Analysis of electric load forecasting using combined method (Study case 2019 – 2029 in PT. PLN (Persero) UP3 Sukabumi)

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Abstract. The purpose of this study is to find out how much electric load to Sukabumi from 2019 until 2029 at PT. PLN (Persero) UP3 Sukabumi. Forecasting of electrical load using historical data. This research uses a combined method, which is a method compiled by combining several models such as econometrics, analysis, and trends with a sectoral approach, which is an approach by grouping electricity consumers into four sectors, namely the resident, commercial, public, and industrial sectors. The population forecast of Sukabumi in 2019-2029 shows an average growth of 0.36% per year. Gross Regional Domestic Product (GRDP) for resident sector growth of 6.26% per year, commercial sector growth of 6.26% per year, public sector growth of 6.26% per year, and the industrial sector growth of 10.07% per year. The electric customers for the resident sector growth of 5.26%, commercial sector growth of 13.96% per year, public sector growth of 7.58% per year, and industrial sector growth of 3.53% per year. The electric contracted power for the resident sector growth of 5.19% per year, commercial sector growth of 14.96% per year, public sector growth of 7.28% per year, and industrial sector growth of 3.36% per year. Growth of population, GRDP, number of electric customers, and power contracted, as shown in forecasting 2019-2029, will affect to increasing electrical load. The total electrical load will be 1,054.22 MVA in 2019 and 2,043.80 MVA in 2029 or growth of 6.74% per year

1. Introduction
The Electric load forecasting means estimating future electricity demand, which has broad application prospects in areas such as power system operations and planning, revenue management, energy trading, etc. [1]. Electric load forecasting can be divided by time scales, which include long-term forecasting, medium-term forecasting, and short-term forecasting. In general, a long-term prediction is based on year as the time scale, and its main periodic regularity is the year to year variability. Medium-term forecasting is based on month as the time scale, and its main regular routine is the seasonality of month. Short-term forecasting is based on day or hour as the time scale, and its main periodic regularity is the intraday cycle and the intraweek cycle [2].

The increasing of demand for electric load in long term forecasting can be caused by population growth, economic growth of the community [3,4], growth in the number and behaviour of electric customers [5], as well as massive socio-demographic development soon so that it needs to supply and distribute adequate electricity both technically and economically [6].

The accurate peak load forecasting is a critical role in preventing a blackout or loss of energy [7]. Therefore, forecasting electrical load needs must be by the characteristics of each area in increasing
accuracy optimization [8]. To optimization the forecasting accuracy, many researchers have developed models and techniques a variety of algorithm [9-14].

However, these models generally lead to estimates of performance that are not yet fully optimal. Therefore, it is significant to study the combined forecasting method that is carried out by combining several models such as econometrics, analysis, and trends with a sectoral approach, which is an approach by classifying consumers into four sectors, namely households, industry, commercial, and public.

Based on data, the average population growth of Sukabumi was 0.36% [15,16], and the average GRDP growth of Sukabumi was 4.43% [17,18]. The number of electric customers also increased until 4.7%, and the growth of power connected at Sukabumi was 5.52%. Besides that, the Sukabumi region is currently incessantly carrying out developments such as airports, dual-rail lines, highways, Sukabumi toll Southern Ring Road, and housing. So, with the many activities and factors mentioned above, this paper study analysis Electric load using combined method (study case 2019 - 2029 in PT. PLN (Persero) UP3 Sukabumi).

2. Methods
This study uses quantitative descriptive methods with data collections of population, GRDP, number electricity customers, power contracted. It was then classifying data into four sectors, namely households, industry, commercial, and the public, to be forecasted by considering development planning for 2019-2029. The data used in this study were obtained from the Central Statistics Agency of the City and District of Sukabumi and PT. PLN (Persero) UP3 Sukabumi.

![Research flow diagram]

Figure 1. Research flow diagram.

3. Results and discussion

3.1. Results
The population of Sukabumi increased from 2014 to 2018. The average growth was 0.36%.
Table 1. Sukabumi population in 2014 – 2018.

| Year | City Population | District Population | Total Population |
|------|-----------------|---------------------|------------------|
| 2014 | 315.001         | 2.422.113           | 2.737.114        |
| 2015 | 318.117         | 2.434.221           | 2.752.338        |
| 2016 | 321.097         | 2.444.616           | 2.765.713        |
| 2017 | 323.788         | 2.453.498           | 2.777.286        |
| 2018 | 326.282         | 2.460.693           | 2.786.975        |

The GRDP data per sector from 2014 – 2018 had increased. Average GRDP growth of the residential area was 4.43%; commercial sector GRDP was 4.74%; public sector GRDP was 4.97%, and industrial sector GRDP was 5.97%

Table 2. Sukabumi GRDP per sector 2014 – 2018.

| GRDP       | 2014          | 2015          | 2016          | 2017           | 2018           |
|------------|---------------|---------------|---------------|----------------|----------------|
| Resident   | 42.165.036,73 | 44.259.587,20 | 46.826.490,51 | 49.473.038,28  | 52.316.651,69  |
| Commercial | 23.425.217,89 | 24.867.529,25 | 26.253.778,30 | 27.951.231,90  | 29.495.926,30  |
| Public     | 3.904.465,48  | 4.200.985,86  | 4.473.020,20  | 4.763.221,18   | 4.967.467,70   |
| Industry   | 5.774.830,39  | 6.074.042,98  | 6.492.554,78  | 6.993.802,82   | 7.698.265,40   |

Each electric customers from various sectors had increased. The average growth of electric customers in the residential area was 3.73%; commercial sector electric customers were 10.58%; public sector electric customers was 3.42%, and industrial sector electric customers was 2.10%.

Table 3. The number of Sukabumi electric customers in 2014 – 2018.

| Description | Year 2014 | Year 2015 | Year 2016 | Year 2017 | Year 2018 |
|-------------|-----------|-----------|-----------|-----------|-----------|
| Number of Customer | 677.910   | 722.083   | 750.278   | 788.437   | 830.548   |
| Resident    | 638.079   | 679.904   | 703.086   | 734.755   | 772.363   |
| Commercial  | 17.064    | 17.831    | 20.910    | 25.307    | 27.870    |
| Public      | 22.253    | 23.823    | 25.743    | 27.822    | 29.745    |
| Industry    | 514       | 525       | 539       | 553       | 570       |

The power contracted of Sukabumi had increased. The average growth of resident power contracted was 4.55%; commercial sector power contracted was 5.63%; public sector power contracted was 7.92%; and industrial sector power contracted was 7.63%.

Table 4. Power contracted in Sukabumi per sector in 2014 – 2018 (VA).

| Description | Year 2014 | Year 2015 | Year 2016 | Year 2017 | Year 2018 |
|-------------|-----------|-----------|-----------|-----------|-----------|
| Power       | 754.731.220 | 848.509.170 | 893.027.670 | 941.064.870 | 997.900.320 |
| Contracted  | 452.098.600 | 469.339.950 | 505.267.150 | 532.740.400 | 563.960.100 |
| Resident    | 96.674.300  | 100.738.050 | 108.656.450 | 118.800.150 | 126.821.550 |
| Commercial  | 28.833.070  | 30.730.620  | 34.069.420  | 37.587.420  | 42.041.070  |
| Public      | 187.125.250 | 237.700.550 | 245.034.650 | 251.936.900 | 265.077.600 |

3.2. Discussion
The population forecast of Sukabumi in 2019-2029 shows an average growth of 0.36% per year based on historical growth data from 2014 to 2018.
Indonesian’s national GRDP target will be 6.26% in 2024, so the average GRDP forecast of Sukabumi in 2019-2029 for resident sector growth of 6.26% per year, commercial sector growth of 6.26% per year, public sector growth of 6.26% per year, and the industrial sector growth of 10.07% per year.

![Sukabumi Population Forecast](image)

![Sukabumi GRDP Forecast](image)

**Figure 2.** (a) Sukabumi Population Forecast 2019-2029; (b) Sukabumi GRDP Forecast 2019-2029

The electric customers forecast of Sukabumi in 2019-2029 for the resident sector growth of 5.26%; commercial sector growth of 13.96% per year, public sector growth of 7.58% per year, and industrial sector growth of 3.53% per year.

The electric contracted power of Sukabumi in 2019-2029 for the resident sector growth of 5.19% per year; commercial sector growth of 14.96% per year, public sector growth of 7.28% per year, and industrial sector growth of 3.36% per year.
Algorithm

- **Step 1**: Determine the electric load of resident sector \( S_{R,n} \) of the ‘n’ year

  \[
  S_{R,n} = S_{R,n-1} + \left( \left( N_{R,n} - N_{R,n-1} \right) \times \bar{x}_R \right) \quad (1)
  \]

  where \( N_{R,n} \) is defined as the electric customers resident sector of ‘n’ year, \( \bar{x}_R \) is average power contracted per number customer of resident sector from 2014 until 2018.

  \[
  \bar{x}_R = \frac{S_R(2014)}{N_R(2014)} + \frac{S_R(2015)}{N_R(2015)} + \cdots + \frac{S_R(2018)}{N_R(2018)} \quad (2)
  \]

- **Step 2**: Determine the electric load of commercial sector \( S_{C,n} \) of the ‘n’ year

  \[
  S_{C,n} = S_{C,n-1} + \left( \left( N_{C,n} - N_{C,n-1} \right) \times \bar{x}_C \right) \quad (3)
  \]
where \( N_{C_n} \) is defined as the electric customers commercial sector of ‘n’ year, \( \bar{x}_C \) is average power contracted per number customer of commercial sector from 2014 until 2018.

\[
\bar{x}_C = \frac{S_C(2014)}{N_C(2014)} + \frac{S_C(2015)}{N_C(2015)} + \ldots + \frac{S_C(2018)}{N_C(2018)} \tag{4}
\]

- **Step 3**: Determine the electric load of public sector \( S_{P_n} \) of the ‘n’ year

\[
S_{P_n} = S_{P_{n-1}} + \left( (N_{P_n} - N_{P_{n-1}}) \times \bar{x}_P \right) \tag{5}
\]

where \( N_{P_n} \) is defined as the electric customers public sector of ‘n’ year, \( \bar{x}_P \) is average power contracted per number customer of public sector from 2014 until 2018.

\[
\bar{x}_P = \frac{S_P(2014)}{N_P(2014)} + \frac{S_P(2015)}{N_P(2015)} + \ldots + \frac{S_P(2018)}{N_P(2018)} \tag{6}
\]

- **Step 4**: Determine the electric load of industry sector \( S_{I_n} \) of the ‘n’ year

\[
S_{I_n} = S_{I_{n-1}} + \left( (N_{I_n} - N_{I_{n-1}}) \times \bar{x}_I \right) \tag{7}
\]

where \( N_{I_n} \) is defined as the electric customers industry sector of ‘n’ year, \( \bar{x}_C \) is average power contracted per number customer of industry sector from 2014 until 2018.

\[
\bar{x}_I = \frac{S_I(2014)}{N_I(2014)} + \frac{S_I(2015)}{N_I(2015)} + \ldots + \frac{S_I(2018)}{N_I(2018)} \tag{8}
\]

- **Step 5**: Calculate the total electric load of all sector \( S_n \) of the ‘n’ year

\[
S_n = S_{P_n} + S_{I_n} + S_{P_n} + S_{I_n} \tag{9}
\]

\( N_C = \text{Number customer of commercial sector} \)

Growth of population, GRDP, number of electric customers, and power contracted as shown in forecasting 2019-2029 will affect to increasing electric load or demand (S).

**Table 5. Forecast of Total Electric load of Sukabumi 2019-2029**

| Year | Total Electric Load | Growth (%) |
|------|---------------------|------------|
| 2019 | 1.054.222.166,43    | 5,64       |
| 2020 | 1.115.615.364,15    | 5,82       |
| 2021 | 1.182.710.253,94    | 6,01       |
| 2022 | 1.256.237.112,50    | 6,22       |
| 2023 | 1.337.044.431,71    | 6,43       |
| 2024 | 1.426.120.893,43    | 6,66       |
| 2025 | 1.524.621.840,54    | 6,91       |
| 2026 | 1.633.901.229,03    | 7,17       |
| 2027 | 1.755.550.273,53    | 7,45       |
| 2028 | 1.891.444.282,24    | 7,74       |
| 2029 | 2.043.799.529,71    | 8,05       |
Total electric load or demand will be 1,054.22 MVA in 2019 and 2,043.80 MVA in 2029 or growth of 6.74% per year.

4. Conclusion
The population forecast of Sukabumi in 2019-2029 shows an average increase of 0.36% per year. Gross Regional Domestic Product (GRDP) for resident sector growth of 6.26% per year, commercial sector growth of 6.26% per year, public sector growth of 6.26% per year, and the industrial sector growth of 10.07% per year. The electric customers for the resident sector growth of 5.26%, commercial sector growth of 13.96% per year, public sector growth of 7.58% per year, and industrial sector growth of 3.53% per year. The electric contracted power for the resident sector growth of 5.19% per year, commercial sector growth of 14.96% per year, public sector growth of 7.28% per year, and industrial sector growth of 3.36% per year.

Growth of population, GRDP, number of electric customers, and power contracted, as shown in forecasting 2019-2029, will affect to increasing electrical load or demand. Total electrical load or demand will be 1,054.22 MVA in 2019 and 2,043.80 MVA in 2029 or growth of 6.74% per year.

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