Analysis of use and need of sectoral electrical power and energy in West Java Region

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Abstract. The current and future usage and power needs of electricity are important in electricity utilities. This study aims to predict the amount of power and electricity usage and demand from various sectors in order to be used as a reference and an overview of the amount of sectoral load and electrical energy needs in the West Java region in the future. The method for determining the estimated electrical load and energy requirements can be calculated by a combined method (analytical, econometric and trend) and a simple linear regression method with a sectoral approach by grouping customers into five sectors (household, business, industrial, general and social). The findings of the study using the combined method of the percentage of the amount of power connected by 5.46% with an error of 4.42%, and the amount of energy sold at 4.78% with an error of 4.49%. Whereas by using the regression method the percentage of total connected power is 5.27% with an error of 3.54%, and the amount of energy sold is 4.24% with an error of 3.98%. By doing these forecasts it is hoped that the future electricity needs can be met.

1. Introduction
Electricity changes every day due to modern civilization and technological advancements [1]. Where along with increasing population growth in an area each year, making the need for electrical energy has increased in accordance with population growth and regional economic growth. The growth of these two conditions will lead to an increase in demand for electricity and the need for electricity reserves for the next few years. This is to anticipate power cuts, especially at peak load times. Thus, it requires development in the field of electrical energy to balance the demands and needs of a region.

Estimates of electricity consumption and demand for electricity in the next decade or two are important in electricity utilities [2,3]. Forecast in the future is needed to determine and estimate the amount of load needed so that it can prepare the electricity generation capacity needed to anticipate the growing demand for electrical energy demand in the future [1,4]. In addition, load forecasts help electricity utilities to make important decisions, including decisions on purchasing and generating electricity, the development of transmission and distribution infrastructure [5].

Factors that influence the use of loads are such as population, weather forecasts, and others. This is done by using the value of the demand for electricity in the future by mostly estimating past load consumption and considering other factors that influence the amount of electricity load used in an area [6]. Load forecasting is a method of estimating the electrical load required by consumers [7].
The aim is to balance the electricity supply from the demand for electricity. Medium-term load forecast is a load forecast for a period of one month to one year, which is used to determine the planning of both the transmission and distribution network expansion planning and the addition of a new electricity center. And the long-term load forecast is the estimated load over a period of over one year, which is used for planning and forecasting the condition of the electricity grid in the future and determining energy needs in the future [8,9]. Short-term, medium-term and long-term forecasts in the demand forecast load requirements, are indispensable for the correct operation of the electric utility and are also needed for proper scheduling activities, such as scheduling generator operation, maintenance scheduling and scheduling of electricity investment in the future [10]. In this study, we predict the amount of power and electricity usage and demand from various sectors as a reference and an overview of the amount of sectoral load and electrical energy needs in the West Java region in the future.

2. Methods

2.1. Research design

Research "Forecast Analysis of Long-Term Electricity Load Needs for Various Sectors in PT. West Java Regional PLN" is using a quantitative approach, which is to determine how large the number of customers, connected power, and energy sold per sectoral from 2018 to 2022. In this study, the method used is to compare the results of the number of customers, connected power, and energy sold by sector from 2018 to 2022 using the combined method with the regression method.

There are several data findings that become the main data for data processing. The data will be input for calculations using Microsoft Office Excel software. Data obtained in the form of data on the population of West Java last 5 years, West Java GRDP data of the last 5 years contained in West Java BPS data and data on the number of customers, connected power data, energy data sold per sectoral contained in the data ESDM electricity system. The following are data obtained from the West Java BPS data and the EMR Electricity System in 2013 to 2017 showed as Table 1, Table 2, and Table 3.

Table 1. Number of customers, connected power and electricity energy sold.

| Sector      | Number of Customers | Connected Power (MVA) | Sold Energy (MWh) | Number of Customers | Connected Power (MVA) | Sold Energy (MWh) |
|-------------|---------------------|-----------------------|-------------------|---------------------|-----------------------|-------------------|
| Household   | 9,698,695           | 8,189,72              | 14,486,340        | 12,388,399          | 10,858,71             | 17,555,200        |
| Business    | 310,838             | 2,847,01              | 3,398,560         | 506,173             | 3,591,92              | 5,231,900         |
| Industry    | 12,471              | 6,246,44              | 19,879,770        | 14,590              | 7,948,31              | 22,956,680        |
| Public /    | 50,675              | 301,65                | 587,030           | 79,087              | 406,59                | 730,510           |
| Public      |                     |                       |                   |                     |                       |                   |
| Social      | 203,449             | 413,99                | 529,960           | 265,362             | 661,48                | 951,150           |
| Total       | 10,276,128          | 17,998,81             | 38,881,660        | 13,253,611          | 23,467,00             | 47,425,440        |

Table 2. Data of growth rate of gross regional domestic product of ADHK 2010.

| Year  | Total         | Growth (%) |
|-------|---------------|------------|
| 2013  | 1,093,543,55  | -          |
| 2014  | 1,149,216,06  | 5,09       |
| 2015  | 1,207,232,34  | 5,05       |
| 2016  | 1,276,627,64  | 5,75       |
| 2017  | 1,342,953,38  | 5,20       |
| Growth Rate | 5,27       |            |
Table 3. Data on population numbers.

| Year | Total Population | Average Population Growth |
|------|------------------|---------------------------|
| 2013 | 45,340,799       | 1.56                      |
| 2014 | 46,029,668       | 1.52                      |
| 2015 | 46,709,569       | 1.48                      |
| 2016 | 47,379,389       | 1.43                      |
| 2017 | 48,037,827       | 1.39                      |

Average population growth 1.476

2.2. Forecast phase with combined method

In calculating the estimated electrical energy requirements for each sector, it is determined by data that has been obtained previously, while the variables used are as follows: Total Population, Electricity customers, Connected Power, and Energy Consumption [11].

Estimates of total energy consumption (ET) are obtained from the sum of energy consumption in the household (RT), industry (I), business (B), general (U), and social (S) sectors expressed by the equation (1) as in [11], that is,

\[ ET_t = ERT_t + EI_t + EB_t + EU_t + ES_t \]

2.3. Forecasting phase with a simple linear regression method

Simple linear regression is a method used to test the extent of the relationship between the cause variable \(X\) and the effect variable \(Y\). Simple linear regression (Simple Linear Regression) is a statistical method that is often used in production both for predicting or estimating the characteristics of quality and quantity [12].

The linear regression equation model is like the equation (2):

\[ Y = A + BX \]

The cause variable used is the period of year \(X\) that will be predicted and the consequent variable is the household expense \(Y\), industry \(Y\), business \(Y\), general \(Y\) and social \(Y\), on electricity customers, connected power, and energy is sold [12].

2.4. Accuracy value forecast

The accuracy of the forecast is a very important thing in the forecast where, the data that already exists with the forecast data is measured accordingly. There are several calculations that can be used to calculate the estimated error rate of the total. There are three most well-known calculations in calculating forecast errors including the mean absolute deviation (MAD), mean square error (MSE), and the mean absolute percent error (MAPE) [13].

\[ MAD = \frac{\sum_{t=1}^{n} |X_t - F_t|}{n} \]  \hspace{1cm} (3)

\[ MSE = \frac{\sum_{t=1}^{n} (X_t - F_t)^2}{n} \]  \hspace{1cm} (4)

\[ MSE = \left(\frac{100\%}{n}\right) \frac{\sum_{t=1}^{n} |X_t - F_t|}{n} \]  \hspace{1cm} (5)

3. Results and discussion

Based on the results of the calculation of the number of residents and the need for electrical energy loads for the number of customers, connected power and energy sold sectorally from the West Java BPS data and ESDM electricity system data. From the results of the study obtained data as follows:
Table 4. Forecast of population of West Java in 2018 – 2022.

| Year | Population | Average Population Growth |
|------|------------|---------------------------|
| 2018 | 48,746,865 | 1.48                      |
| 2019 | 49,466,369 | 1.48                      |
| 2020 | 50,196,493 | 1.48                      |
| 2021 | 50,937,393 | 1.48                      |
| 2022 | 51,689,229 | 1.48                      |

In Table 4, the population of West Java in 2018 - 2022 increases in income every year with an average increase of 1.48% and the estimated population in 2022 is 51,689,229.

Table 5. Forecast results of West Java electric energy load needs for the period 2018-2022 using the combined method and regression method.

| Information | Combined | Regression |
|-------------|----------|------------|
|             | Year     | Year       | Rate   | Year     | Rate   |
| Total population | 2018 | 48,746,865 | 48,746,865 | 2022 | 51,689,229 | 51,689,229 |
| Number of Customers | 2018 | 13,704,888 | 13,704,888 | 2022 | 17,010,507 | 17,010,507 |
| Household | 2018 | 13,041,362 | 13,041,362 | 2022 | 16,015,996 | 16,015,996 |
| Business | 2018 | 561,594 | 561,594 | 2022 | 850,972 | 850,972 |
| Industry | 2018 | 15,077 | 15,077 | 2022 | 17,193 | 17,193 |
| Public / Public | 2018 | 86,855 | 86,855 | 2022 | 126,346 | 126,346 |
| Social | 2018 | 280,562 | 280,562 | 2022 | 350,582 | 350,582 |
| Connected Power (MVA) | 2018 | 24,132,35 | 24,132,35 | 2022 | 30,596,45 | 30,596,45 |
| Household | 2018 | 11,416,58 | 11,416,58 | 2022 | 14,098,69 | 14,098,69 |
| Business | 2018 | 4,058,94 | 4,058,94 | 2022 | 6,497,46 | 6,497,46 |
| Industry | 2018 | 8,207,57 | 8,207,57 | 2022 | 9,334,07 | 9,334,07 |
| Public / Public | 2018 | 449,27 | 449,27 | 2022 | 666,23 | 666,23 |
| Social | 2018 | 695,73 | 695,73 | 2022 | 853,53 | 853,53 |
| Sold Energy (MWh) | 2018 | 48,841,539 | 48,841,539 | 2022 | 59,896,476 | 59,896,476 |
| Household | 2018 | 18,428,240 | 18,428,240 | 2022 | 22,376,708 | 22,376,708 |
| Business | 2018 | 4,058,94 | 4,058,94 | 2022 | 6,497,46 | 6,497,46 |
| Industry | 2018 | 8,207,57 | 8,207,57 | 2022 | 9,334,07 | 9,334,07 |
| Public / Public | 2018 | 449,27 | 449,27 | 2022 | 666,23 | 666,23 |
| Social | 2018 | 695,73 | 695,73 | 2022 | 853,53 | 853,53 |

Figure 1. shows that the results of forecasts using the regression method of population increases each year are proportional to the increase in the need for electrical energy load each year which covers the number of customers, connected power and energy sold. However, for the amount of energy sold in excess of the population of West Java this is because each year the need for energy sold is increasing where the industrial sector has the greatest need for energy needs sold each year. Table 5 also shows that the average total growth rate of all sectors for the number of customers is 5.14%, while the average total growth of all sectors for the total connected power is 5.27%, and the average growth rate for all sectors for all sectors the amount of energy sold was 4.24%.
Figure 1. Graph of increase in population by increasing electricity load needs for 2018-2022 by the combined and regression methods.

Table 6. Comparison of the accuracy of forecasting the combined method with the regression method.

| No | Information          | Error  | Combined         | Regression        |
|----|----------------------|--------|------------------|-------------------|
| 1  | Number of Customers  | MAD    | 13.671,60        | 36.800,80         |
|    |                      | MSE    | 435.747,560,80   | 3.605,602,610     |
|    |                      | MAPE   | 2.59             | 3.38              |
| 2  | Connected Power      | MAD    | 150.596          | 138.04            |
|    |                      | MSE    | 38.165,76        | 36.566            |
|    |                      | MAPE   | 4.42             | 3.54              |
| 3  | Sold Energy          | MAD    | 308.070,20       | 353.641,80        |
|    |                      | MSE    | 240.580,808,055  | 268.353,459,910   |
|    |                      | MAPE   | 4.49             | 3.98              |

Table 6. illustrates that:
- The estimated error rate of all customers in all sectors using the combined method has a relatively smaller error rate compared to the estimated number of customers using the regression method. Where if seen from the error level of the mape model the estimated number of customers with the combined method has an error value of 2.59% while the regression method has an error value of 3.38%. These results show that the accuracy of the estimated number of sectoral customers with the combined method is more accurate than the regression method.
- The error rate for power connected to all sectors by the combined method has a relatively greater error rate compared to the power forecast connected to the regression method. Where if seen from the error level of the mape model the power forecast connected to the combined method has an error value of 4.42% while the regression method has an error value of 3.54%. From these results, it is shown that the accuracy of the sectoral connected power forecast by the regression method is more accurate than the combined method.
- The estimated error rate of energy sold by all sectors using the combined method has a relatively higher error rate compared to the estimated energy sold by the regression method. Where if seen...
from the error level of the MAPE model the estimated energy sold by the combined method has an error value of 4.49% while the regression method has an error value of 3.98%. From these results, it shows that the accuracy of the energy forecast sold by the sectoral regression method is more accurate than the combined method.

4. Conclusions
Based on the results of a research analysis of the forecast needs of the West Java regional electrical energy load the authors conclude the following matters. The estimated electricity demand for the next 5 years using the combined method is for the number of sectoral customers of 17,023,702, the sectoral connected power of 30,335.33 MVA, and the energy sold by the sector at 58,366,380 MWh. The results of the calculation of the forecast needs of the West Java regional electrical energy load from 2018 to 2022 obtained the results of the regression method for the average growth rate of all sectors, namely the number of customers by 5.14% with an estimated error value of the MAPE model of 3.38%, the amount of connected power is 5.27% with the estimated MAPE model error value of 3.54%, and the amount of energy sold is 4.24% with the estimated MAPE model error value of 3.98%. The increasing number of populations each year is proportional to the increase in electricity energy needs each year which includes the number of customers, connected power, and energy sold per sectoral (household, business, industrial, general and social sectors). The estimates of the connected power and energy sold the sectoral method of regression is more accurate than using the combined method.

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