Forecasting electricity consumers and consumption in 2019-2050 to prevent electricity waste and reduce use of fossil fuels

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Abstract. Electricity demand of Bangka Belitung Islands Province from time to time always increases. This is caused by the fact that electricity has become an important part of human civilization in various fields including the fields of economy, technology, social and human culture. Electricity distribution to consumers must be optimal in accordance with the needs of the community and industry. Problems will arise if the power sent from a power plant is far greater than the demand at the load, there will be an energy waste in the electricity company and a swelling use of fossil energy as a fuel generator because most of the power plants in Bangka Belitung Islands Province use fossil energy. To avoid these problems, we need a forecast method. This study used the least square method and linear regression that produces electricity consumers and electricity consumption forecasts in Bangka Belitung Islands Province in 2050 which is estimated to be 3,412554 GWh with an average increase of 3.7% every year.

1. Introduction

Electricity consumption of Bangka Belitung Islands Province always increases. This is due to the fact that electricity has become an important part of human civilization in various fields including the fields of economy, technology, social and human culture. The need for electricity continues to grow every year. Besides population growth, economic growth in a region is believed to be one of the factors that influence the increase in electricity consumption in the area. This condition certainly must be anticipated so that the availability of electricity can be available in sufficient quantities.

The limitations and constraints of electric distribution in Bangka Belitung Islands Province are due to the fact that there are many small islands separated by the sea so it is very difficult to distribute electricity from the main sources on Bangka Island. [1] These constraints also cause a large supply of electricity in Bangka Belitung Islands Province which is still highly dependent on fossil energy such as the PLTU Air Anyir in Bangka Regency and the PLTD Toboali in South Bangka. [2],[3].

Based on the above conditions, the need for electricity distribution to consumers must be optimal in accordance with the large needs of the community and industry in the area. Problems will arise if the power sent from a power plant is far greater than the power demand on the load, there will be energy waste in the electricity company. Therefore, strategies and methods for forecasting are needed in adjusting the fulfillment of power demand. In order to achieve a balance between generation and
demand, the electricity provider in Bangka Belitung Islands Province must know the load for the future by forecasting the electricity load.

To avoid an electricity crisis in Bangka Belitung Islands Province, a forecast model is needed as a first step to develop the electricity system by conducting an electricity demand forecast in the coming years. So that it can know the electricity supply needed and the right time to increase the electricity supply. This study used the least square and linear regression.

Previous research that has discussed electricity forecasting was performed by R Mahendara et al, but was limited to Bangka Island using LEAP Software [4] (Long-range Energy Alternative Planning System) [5]. LEAP is claimed to be able to provide diverse information such as climate change mitigation assessments and energy policy analysis in order to get information about greenhouse gas emissions, energy consumption, and production for each sector load and others. [6]

The initial data of this research were taken from the 2014 – 2018 electricity consumers and electricity consumption data in the Bangka – Belitung Province and this data is provided by PT. PLN (Persero) Babel. The data is analyzed by POM-QM software for electricity consumers and electricity consumption forcast 2019-2050.

2. Basic Theory
2.1. Load Flow Analysis
Electric power system load is the consumption of electricity from consumers. Therefore, the load and its changes depend on the needs of consumers. There are three groups of load forecasting, namely: A. Long Term Load Forecast for periods over one year, B. Medium Term Load Forecast for periods from one month to one year, and C. Short Term Load Forecast for a period of several hours until one week [7]

2.2. Least Square Method
The least square method is the most widely used method for determining trend data equations. [8] The least square method is divided into two cases, namely even data cases and odd data cases. Trend equation with least square method is as follows: [9]

\[ Y_n = a + (b \times X) \]

Description:
- \( Y_n \): Forecast
- \( a \): Constant
- \( b \): Slope
- \( X \): Period

The \( X \) values of even data are \( ......., -5, -3, -1, 1, 3, 5, ........ \)
The \( X \) values of odd data are \( ......., -3, -2, -1, 0, 1, 2, 3, ....... \)

To calculate the values of \( a \) and \( b \), the following formula is used:

\[ a = \frac{\sum Y}{n} \]

\[ b = \frac{\sum XY}{\sum X^2} \]

Description:
- \( \sum XY \): The cumulative time multiplied by historical data
- \( \sum X^2 \): Squared total period
- \( \sum Y \): Total data
- \( N \): The number of period (years)
2.3. Linear Regression Method

Regression analysis is widely used in data analysis for various disciplines because the mathematical equation is able to explain the relationship between dependent and independent variables. [10] The linear regression method shows cause and effect for the forecast. This method is used to estimate in the future by finding and measuring several independent variables and their effects on the independent variables that will be estimated. The equation for linear regression is as follows:

\[ Y_n = a + (b \cdot X) \]  

\[ a = \frac{(\sum y)(\sum x^2) - (\sum x)(\sum xy)}{n(\sum x^2) - (\sum x)^2} \]  

\[ b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \]

Description:
- \(Y_n\) : Forecast
- \(a\) : Constant
- \(b\) : Slope
- \(X\) : Independent variable for \(X = 1, 2, 3, \ldots, n\)

3. Results and Discussion.

3.1. Forecasting Electricity Consumers in Bangka Island

The following are the results of electricity consumers forecast in Bangka Island:

| Year | Total Consumers | Percentage of increase (%) | Year | Total Consumers | Percentage of increase (%) |
|------|----------------|-----------------------------|------|----------------|-----------------------------|
| 2019 | 372318         | 6.4                         | 2035 | 720738         | 3.1                         |
| 2020 | 394094         | 5.8                         | 2036 | 742515         | 3.0                         |
| 2021 | 415872         | 5.5                         | 2037 | 764290         | 2.9                         |
| 2022 | 437647         | 5.2                         | 2038 | 786067         | 2.8                         |
| 2023 | 459423         | 5.0                         | 2039 | 818882         | 4.2                         |
| 2024 | 481199         | 4.7                         | 2040 | 829618         | 1.3                         |
| 2025 | 502974         | 4.5                         | 2041 | 851396         | 2.6                         |
| 2026 | 524753         | 4.3                         | 2042 | 873171         | 2.6                         |
| 2027 | 546528         | 4.1                         | 2043 | 894947         | 2.5                         |
| 2028 | 568305         | 4.0                         | 2044 | 916723         | 2.4                         |
| 2029 | 590080         | 3.8                         | 2045 | 938498         | 2.4                         |
| 2030 | 611856         | 3.7                         | 2046 | 960277         | 2.3                         |
| 2031 | 633634         | 3.6                         | 2047 | 982052         | 2.3                         |
| 2032 | 655409         | 3.4                         | 2048 | 1003829        | 2.2                         |
| 2033 | 677185         | 3.3                         | 2049 | 1025604        | 2.2                         |
| 2034 | 698961         | 3.2                         | 2050 | 1047380        | 2.1                         |

Based on the forecast, total electricity consumers on Bangka Island in 2050 are estimated to 1,047,380 consumers with an average increase of 3.5%.
3.2. **Forecasting electricity consumers in Belitung Island**

The following are the results of electricity consumers forecast in Belitung Island:

| Year | Total (MWh) | Percentage of Increase (%) | Year | Total (MWh) | Percentage of Increase (%) |
|------|-------------|----------------------------|------|-------------|----------------------------|
| 2019 | 103840      | 5.3                        | 2035 | 190169      | 2.9                        |
| 2020 | 109237      | 5.2                        | 2036 | 195564      | 2.8                        |
| 2021 | 114631      | 4.9                        | 2037 | 200958      | 2.8                        |
| 2022 | 120026      | 4.7                        | 2038 | 206355      | 2.7                        |
| 2023 | 125422      | 4.5                        | 2039 | 211750      | 2.6                        |
| 2024 | 130818      | 4.3                        | 2040 | 217147      | 2.5                        |
| 2025 | 136214      | 4.1                        | 2041 | 222541      | 2.5                        |
| 2026 | 141609      | 4.0                        | 2042 | 227936      | 2.4                        |
| 2027 | 147003      | 3.8                        | 2043 | 233332      | 2.4                        |
| 2028 | 152400      | 3.7                        | 2044 | 238728      | 2.3                        |
| 2029 | 157795      | 3.5                        | 2045 | 244124      | 2.3                        |
| 2030 | 163192      | 3.4                        | 2046 | 249519      | 2.2                        |
| 2031 | 168586      | 3.3                        | 2047 | 254913      | 2.2                        |
| 2032 | 173981      | 3.2                        | 2048 | 260310      | 2.1                        |
| 2033 | 179377      | 3.1                        | 2049 | 265705      | 2.1                        |
| 2034 | 184773      | 3.0                        | 2050 | 271102      | 2.0                        |

Based on the forecast, total electricity consumers on Belitung Island in 2050 are estimated to 271,102 consumers with an average increase of 3.2 %.

3.3. **Forecasting Total Electricity Consumers in Bangka Belitung Islands Province**

Based on two tables above, electricity consumers in Bangka Belitung Islands Province in 2050 are estimated to 1,318,482 consumers with an average increase of 3.4 %

3.4. **Forecasting Total Electricity Consumption in Bangka Island**

The following are the results of total electricity consumption forecast in Bangka Island:

| Year | Total (MWh) | Percentage of Increase (%) | Year | Total (MWh) | Percentage of Increase (%) |
|------|-------------|----------------------------|------|-------------|----------------------------|
| 2019 | 892.853     | 8.4                        | 2035 | 1856.968    | 3.4                        |
| 2020 | 953.11      | 6.7                        | 2036 | 1917.222    | 3.2                        |
| 2021 | 1013.367    | 6.3                        | 2037 | 1977.476    | 3.1                        |
| 2022 | 1073.624    | 5.9                        | 2038 | 2037.74     | 3.0                        |
| 2023 | 1133.881    | 5.6                        | 2039 | 2097.994    | 3.0                        |
| 2024 | 1194.138    | 5.3                        | 2040 | 2158.248    | 2.9                        |
| 2025 | 1254.395    | 5.0                        | 2041 | 2218.512    | 2.8                        |
| 2026 | 1314.652    | 4.8                        | 2042 | 2278.766    | 2.7                        |
| 2027 | 1374.909    | 4.6                        | 2043 | 2339.02     | 2.6                        |
| 2028 | 1435.166    | 4.4                        | 2044 | 2399.274    | 2.6                        |
| 2029 | 1495.423    | 4.2                        | 2045 | 2459.538    | 2.5                        |
| 2030 | 1555.68     | 4.0                        | 2046 | 2519.792    | 2.4                        |
| 2031 | 1615.937    | 3.9                        | 2047 | 2580.046    | 2.4                        |
| 2032 | 1676.194    | 3.7                        | 2048 | 2640.31     | 2.3                        |
| 2033 | 1736.451    | 3.6                        | 2049 | 2700.564    | 2.3                        |
| 2034 | 1796.708    | 3.5                        | 2050 | 2760.818    | 2.2                        |
Based on the forecast, total electricity consumption in Bangka Island in 2050 is estimated to 2.468 GWh with an average increase of 3.9%.

### 3.5. Forecasting Total Electricity Consumption in Belitung Island

The following are the results of total electricity consumption forecast in Belitung Island:

| Year | Total (MWh) | Percentage of Increase (%) | Year | Total (MWh) | Percentage of Increase (%) |
|------|-------------|----------------------------|------|-------------|----------------------------|
| 2019 | 247.93      | 5.1                        | 2035 | 456.346     | 2.9                        |
| 2020 | 260.956     | 5.3                        | 2036 | 469.372     | 2.9                        |
| 2021 | 273.982     | 5.0                        | 2037 | 482.398     | 2.8                        |
| 2022 | 287.008     | 4.8                        | 2038 | 495.424     | 2.7                        |
| 2023 | 300.034     | 4.5                        | 2039 | 508.45      | 2.6                        |
| 2024 | 313.06      | 4.3                        | 2040 | 521.476     | 2.6                        |
| 2025 | 326.086     | 4.2                        | 2041 | 534.502     | 2.5                        |
| 2026 | 339.112     | 4.0                        | 2042 | 547.528     | 2.4                        |
| 2027 | 352.138     | 3.8                        | 2043 | 560.554     | 2.4                        |
| 2028 | 365.164     | 3.7                        | 2044 | 573.58      | 2.3                        |
| 2029 | 378.19      | 3.6                        | 2045 | 586.606     | 2.3                        |
| 2030 | 391.216     | 3.4                        | 2046 | 599.632     | 2.2                        |
| 2031 | 404.242     | 3.3                        | 2047 | 612.658     | 2.2                        |
| 2032 | 417.268     | 3.2                        | 2048 | 625.684     | 2.1                        |
| 2033 | 430.294     | 3.1                        | 2049 | 638.71      | 2.1                        |
| 2034 | 443.32      | 3.0                        | 2050 | 651.736     | 2.0                        |

The average increase was 3.2%, but the percentage of increase from year to year tends to decrease. Based on the forecast, total electricity consumption in Bangka Island in 2050 is estimated to 651.736 MWh.

### 3.6. Total Electricity Consumption in Bangka Belitung Islands Province

Based on two tables above, total electricity consumption in Bangka Belitung Islands Province in 2050 is estimated to 3,412,554 GWh with an average increase of 3.7%.

### 4. Conclusion

From the study conducted, it can be concluded that electricity consumers in Bangka Belitung Islands Province in 2050 are estimated to 1,318,482 consumers with electricity consumers in Bangka Island are 1,047,380 consumers and 271,102 consumers in Belitung Island and electricity consumption in Bangka Belitung Islands Province in 2050 is estimated to 3,412,554 GWh with electricity consumption in Bangka Island is 2.468 GWh and 651.736 MWh in Belitung Island.

### References

[1] Tiandho Y, Dinata I, Sunanda W, Gusa RF and Novitasari D 2019 Solar energy potential in Bangka Belitung Islands, Indonesia IOP Conf. Ser.: Earth Environ. Sci. 257 012022

[2] Yofianti D and Yukho HA 2019 Utilization of FABA Waste from coal combustion at the PLTU Air Anyir as an alternative to local construction materials IOP Conf. Ser.: Earth Environ. Sci. 353 012027

[3] Khoirun, Asmar, Puriza MY, Kurniawan R, Tiandho Y and Siregar EM 2019 Feasibility Study on The Operation of Toboali Substation to Reduce The Use of Fossil Fuels as Power Plants and Energy Loss by Computer Simulation IOP Conf. Ser.: Earth Environ. Sci. 353 012022

[4] Mahendra R, Gusa RF, Sunanda W, Asmar and Arkan F 2019 Forecasting the electrical energy
needs in Bangka Island *IOP Conf. Ser.: Earth Environ. Sci.* **353** 012058

[5] Windarta J, Purwanggono B and Hidayanto F 2018 Application of LEAP model on long-term electricity demand forecasting in Indonesia, period 2010-2025 *SHS Web of Conf.* **49** 02007

[6] Raouz K 2015 *Morocco’s Energy System Forecasted Using LEAP* (Stockholm: Royal Institute Of Technology) p 3

[7] Putra CP, Tuegeh M, Tumaliang H, and Patras LS 2014 Analisa Pertumbuhan Beban Terhadap Ketersediaan Energi Listrik di Sistem Kelistrikan Sulawesi Selatan *Jurnal Teknik Elektro dan Komputer* **3** pp 1-12

[8] See JJ, Jamaian SS, Salleh RM, Nor ME and Aman F 2018 Parameter estimation of Monod model by the Least-Squares method for microalgae Botryococcus Braunii sp *IOP Conf. Series: Journal of Physics* **995** 012026

[9] Sadli M and Safwandi 2017 Implementasi Sistem Cerdas Least Square dalam Meramalkan Pemenuhan Kebutuhan Stok Listrik di Kota Lhokseumawe *J.Ecotipe* **4** pp 21-9

[10] Wahab NS et al 2018 A Technique of Fuzzy C-Mean in Multiple Linear Regression Model toward Paddy Yield *J. Phys.: Conf. Ser.* **995** 012010

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