Estimation Analysis of Long-Term Electrical Energy Needs In PT. PLN (Persero) P2B REGION MERAUKE Area Using Linear Regression Method

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Abstract. Electrical energy is one of the important parts in the development of an area. The development of sustainable development and improvement in living standards can cause electricity consumption to continue to increase high, not least for Merauke Regency. In meeting the future electrical energy needs, it is necessary to prepare the development of the electrical system so that it is able to serve the demand for electrical energy needs in the future. One of the ways is to make predictions or estimates the electrical energy requirements. The estimation of the need for electrical energy is needed to answer the high demand for electricity that continues to increase, so that we see the development of electricity consumption in Merauke Regency that is linear. The method used in this research is analyzing the calculation of electricity needs using the Linear Regression Method.

The estimation results of electrical energy needs in 2018 electrical energy needs amounted to 127,035,341 KWh, while in 2022 amounted to 17,139,908 KWh with an average increase per year of 8,747,989 KWh or 5.84%. From the calculation results, the household sector becomes the sector that has the highest electrical energy needs up to 2022 amounting to 114,294,938 KWh with an average percentage increase per year of 5.82%

1. The first section in your paper

Human activity in the use of electricity from time to time will increase. This is because electric energy has become an important part of the development of human civilization in various fields including the fields of economics, technology, social and human culture. The disruption of electricity supply can result in disruption of the community’s economic routine.[1] Therefore, the reliability of the electricity supply is very important. In the electricity system, a strategy to estimate electrical energy requirements is needed. Community needs on electricity continues to grow every year. Besides population growth, the economic growth of a region is believed to be one of the factors that influence the increase in electricity consumption in the area. This condition must be anticipated as early as possible so that the availability of electrical energy can be available in sufficient quantities[2].

Estimation of electrical energy need is needed to estimate how much electricity is needed to serve the load and electrical energy requirements in the distribution of electrical energy. Calculation of Electrical Energy Needs is not new thing; there have been many researches on Estimation of Electricity Needs and in their calculations using different calculation methods.
Merauke Regency is the second Regency in Papua Province which has the highest population after Jayapura City Regency and its community economy is better, this can be seen in the least number of poor population presentations in Papua Province [3]. As economic growth continues to increase, of course, energy demand is rapidly increasing [4] of course Merauke as the second largest city in Papua has a large consumption of electricity needs compared to other cities in the Papua Province. The estimation of electrical energy needs of Merauke Regency needs to be done to anticipate the availability of electricity needs. The Electricity Requirement Calculation Method that the researcher use is Linear Regression, because the data taken is based on electricity usage data from time to time which will be considered with supporting factors.

2. Literature Review
2.1. Time Series
Time series analysis is the relationship between variables that are dependent with variables that affect it (independent variable), which is associated with time such as weekly, month, three months, quarterly, semester or year. In the time series analysis, the variable that is sought is time [5]. This forecasting method consists of:

- Smooting method, is a type of short-term forecasting such as inventory planning, financial planning. The purpose of using this method is to reduce past data irregularities such as seasonality.
- Box Jenkins method, is a time series using a mathematical model and is used for short-term forecasting.
- The trend projection method with regression, is a method used both for short and long term. This method is a trend line for mathematical equations.

2.2. Causal Methods
Is a forecasting method that is based on the relationship between variables that are estimated with other variables that influence it but not time. In practice, this type of forecasting method consists of:

- Regression and correlation methods, are methods that are used both for long and short term and are based on the least squares technique equation which is statically analyzed.
- Input Output Model, is a method used for long-term forecasting which is commonly used to compile long-term economic trends.
- Econometry model, is a forecast that is used for long and short term.

Based on the development of Merauke Regency which is linear (static), the forecasting calculation uses Causal Methods, namely the Simple Linear Regression Method because the researcher uses one independent variable in calculating electricity consumption forecasting. The data that researcher use is secondary data in the form of electricity usage and the number of electricity customers in the last five years, as well as supporting data including the number of households and per capita income for the last five years for all sectors.

2.3. Simple Linear Regression Analysis
Simple Linear Regression is a Statistical Method that serves to test the extent to which the causal relationship between the Variables of the Cause Factor (X) to the Consequent Variable (Y). The cause factor is generally represented by X or also called the Predictor while the Consequent Variable is denoted by Y, also called Response. Simple Linear Regression or often abbreviated as SLR (Simple Linear Regression) is also one of the Statistical Methods used in production to forecast or predict characteristics of quality and quantity [6]. The Simple Linear Regression Equation Model is as follows:

\[ Y = a + bX \] (1)

The values of a and b can be calculated using the formula below:
\[ a = \frac{(\Sigma y)(\Sigma x^2) - (\Sigma x)(\Sigma xy)}{n(\Sigma x^2) - (\Sigma x)^2} \]  
\[ b = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2} \]  

2.4. Simple Linear Regression Analysis

- **Household Sector**: Estimation of Household Sector Consumption will be calculated using the causal variable, namely the amount of electricity consumption in the household sector per year with the number of Merauke Regency households per year and the consequent variable namely the KWh Data of Merauke Regency Electricity Use of the Household Sector.

- **Business Sector**: The calculation of long-term electricity consumption for the business sector uses the causal variable, namely the annual Business Sector Electricity Consumption and Gross Regional Income of Merauke Regency Business Sector and KWh Data of Merauke Regency Electricity Utilization Business Sector as the consequent variable.

- **Office Sector**: The Office Sector uses consequent variable namely Electricity Consumption of Office Sector per year and the causal variable namely the Gross Regional Income of Office sector per year and data on the Number of Customers of Office Sector.

- **Industrial Sector**: Consequent variable used as the basis to estimate short-term electricity consumption, namely the amount of electricity consumption in the industrial sector per year and the causal variables are the Gross Regional Income of the Industrial Sector in Merauke Regency per year and the Number of Customers of Industrial Sector.

- **Social Sector**: The consequent variables used are the Social Sector Electricity Usage Data and the Causal Variables using Data of Total PDRB of Social Sector and Data Of Number of Customer of Social Sector.

- **Energy Consumption Needs**: The estimated total energy consumption needs are obtained by summing the estimated results of the total energy consumption of the household sector, business sector, office sector, industrial sector and social sector, with the following formula:

\[ ET_t = ER_t + EB_t + EP_t + EI_t + Est \]  

2.5. Correlation Coefficient Test

Correlation is the degree of linear relationship between two or more variables from observational data. Two variables are said to correlate if changes in one variable are followed by changes in other variables, whether in the same direction or not. Relationships between variables can be grouped into three types: positive correlation, negative correlation and zero correlation [7]. Based on the relationship between variables one with the other variables expressed by the correlation coefficient symbolized by ‘r’ The magnitude of the correlation ranges from \(-1 < r < 1\). To find the correlation between variables, it can be formulated as follows:

\[ r = \frac{n \Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{n \Sigma x^2 - (\Sigma x)^2}(n \Sigma y^2 - (\Sigma y)^2)} \]  

Correlation coefficient value is if two variables are negatively correlated then the correlation coefficient value will be close to -1, if two variables are not correlated, the correlation coefficient value will be close to 0, whereas if two variables are positively correlated, the correlation coefficient value will be close to 1. To find out how far the degrees between these variables, it can be seen in the following formulation:

- \(1,00 \leq r \leq 0,80\) means a negative strong correlation
- \(-0,79 \leq r \leq -0,50\) means negative moderate correlation
- \(-0,49 \leq r \leq 0,49\) means a weak correlation
0.50 ≤ r ≤ 0.79 means a positive moderate correlation
0.80 ≤ r ≤ 1.00 means a positive strong correlation

3. Result and Discussion

Seeing the development of electricity usage of Merauke Regency in the last 5 (five) years, it can be said that the development is linear with a percentage of average growth of 9.01% as shown in table 1 below:

| Sector    | Electricity Usage (kWh/year) |
|-----------|------------------------------|
|           | 2013 | 2014 | 2015 | 2016 |
| Household | 62,246,224 | 67,909,203 | 72,328,593 | 82,443,812 |
| Business  | 21,168,288 | 23,533,738 | 24,916,178 | 28,163,788 |
| Office    | 6,891,455 | 6,949,153 | 7,212,824 | 8,269,268 |
| Industrial| 136,270 | 147,415 | 145,770 | 117,256 |
| Social    | 3,150,555 | 3,401,54 | 3,921,883 | 4,411,390 |

The development of the electricity consumption of the Merauke Regency in the last 5 years (2013-2017) is linear, then the calculation of electricity needs the writer uses the Linear Regression Method. The calculation steps to be performed are the Correlation Test. This correlation test aims to determine the extent of the correlation between the data used. The calculated correlation test is divided into 5 sectors:

- **Household Sector**: The Household Sector will be tested for correlation between the number of households in Merauke Regency and Merauke Regency Electricity Utilization which will be compared with the correlation test between the number of household customers in Merauke Regency and Merauke Regency Electricity Utilization. From the results of the correlation calculated between the two tests the data will be used with the strongest correlated correlation test that will be used to calculate the estimated electrical energy needs of Merauke Regency.

- **Business Sector**: The Business Sector will be tested for the correlation between the PDRB of the Merauke Regency Business Sector and the Business Sector Electricity Use of Merauke Regency which will be compared with the correlation test between the Number of Customers of Business Sector in the Merauke Regency and Merauke Regency Electricity Use. From the results of the correlation calculated between the two tests, the data with the strongest correlation test will be used to calculate the estimation of electricity energy need of Merauke Regency.

- **Office Sector**: The Office Sector will be tested the correlation between the BDRB of the Merauke Regency Office Sector and the Electricity Use of the Office Sector of Merauke Regency which will be compared with the correlation test between the Number of Customers in the Merauke Regency Office Sector and the Electricity Use of Merauke Regency Office Sector. From the results of the correlation calculated between the two tests, the data with the strongest correlated correlation test that will be used to calculate the estimated electrical energy needs of Merauke Regency.

- **Industrial Sector**: The Industrial Sector will be tested for the correlation between the PDRB of the Industrial Sector in Merauke Regency and the Electricity Usage of the Industrial Sector in Merauke Regency which will be compared with the correlation test between the Number of Customers in the Industrial Sector of Merauke Regency and the Electricity Use of the Industrial Sector in Merauke Regency. From the results of the correlation calculated between the two tests, the data with the strongest correlated correlation test that will be used to calculate the estimated electrical energy needs of Merauke Regency.

- **Social Sector**: The social sector will be tested for the correlation between the PDRB of the Social Sector of Merauke Regency and the Electricity Usage of the Merauke Regency Social
Sector which will be compared with the correlation test between the Number of Customers in the Merauke Regency Social Sector and Electricity Use of the Merauke Regency Social Sector. From the results of the correlation calculated between the two tests, the data with the strongest correlated correlation test that will be used to calculate the estimated electrical energy needs of Merauke Regency.

Table 2. Data on gross regional income per sector per year

| Sector   | Electricity Usage (kWh/year) | 2013     | 2014     | 2015     | 2016     | 2017     |
|----------|------------------------------|----------|----------|----------|----------|----------|
| Household| Number of Households & KWh  | 6.199.423| 7.136.103| 8.190.389| 9.513.672| 30.037.713|
| Business | Number of Customers & KWh   | 858.313  | 944.203  | 1.068.115| 1.147.944| 8.429.953 |
| Office   | PDRB & KWh                   | 351.477  | 315.710  | 391.965  | 432.464  | 122.006  |
| Industrial| Number of Customers & KWh   | 429.470  | 474.249  | 520.665  | 575.718  | 621.315  |
| Social   | PDRB & KWh                   | 6.199.423| 7.136.103| 8.190.389| 9.513.672| 30.037.713|

Table 3. Correlation test results for each sector

| Sector   | Data                              | Test Result | Data Used                          |
|----------|-----------------------------------|-------------|------------------------------------|
| Household| Number of Households & KWh        | 0.9825      | Total Electricity Consumption & Number of Households |
|          | Number of Customers & KWh         | 0.9559      |                                      |
| Business | PDRB & KWh                        | 0.7243      | Total Electricity Consumption & Number of Customers |
|          | Number of Customers & KWh         | 0.9749      |                                      |
| Office   | PDRB & KWh                        | 0.7893      | Total Electricity Consumption & Number of Customers |
|          | Number of Customers & KWh         | 0.8941      |                                      |
| Industrial| PDRB & KWh                       | 0.6349      | Total Electricity Consumption & Number of Customers |
|          | Number of Customers & KWh         | 0.8107      |                                      |
| Social   | PDRB & KWh                        | 0.9905      | Total Electricity Consumption & Number of Customers |
|          | Number of Customers & KWh         | 0.0133      |                                      |

the Total Electricity Usage for the Household Sector:
2018 = 91.136.602,13 kWh
2019 = 96.926.186,17 kWh
2020 = 102.715.770,21 kWh
2021 = 108.505.354,25 kWh
2022 = 114.294.938,30 kWh

for the Business Sector:
2018 = 31.355.688,04 kWh
2019 = 33.347.729,99 kWh
2020 = 35.339.771,94 kWh
2021 = 37.331.813,89 kWh
2022 = 39.323.855,84 kWh

for the Office Sector:
2018 = 9.082.902,85 kWh
2019 = 9,566,684,14 kWh  
2020 = 10,050,465,42 kWh  
2021 = 10,534,246,70 kWh  
2022 = 11,018,027,99 kWh

for the Industrial Sector:  
2018 = 107,973,15 kWh  
2019 = 99,547,00 kWh  
2020 = 92,120,85 kWh  
2021 = 84,694,70 kWh  
2022 = 77,268,55 kWh

for the Social Sector:  
2018 = 5,465,786,15 KWh  
2019 = 5,955,793,93 KWh  
2020 = 6,445,801,71 KWh  
2021 = 6,935,809,49 KWh  
2022 = 7,425,817,27 KWh

The calculation results of electricity consumption per sector then using equation 4, will obtain the value of the total electrical energy needs for Merauke regency in the next 5 years can be seen in the following table:

| Year | Sector                                      | Total (kWh) |
|------|---------------------------------------------|-------------|
|      | Household | Business | Office | Industry | Social |             |
| 2018 | 91.136.602 | 31.355.688 | 9.082.903 | 106.973 | 5.465.786 | 137,147,952 |
| 2019 | 96.926.186 | 33.347.730 | 9.566.684 | 99.547 | 5.955.793 | 145,895,941 |
| 2020 | 102.715.770 | 35.339.772 | 10.050.465 | 92.121 | 6.445.801 | 154,643,930 |
| 2021 | 108.505.354 | 37.331.814 | 10.354.247 | 84.695 | 6.935.809 | 163,391,919 |
| 2022 | 114.294.938 | 39.323.856 | 11.018.028 | 77.269 | 7.425.817 | 172,139,908 |

The calculation results of the estimated amount of electricity consumption using the linear regression method will obtain the amount of electrical energy requirements of Merauke Regency in 2022 amounting to 17,139,908 KWh with an average increase of 5.8% per year. The amount of electricity needs consisted of the Household Sector amounting to 114,294,938, Business Sector amounting to 39,323,856 KWh, Office Sector amounting to 11,018,028 KWh, Industrial Sector amounting to 77,269 KWh and Social Sector amounting to 7,425,817 KWh. The calculation results of Energy Needs using the Linear Regression method when compared with the results of Calculation of Electricity Usage Planning from PT. PLN Merauke Regency by using software can be illustrated with a graph below:

**Figure 1.** Estimated Electricity Needs of Merauke Regency

In 2022, the amount of electricity needs from PT. PLN is 191,561,088 KWh. From the data from the calculation of linear regression of 172,139,908 KWh there is a difference of 11% less than the
calculation results using the application by PT. PLN. From these results, it can be said that the calculation of electricity needs using the Linear Regression Method is still feasible to use.

4. Conclusion
The analysis results of the estimated electrical energy needs of Merauke Regency by using linear regression, it can be concluded that the electrical energy requirements of Merauke Regency from 2018-2022 tend to increase except in the Industrial Sector. For the estimation of 2018 the amount of the electricity needs of Merauke Regency is 137,147,952 KWh while for 2022 the amount is 17,139,908 KWh, with an average increase of 5.84% per year.

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