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Research Article

Forecasting the Electricity Need for the Household Sector PT. PLN (Persero) Rayon Lhoksukon with Time Series Linear Regression

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A B S T R A C T

Predictions of electricity demand such as connected power and the country's consumption of electrical energy continue to increase every year by population growth in Indonesia. This will cause the number of electricity customers to increase. PLN as a provider of electricity is important to predict long-term electricity demand as the direction of the company's economic policy to meet customer needs. This activity will be reviewed in the electricity distribution area of PT. PLN (Persero) Rayon Lhoksukon and its surroundings. Prediction of electricity demand is done through forecasting the number of electricity customers using the time series analysis method with regression from the previous data review from 2016 to 2019. The results show, the form of forecasting Y=4596+100,6X, results in the number of electricity customers in 2030 being 6005 customers or an average increase of 2 0.08%/year. The functional relationship between the number of subscribers and connected power is close to a straight line, approached by linear regression, in the form of Y=-1226123,8+1358X, resulting in connected power in 2030 being 6927851.4 VA or an average increase of 2.51%/year. Meanwhile, the functional relationship between the number of customers and consumption of electrical energy is close to a straight line, approached by linear regression, in the form of Y=27894883,46+6609,45X, resulting in electrical energy consumption in 2030 being 67580665.04 kWh or an average increase of 1.15%/year.

INTRODUCTION

The Ministry of Energy and Mineral Resources (ESDM) through the Directorate General of Electricity continues to support the efforts of the State Electricity Company (PLN) in meeting the needs of electrical energy in the country. The achievement target of all households in Indonesia (to be 100%) has enjoyed electricity until 2020 [1]. Although in reality there are still remote communities who have not enjoyed it due to certain factors. The efforts made by the competent authorities are to fulfill the national interest in accordance with the mandate of Article 33 of the 1945 Constitution and related laws and regulations in the context of fulfilling the prosperity of the people.

Today, electrical energy has become a primary need, which dominates its use in activities in Indonesian households, beating LPG and kerosene which continue to decline/abandon their use by the community. According to data from the Ministry of Energy and Mineral Resources in 2020, the use of electrical energy in the household sector reached 50.80%, followed by LPG at 47.01%, kerosene at 1.88%, and the rest from other sources such as gas, biogas and others [2]. This can be seen clearly in the use of electricity in various types such as as a source of light, energy generator, motion generator, in the medical field, in gadgets, sound generator, and in sports facilities, and there are many other uses that have not been mentioned.

Electrical energy as a supporter of activities in the household, has made the country's electricity customers increase every year in line with the increase in the population in Indonesia [3]. An estimate of the increase in the number of electricity customers every year is an initial step that must be done in formulating an electricity system planning policy. Estimates made based on facts and data, estimates that are too high will result in losses for the company and conversely estimates that are too low will cause losses for customers [4]. This has an impact on the disruption of the flow of electricity in an area.

The electricity distribution area of PT. PLN (Persero) Rayon Lhoksukon needs special attention, because this area experiences regular flooding every year which will cause disturbances to several local electricity systems. In some conditions the electricity must be turned off considering the safety of the residents and the flooded electricity network. When conditions are stable, the electricity will flow back [5]. The planning of the electricity system in this area needs serious estimation considering that when the natural conditions are flooded, it fulfills the slogan 'electricity for a better life'. Planning for electricity

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needs changes every time period, therefore this planning is carried out through forecasting techniques.

Supporting the above, it is necessary to research the forecasting of the number of long-term electricity customers in this area as a form of initial planning in determining the economic policies of local companies. Forecasting will use the *time series method* with regression, where the time variable is the most influential variable in this forecasting. Several studies using *time series analysis* with regression for electricity forecasting have been carried out by [6] those who have reviewed the Lhokseumawe city and surrounding areas, where the growth of electricity demand for the population of Lhokseumawe City in 2020 is estimated to increase up to 10% with the implementation of a smart system at *least square* can make it easier for PLN to predict the electricity needs of each sector. Then [7] those who review the area of the city of Batam for 2016 to 2021 with Minitab version 18 simulation, the predicted total increase in the number of electricity customers at industrial loads is 104 customers (an average growth of 4.33%) and 81,632 customers for non-industrial loads (the average growth per year is 4.11%), connected power at industrial loads is 219.769 MVA (average growth per year is 8.22%) and at non-industrial loads is 586.083 MVA (average growth per year) amounted to 7.72%), electrical energy sold to industrial loads was 289.481 GWh (an average growth of 6.95% per year) and to non-industrial loads to 441.118 GWh (annual growth average of 7.72 %). Followed by [8] reviewing the Samarinda city area with SPSS 24 analysis, forecasting the growth of electricity customers in 2019 is 486,270 customers, in 2020 it is 491,207 customers, in 2021 it is 513,935 customers and in 2022 it is 536,767 customers, while the forecast for growth in connected power in 2019 is 842,102 kVA, in 2020 of 889,686 kVA, in 2021 it will be 938,764 kVA and in 2022 it will be 987,054 kVA. As well as for the City of Subulussalam by [9], the amount of electrical energy demand for 2016 to 2020 has increased significantly which is in the range of 3,470,887,446 Kwh for 2020.

In particular, PT. PLN (Persero) becomes the intermediary for implementing the government's responsibilities in the welfare of people's lives as a provider of electrical energy for human survival. Many factors affect the supply of electricity in an area, including the increase in the number of electricity customers which will be discussed in this paper. This study will review the electricity service area of Lhoksukon and its surroundings to forecast the number of long-term household electricity customers until 2030 to determine the amount of connected power and consumption of electrical energy. Forecasting the number of electricity customers uses the *time series method* with regression, because the availability of previous quantitative information/data is closely related/sustainable for the future.

METHODS

The initial step of the forecasting is to analyze the past data through tabulations to find out the pattern of the data, continue to determine the forecasting method to be used, and project the past data using the method used by considering the changing factors. Forecasting connected power and electricity consumption of PT. PLN (Persero) rayon Lhoksukon with a review of the number of electricity customers. The forecasting technique uses *time series relationship analysis* with trend data pattern regression in the form of $Y = a + bX$, where Xas the determining variable (time, in years), and Y as the determined variable (estimated number of electricity customers), and $a$and $b$as the regression coefficient. The analysis will use data on the number of electricity customers, connected power, and electricity consumption from 2016 to 2019 as raw data as shown in table 1. Regression coefficient $a$and $b$calculated using the *least squares method* with the aim of minimizing forecast errors that occur.

The regression equation obtained will be tested for the accuracy of the time variable X which affects the determining variable Y using the *coefficient of determination test* or R^2 test, where $0 < R^2 < 1$. A value R^2close to 1 symbolizes the amount of confidence in the accuracy of the time variable X that affects the *Y variable*. Followed by the test of the accuracy of the regression equation used is linear through the *significance test* . The *significance test* for the coefficients $b$is statistically different from zero $F\ test$and the *significance test* for the estimated value of $a$and $b$may vary due to the influence of sampling and/or the random effect of *t test* [10].

The analytical model obtained will be used for forecasting the number of long-term electricity customers until 2030. The results of this analysis are used to determine the amount of connected power in VA and electrical energy consumption in kWh by first obtaining the right functional relationship between the two with regression analysis and selection better correlation coefficient using the techniques and formulas in the book [11].

RESULTS AND DISCUSSION

The increasing number of household electricity customers each year at PT. PLN (Persero) Rayon Lhoksukon according to the data in table 1, will affect the supply of connected power and adequate consumption of electrical energy for the coming years. This has been traced by the regression model *time series forecasting method.* The research results can be used as a solution in determining the direction of the local electricity company's economic policy for the long term until 2030 in meeting customer needs.

Table 1. Number of customers, connected power, and household sector electricity consumption at PT. PLN (Persero) Rayon Lhoksukon

Year	Customer	Connected Power (VA)	Energy Consumption (kWh)
2016	4,610	5,047,950	2,288,280
2017	4,670	5,113,650	3,307,670
2018	4,808	5,264,760	3,946,240
2019	4,899	5,453,405	4,371,860

Functional Relationship between Number of Customers and Connected Power

Based on the data listed in table 1 and figure 1, the graphic form that connects the number of customers with connected power forms a straight line, so that the functional relationship between the two is approached with a linear regression model of the form $Y = a + bX$. Then by using the *least square method* to determine the regression coefficients *a* and *b* to minimize errors that occur. The results obtained, the functional relationship between the two

is in the form of $Y = -1226123{,}8 + 1358X$. This relationship is positively correlated between the two of 98.77%. This means that the relationship between the two can be said to increase/decrease in connected electricity, which is influenced by the number of customers by 98.77%. The functional relationship obtained can be used to determine the amount of electricity connected in the future period through the number of electricity customers. For example, the number of electricity customers reaches 5,000 customers, then the connected power that must be met is 5,563,876 VA.

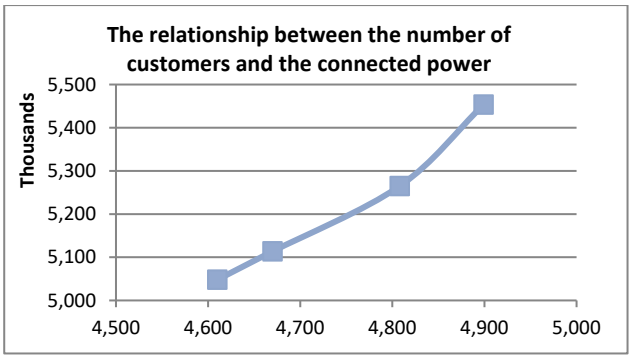

Figure 1. The relationship between the number of customers and the connected power

Functional Relationship between Number of Customers and Energy Consumption

Based on the data in table 1 and figure 2, the graph that connects the number of customers and electricity consumption forms a straight line, so that the functional relationship between the two is approximated by linear regression of the form $Y = a + bX$. Then by using the *least square method* to determine the regression coefficient to minimize errors that occur. The results obtained, the functional relationship is in the form of $Y = 27894883{,}46 + 6609{,}45X$. This relationship is correlated between the two of 95.60%. The positive correlation formed between the two can be said that the increase/decrease in the consumption of electrical energy is influenced by the number of customers by 95.60%. The obtained functional relationship can be used to determine the amount of electrical energy consumption in the future period. For example, the number of electricity customers reaches 5,000 customers, the consumption of electrical energy used is 5,152,367 kWh.

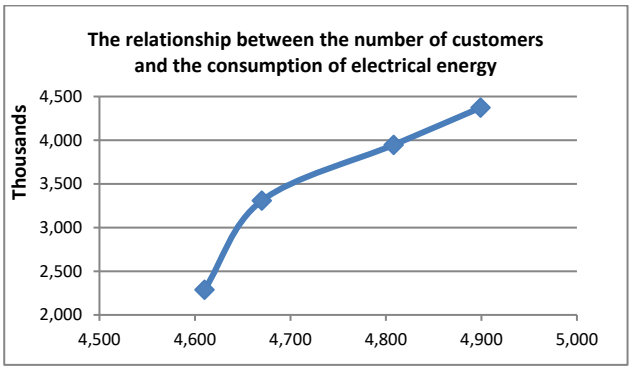

Figure 2. The relationship between the number of customers and the consumption of electrical energy

Forecasting the Number of Electricity Customers

Estimates of the number of electricity customers from 2022 to 2030 have been analyzed using the *least squares regression forecasting method* to minimize forecast errors of the form $Y = a + bX$. Forecasting the number of electricity customers each year, assuming that the past relationship pattern will be sustainable/can be used to estimate the relationship pattern in the future with *times series analysis*, where time is used as a variable that affects the results of this forecast. The pattern of observation data shown in Figure 3, which is in the form of a *trend data pattern* that continues to increase with increasing service time or in the form of a straight-line graph.

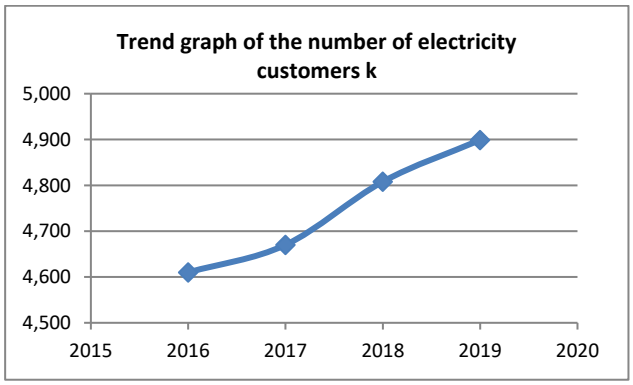

Figure 3. The trend pattern of the data on the number of electricity customers

The results of the analysis with *time series*, produce a functional relationship between the time variable and forecasting the number of electricity customers in the form of $Y = 4596 + 100{,}6X$. The forecasting equation above has been tested for feasibility in two analyzes, where the first analysis is to determine the feasibility of the time variable as a determining variable in forecasting the number of electricity customers using the *coefficient of determination test* and the second analysis is for the feasibility of the linear regression equation to determine forecasting the number of electricity customers with a *significance test* , both meet the criteria in question.

The results of the first analysis, namely determining the feasibility of the time variable as a determining variable in forecasting the number of electricity customers with the *coefficient of determination test*, the value of R2 = 0.980174, which is close to 1. it is said that about 98.0174% of the time variable determines the amount of forecasting the number of electricity customers. Because the correlation between the time variable and the number of electricity customers is 0.980174, the time variable can be used to predict the number of electricity customers.

The result of the second analysis is to determine the feasibility of the linear regression equation $Y = a + bX$to determine the forecasting of the number of electricity customers with the *significance test*. The two variables (X = time and Y = number of electric customers) are positively correlated. Statistically, a *test* to determine whether the coefficient *b* is statistically different from 0 (zero), with an *F-test* and a *test* to determine whether the estimated values of *a* and *b* can vary due to the influence of sampling and/or random effects, using *the t-test*.

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The results are obtained with a 95% confidence level, the *F test value* = 98.87665 and from the value of the distribution table with numerator 1 and denominator 2 obtained a value of 18.51. By comparing the *F test* and *F* table, it is obtained that the *F ratio* is greater, indicating that the coefficient *b* in the simple linear regression equation is *significantly* different from zero, so that the prediction regression equation in the linear form *Y=a+bX is correct*. While the results with the *t test* show that the value of *t test a = 406.7296* and the value of *t test b = 9.943674* compared to the value of *t* table (0.95;2) = 2.92. Because the value comparison between the *t test* and *t* table values for both coefficient *a* and coefficient *b* with a greater sign, it is statistically significant (significant) from 0. It can be said that the linear regression equation is appropriate to use for forecasting the number of electricity customers. and testing the truth as a statistical linear regression with a *significance test.*

The obtained forecasting equation $Y = 4596 + 100{,}6X$. has met the required criteria, this forecasting equation can be used to determine the forecasting of the number of long-term electricity customers until 2030. The results are shown in Figure 4, namely the number of electricity customers in 2030 will reach 6005 customers. Statistically, it can be said that the average increase in the number of electricity customers is 2.08% per year. In detail, the estimated number of electricity customers in the electricity distribution area of PT. PLN (Persero) Rayon Lhoksukon and its surroundings every year can be seen in Figure 4.

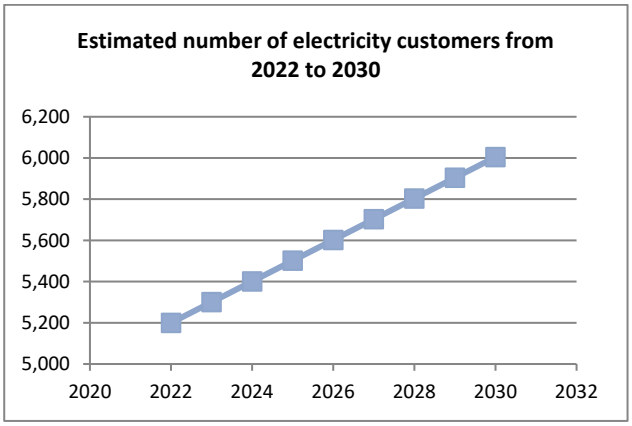

Figure 4. The results of forecasting the number of electricity customers with *time series* regression

Determination of Connected Power and Energy Consumption

Forecasting the number of long-term electricity customers until 2030 will be used to determine the amount of power connected to local electricity. By using the functional relationship between the number of subscribers and the power connected to electricity $Y = -1226123{,}8 + 1358X$. The amount of connected power in 2030 is 6927851.4 VA or there is an increase in the average connected power of 2.51% per year. In detail, the amount of electricity connected each year in the distribution area of PT. PLN (Persero) Rayon Lhoksukon and its surroundings can be seen in Figure 5.

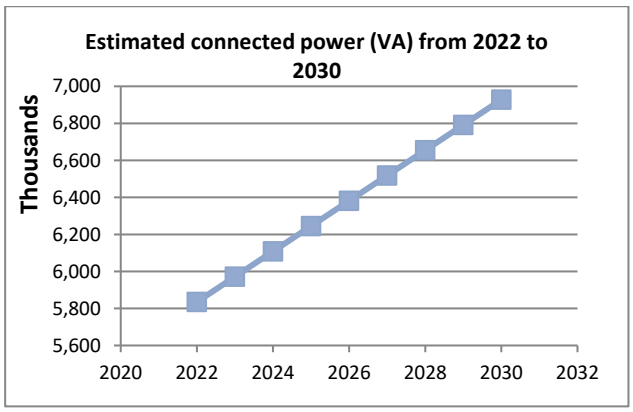

Figure 5. The results of the analysis of connected power

Forecasting the number of long-term electricity customers until 2030 will also be used to determine the amount of electricity consumption. The determination is made based on the functional relationship between the two in the form of $Y = 27894883{,}46 + 6609{,}45X$. So that the amount of electrical energy consumption in 2030 becomes 67580665.04 kWh or an increase in the average consumption of electrical energy of 1.15% per year. In detail, the estimated amount of electrical energy consumption in the electricity distribution area of PT. PLN (Persero) Rayon Lhoksukon and its surroundings every year can be seen in Figure 6.

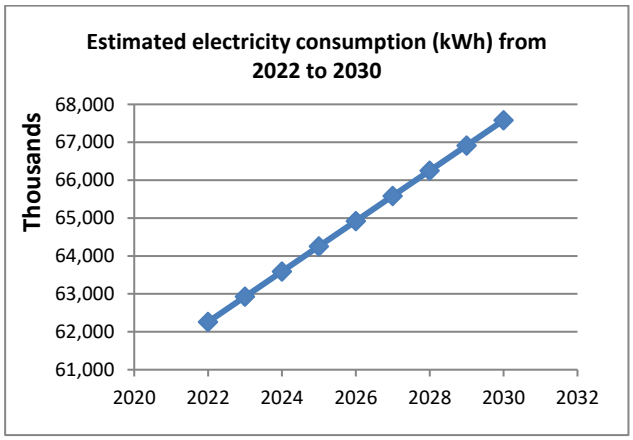

Figure 6. Electrical energy consumption

CONCLUSIONS

Forecasting the number of electricity customers at PT. PLN (Persero) Rayon Lhoksukon using the *time seeies forecasting method* with regression produces:

1. The number of electricity customers in 2030 will reach 6004.4 or 6005 customers and there is an average increase in the number of electricity customers by 2.08% per year
2. The form of the functional relationship between the number of customers and the connected power is $Y = -1226123{,}8 + 1358X$, generating electricity connected by 2030 to 6927851.4 VA and an average increase of 2.51% of connected power per year
3. The form of the relationship between the customer and the consumption of electrical energy is $Y = 27894883{,}46 + 6609{,}45X$, resulting in the consumption of electrical energy in 2030 to be 67580665.04 kWh,

which is an increase in electrical energy consumption by an average of 1.15% per year

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