasted loads have a certain period of time that is adjusted to the needs of forecasting.

Arjasa repeater gets network supply from GI transformer 1 Jember City area with a capacity of 60MVA 400A. While the location of taking electricity load data at PLN UP3 Jember City. The load data taken in this study starts from January 2022-August 2023 where the time series data is daily data with day and night conditions. So that way 3 forecasting schemes can be presented, namely day, night, and day-night. In addition, this sampling aims to study and determine the pattern of increase and decrease in electricity consumption during the day and night.

The first stage in making electricity load forecasting is data identification. Data identification starts from making a reference data plot and analyzing the graph formed. The goal is to see whether the data is experiencing a certain trend or random pattern. The following is a time series plot of data formed from 19 months starting from January 2022 to July 2023.

The daily data in Figures 3 and 4 are composed of a combination of day and night time for each period. So that three forecasting models are carried out, namely day, night and day-night. For the day and day-night forecasting models, the maximum data was obtained on January 9, 2022 with a value of 353 and for the minimum data obtained on March 18, 2023 with a value of 55. While the night forecasting model obtained the maximum data on January 11, 2022 with a value of 264 and for the minimum data obtained on May 7, 2023 with a value of 55.

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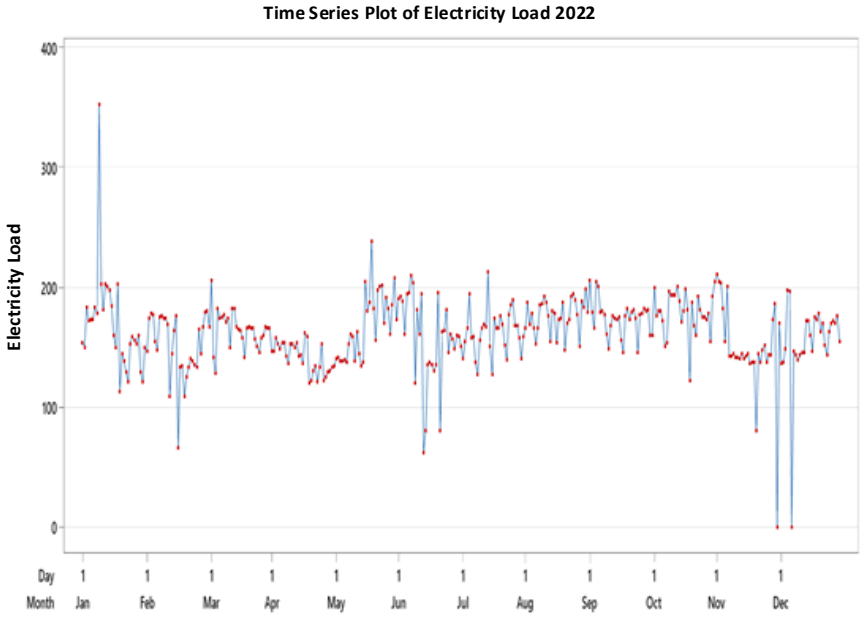

Figure 3. Time Series Graph on Electricity Load 2022

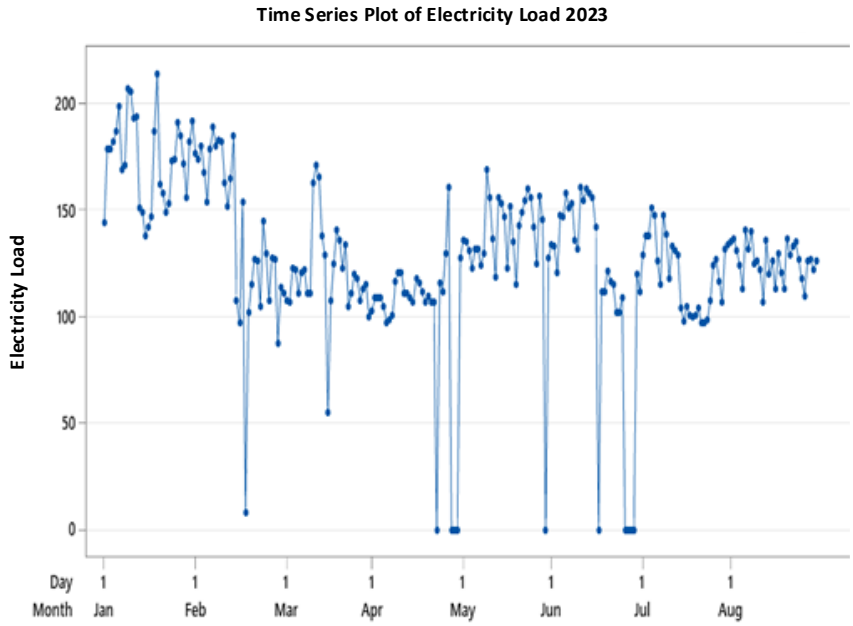

Figure 4. Time Series Graph of Electricity Load 2023

DISCUSSION

From the experiment table above, it can be seen that the results of the 3 training models produce test MSE values that vary and are quite good. The testing model with daytime has the highest test MSE value at no. 8 which is 0.0039 and the lowest training MSE value is at no. 28 which is 6.77E-04. Then the training model with night time has the highest training MSE value at no 15 which is 0.0041 and the lowest training MSE value is at no 28 which is 0.001. While the training model with day-night time has the highest training MSE value at no. 1 and 2, namely 0.002 and the lowest training MSE value is at no. 21, namely 0.0011.

The lowest MSE result from the combination of hidden layer and input in each model will be taken for forecasting. A total of 30 periods of forecasting data will be generated and observations will be made to see the trend of the resulting pattern, the following are the forecasting results of each model.

ISSN: 2720-9598

TABLE 1

MSE OF DAYTIME MODEL

Daytime				
No	Input	HL1	HL2	MSE
8	6	2	2	0.0039
28	8	8	8	0.001

TABLE 2

MSE OF NIGHT MODEL

Night				
No	Input	HL1	HL2	MSE
15	8	2	2	0.0041
28	10	8	8	0.001

TABLE 3

MSE OF DAY-NIGHT MODEL

Day-Night				
No	Input	HL1	HL2	MSE
1	4	2	2	0.002
21	8	8	8	0.0011

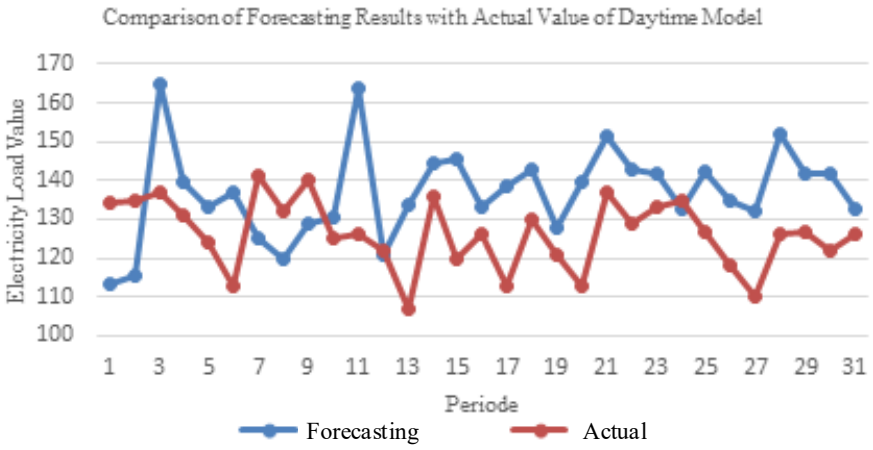

Figure 5. Comparison Chart of Electricity Load Forecasting Daytime Model

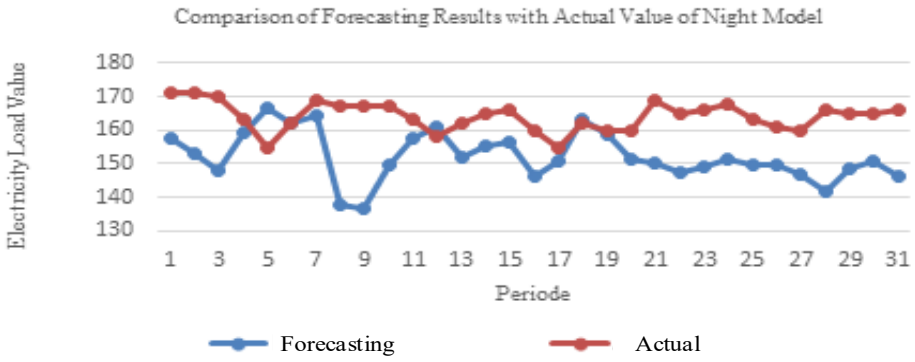

Figure 6. Comparison Chart of Electric Load Forecasting Night Model

ISSN: 2720-9598

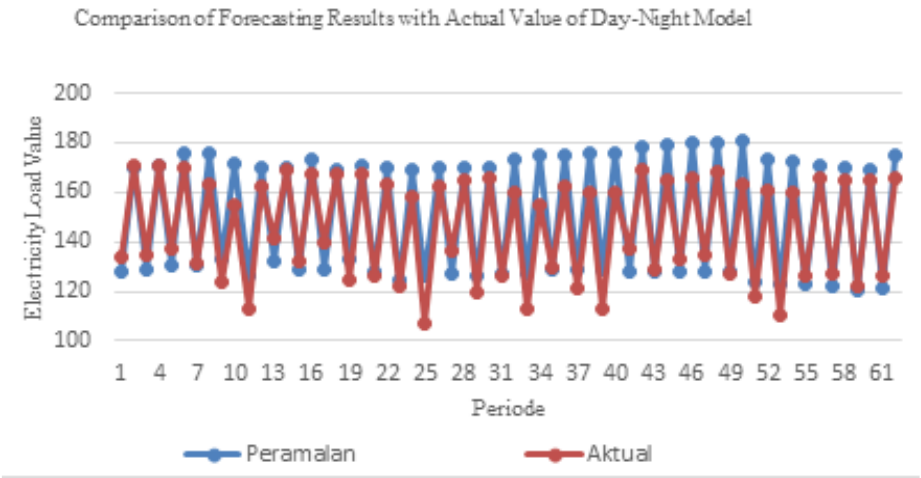

Figure 7. Comparison Chart of Electric Load Forecasting of Day-Night Model

The three models have forecasting results with varying patterns. The forecasting results in the daytime model are relatively in the range of values 124 to 135 where the resulting data still moves at a fixed average value. So that the forecasting results can be categorized into horizontal / stationary patterns. In the forecasting results on the night time model, there is a significant increase and decrease and there is no repeating or seasonal pattern. So that the forecasting results can be categorized into random patterns. Finally, the forecasting results on the day-night time model are very relative in the range of values 115 to 165 which can be categorized into horizontal / stationary patterns because the data generated fluctuates around a fixed average value.

CONCLUSION

Based on the results and data analysis in the previous chapter, this research can be concluded as follows. Electricity load forecasting using the backpropagation neural network method can find out the ups and downs of the state of consumer electricity consumption on the Arjasa extension so that if at any time electricity consumption exceeds or is less than the electricity provided or other problems regarding the prediction of electricity consumption from consumers, PT PLN (PERSERO) can take preventive action earlier. The results of electricity load forecasting using the backpropagation neural network method obtained the highest MSE value in three forecasting methods, day, night, and day-night, namely 0.0039, 0.0041, and 0.002 while the lowest MSE value in three methods, namely, 6.77E-04, 0.001, and 0.0011.

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