FORECASTING ANALYSIS ON ELECTRICITY DEMAND IN THE SPECIAL REGION OF YOGYAKARTA UNDER THE IMPACT OF THE COVID-19 PANDEMIC

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Abstract

The COVID-19 pandemic as a global pandemic on 2020 has encouraged the Indonesian Government to establish pandemic response policies in many provinces. The policies that had been restricting mobility during the pandemic showed significant impacts in many aspects in the Special Region of Yogyakarta. A shifting pattern in electricity consumption can be seen as the growth of economic sectors in the GDP encountered contraction after the decline of community mobility. Electricity demand forecasting is required to analyze the impact of the COVID-19 pandemic by applying three scenarios, specifically an unlikely pandemic scenario or Business As Usual (BAU), moderate scenario (MOD), and optimistic scenario (OPT). Also, the household, industrial, business, social, and public sectors are analyzed in order to see the shifting pattern in electricity consumption through the scenarios that have been given. Energy modeling is conducted with Low Emission Analysis Platform (LEAP) software to analyze electricity demand forecasting from 2019 to 2030 based on the three scenarios. The results show that the electricity demand in 2030, according to BAU, MOD, and OPT scenarios, in the amount of 5,301.58 GWh, 4,489.11 GWh, and 4,648.12 GWh, respectively. According to the MOD and OPT scenarios, the electricity demands of the household and industrial sectors will increase relative to the BAU scenario. Meanwhile, according to both scenarios, the electricity demands of the business and social sectors will decrease. In the public sector, the MOD scenario shows the decline of electricity demand relative to the BAU scenario, while OPT scenario shows the opposite.

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1. Introduction

COVID-19 (Coronavirus Disease 2019) pandemic is a widespread epidemic caused by the novel coronavirus that was declared a global pandemic by The World Health Organization (WHO) on March 11, 2020 (Cucinotta & Vanelli, 2020). The appearance of 69 positive cases of COVID-19 in Indonesia has encouraged the Indonesian Government to establish Rapid-Response Team on March 13, 2020 (Vermonte & Wicaksono, 2020). After discovering COVID-19 widespread in some provinces in Indonesia, the government decided to implement large-scale social restrictions (PSBB) policy to minimize the spread of COVID-19. The local government of the Special Region of Yogyakarta (SRY) implemented the Disaster Emergency Response Status of COVID 19 based on Governor Decision No. 65/KEP/2020 on March 20, 2020. On January 11, 2021, the local government issued Governor Instruction No. 2/INSRT/2021 to implement the limited tightening of community activities (PSTKM) policy with specific health protocols. Due to the impact of those policies, government and private offices adjusted The Working From Home (WFH) scheme for their employees (Mungkasa, 2020).

The policies to handle the pandemic that restricted community mobilities have significantly impacted electricity demand (Sugiyono et al., 2020). The decline of community mobility due to the policies has caused a decrease in electricity consumption in the industrial, office, and business sectors, while in the households sector, the electricity consumption increased because of an increase in work and daily activities at home. Some companies could not carry out production and had to experience financial difficulties to pay regular fixed costs such as minimum electricity costs and employee support costs (Muhyiddin & Nugroho, 2021). Due to the high fixed costs, many companies decided to stop production with high energy use characteristics. The consequences of the decline in production were that some people lost their jobs and income, coupled with restrictions on mobility. The government decided to give electricity subsidies to raise purchasing power for communities that will contribute to economic growth.

The study regarding the changes in energy consumption after the outbreak of COVID-19 has been conducted by researchers worldwide. The impact of the COVID-19 pandemic on the electricity sector in the USA showed a decline of 6.36-10.24% in April and 4.44-10.71% in Mei (Ruan, et al., 2020). In Canada, the average household daily electricity consumption indicated a 12.1% increase after the lockdown in 2020 relative to 2019 (Abdeen et al., 2021). The electricity consumption in Spain also decreased by 13.49% from March 14 to April 30, compared to the average value of the previous five years (Santiago et al., 2021). The electricity demand in Kuwait was also depressed slightly in 2020 compared to 2019, when the energy demand fell by 0.1%, while the minimum load grew by 5.3% compared to 2019 (Al-Abdullah et al., 2021). The overall electricity demand in Ontario declined by 14% in April 2020, totaling 1267 GW. However, GHG emission was reduced by 40,000 tonnes of CO_2 and savings of $131,844 for April (Abu-Rayash & Dincer, 2020). From the various recent studies, the impact of the COVID-19 pandemic presents a unique opportunity to analyze scenarios of the pre-and post-COVID-19 pandemic on projected electricity consumption.

This study aims to analyze the electricity demand forecast from 2019 to 2030 in SRY. By looking at the shifting pattern of electricity demand since the outbreak of COVID-19, it can be seen that there was a 6.97% increase in electricity demand from 2019 in the households sector. There were an 11.31% decline and a 7.03% decline in the business and industrial sector, respectively (PT PLN (Persero), 2020). Therefore, it is required for this research to provide the current condition by taking into account the impact of the COVID-19 pandemic and economic recovery on electricity demand forecasting.

2. Methodology

This study was conducted after the concerning impact of the COVID-19 outbreak had emerged. The emergence of COVID-19 needs to be reconsidered in the current condition to provide better measurement in long-term projections. Several stages of this study were conducted as follows:

a. Study of Literatures

The fundamental theories, journals, reports, and outlooks were required to better approach and broad understanding of the study.

b. Data Collection

The required data were obtained from the Central Bureau of Statistics of SRY, PT PLN (Persero), and the Ministry of Energy and Mineral Resources, which provided historical data on growth domestic productivity (GDP), intensity energy, population, and the number of households.

c. Data Processing

The forecasting method was determined based on the data type that should follow a long-term trend pattern. An accurate forecasting method should make fewer errors between observed and expected values.

d. Scenario Analysis

Scenario analysis focuses on the best estimates under different scenarios. The comparison between scenarios was analyzed and explained to conclude. The overall study flow is shown in Figure 1.

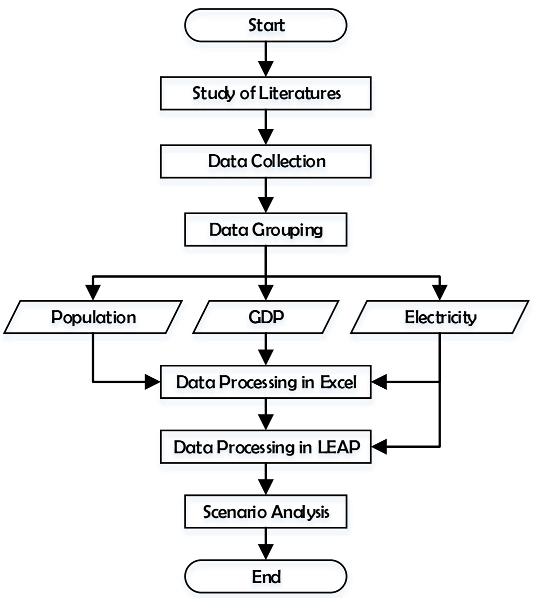

Figure 1. Flowchart of research methodology

2.1. Forecasting Method

Forecasting is a technique that uses historical data as inputs to determine the direction of future trends (Tuovila, 2020). It involves generating a number or scenario that corresponds to a future occurrence. The degree of closeness between estimated and actual values must be measured to determine its accuracy. Therefore, the forecast results should represent the event that will happen. Seven steps have been conducted to get accurate forecast results as follows (Heizer & Render, 2011):

1) Determining the use of the forecast.
2) Selecting the items to be forecasted.
3) Determining the time horizon of the forecast.
4) Selecting the forecasting model(s).
5) Gathering the data.
6) Making the forecast.
7) Validating and implementing results.

Trend analysis is a technique used to predict future direction based on observed trend data (Hayes, 2021). In this study, trend analysis was used to look at the growth rate of the estimated value. The growth rate from the exponential trend model was assumed as the actual value growth rate started from the first-year projection. The mathematical model of an exponential trend is shown in Equation 1.

$$f(t) = b_0 e^{b_1 t} \tag{1}$$

where f(t) is the trend value at year-t, b_0 is the intercept term, b_1 is the trend line slope, and t is the year projection.

The measurement for validation was conducted by estimating the value of Mean Absolute Percentage Error (MAPE) for the time-series forecasting model. Using MAPE only as the way for validation is sufficient to describe forecasting accuracy (Hong et al., 2016). The details of forecasting error calculation using MAPE are shown in Equation 2.

$$MAPE = \sum_{i=1}^{n} \frac{100 \times |A_i - F_i| / A_i}{n} \tag{2}$$

Where A_i is the actual value, F_i is the forecast value, and n is the number of times the summation iteration happens.

The forecast can be highly accurate if the MAPE value is less than 10% (Lewis, 1982). The lower the MAPE value, the better the forecast, but no specific value can be called "good" or "bad". However, the value of MAPE can be interpreted as shown in Table 1.

Table 1. Interpretation of typical MAPE values

MAPE	Interpretation
< 10	Highly accurate forecasting
10 - 20	Good forecasting
20 - 50	Reasonable forecasting
> 50	Inaccurate forecasting

2.2. Energy Modelling

Electricity consumption, as the research object, can reflect changes in the energy sector during the pandemic. It is the best indicator to evaluate how much society can be affected or recovered (Wang, Li, & Jiang, 2021). Energy-economic modeling is commonly used for energy policy studies and long-term impact analysis on electricity demand. The economic aspects can be considered to understand better changes in energy systems in the residential, industrial, commercial, social, and public sectors (Nakata, 2004).

Low Emissions Analysis Platform (LEAP) is an integrated modeling tool based on scenarios that track and analyze energy consumption, production, and resource extraction in many sectors of an economy (Heaps, 2020). Energy demand forecasting can be conducted with the LEAP program by examining the activity levels and energy intensities. Thus, the scenarios can be determined and represented by the users who want to demonstrate their research's designed policies. The planning model of energy demand is shown in Figure 2.

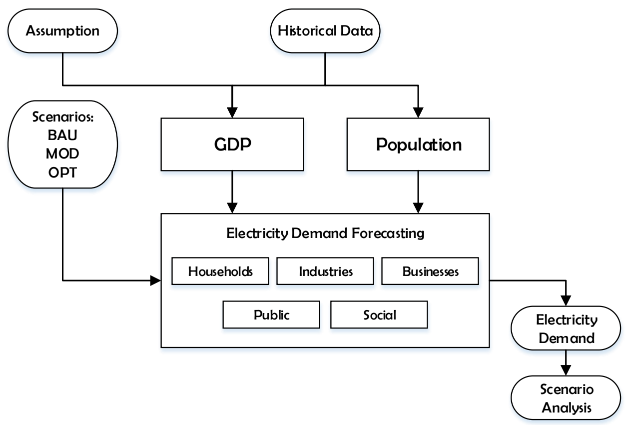

Figure 2. Planning model of electricity demand forecasting

Electricity demand analysis is calculated for each year and sector. Electricity demand in a given sector is calculated by multiplying its overall activity level by its energy intensity, as shown in Equation 3.

$$\mathrm{ED_{b,s,t}} = \sum\nolimits_{\mathrm{b,s,t}} \left(\mathrm{TA_{b,s,t}} \times \mathrm{EI_{b,s,t}}\right) \tag{3}$$

Where ED is electricity demand, TA is total activity, EI is energy intensity, b is a branch, s is a scenario, and t is a year.

Energy intensity is the energy consumption of a branch per unit of activity level, while activities typically are defined as a single absolute value (e.g., the number of households or GDP) multiplied by a series of shares or saturations. The equation calculates energy intensity:

$$\mathrm{EI_{b,t}} = \frac{\mathrm{EC_{b,t}}}{\mathrm{TC_{b,t}}} \tag{4}$$

$$\mathrm{EI_{b,t}} = \frac{\mathrm{EC_{b,t}}}{\mathrm{GDP_{b,t}}} \tag{5}$$

Where EI is energy intensity, EC is electricity consumption, TC is total customers, GDP is a gross domestic product, b is the sector, and t is a year.

2.3. Scenario Development

Scenarios are generated by considering all possible factors and impacts. Building forecasts based on scenarios allows a wide range of possible forecasts to be generated and some extremes to be identified (Hyndman & Athanasopoulos, 2018). In this study, three scenarios have been designed to examine the impact of the COVID-19 pandemic and economic recovery in SRY over the 2019-2030 period, i.e., the business as usual scenario (BAU), and the moderate scenario (MOD), and the optimistic scenario (OPT).

In the BAU scenario, assumptions must be followed as follows:

- The annual population growth rate is 0.5657% based on the population census (SP) 2010 and 2020.
- The average household size was 3.00 in 2019, but the size will decrease gradually by -0.4349% every year, which is extrapolated based on the trend of historical data.
- The growth rate for each economic sector in GDP is calculated from the model trend that has been projected based on historical data for the period 2010-2019.
- The growth rate of energy intensity of households, industrial, commercial, social, and public sectors is 0.4611%, -0.6801%, 3.1357%, 2,0530%, and -1.0883%, respectively, based on the growth rate of each trend.

MOD scenario is based on a situation in which the impact of the COVID-19 pandemic has caused economic and social disruption. Determining the projection of electricity demand requires the following assumptions:

- The annual population growth rate is 0.5657%.
- The average household size was 3.00 in 2019, but the size will decrease gradually by -0.4349% every year, which is extrapolated based on the trend of historical data.
- The growth rate for each economic sector in GDP is calculated from the average growth rate over the 2010-2021 period without including the growth rate in 2020.
- The growth rate of energy intensity of households, industrial, commercial, social, and public sectors starting from 2021 is 0.5209%, 0.2135%, 1.5276%, 1.4780%, and 0.9138%, respectively, based on the average growth rate over the 2010-2021 period without including the growth rate in 2020.

OPT scenario is based on the same situation as the MOD scenario, but with a target to achieve in 2030 that the GDP will not remain below pre-pandemic trends for a prolonged period. Assuming a certain value of growth rate needs to be achieved in order to hit the baseline of the BAU scenario in 2030, then the assumption for growth rate is as follows:

- The annual population growth rate is 0.5657%.
- The average household size was 3.00 in 2019, but the size will decrease gradually by -0.4349% every year, which is extrapolated based on the trend of historical data.
- The growth rate for each economic sector in GDP will be targeted to a certain value that can accelerate GDP to hit the baseline of the BAU scenario.
- The growth rate of energy intensity for OPT scenario is assumed to have the same value equal to the MOD scenario

3. Results & Discussion

3.1. Population and Household

Assuming the annual population growth rate of SRY is 0.5657%, and the average household size will decrease by -0.4349%, the projected population and household can be estimated as shown in Table 2.

3.2. Growth Domestic Product

The GDP (constant prices 2010) of SRY in BAU and OPT scenario will reach Rp190,083,434.75 million in 2030, while the MOD scenario shows that the GDP will reach Rp179,053,806.21 million. The average growth rate of the BAU scenario over the 2019-2030 period is approximately 5.59%, while the average growth rate of MOD dan OPT scenario for the period 2021-2030 is about 5.82% and 6.46%, respectively. The GDP in OPT scenario is encouraged to meet a certain criteria to reach the same value as in the BAU scenario. The estimated value of GDP is shown in Table 3.

Table 2 Forecast of population and household

Year	Population	Average Household Size	Household
2019	3,648,081	3.00	1,217,733
2020	3,668,719	2.92	1,254,844
2021	3,689,473	2.93	1,258,044
2022	3,710,345	2.92	1,270,686
2023	3,731,335	2.90	1,286,079
2024	3,752,444	2.88	1,301,659
2025	3,773,672	2.86	1,317,427
2026	3,795,020	2.85	1,333,386
2027	3,816,489	2.83	1,349,539
2028	3,838,079	2.81	1,365,887
2029	3,859,792	2.79	1,382,434
2030	3,881,627	2.77	1,399,180

Table 3. Forecast of GDP (Constant Prices 2010)

Year	GDP (million Rupiahs)		
	BAU	MOD	OPT
2019	104,485,457.43	104,485,457.43	104,485,457.43
2020	110,220,871.48	101,683,520.00	101,683,520.00
2021	116,294,991.20	107,308,555.00	107,308,555.00
2022	122,728,506.26	113,440,764.99	114,169,418.67
2023	129,543,396.03	119,964,015.51	121,518,030.09
2024	136,763,011.16	126,904,788.65	129,391,020.89
2025	144,412,160.36	134,291,434.79	137,827,883.49
2026	152,517,202.79	142,154,308.51	146,871,201.37
2027	161,106,146.27	150,525,914.60	156,566,898.39
2028	170,208,751.88	159,441,064.99	166,964,508.73
2029	179,856,645.20	168,937,047.32	178,117,469.07
2030	190,083,434.75	179,053,806.21	190,083,435.02

In the BAU scenario, as shown in Figure 3, the growth rate of the information and communication sector will grow by 7.0365% in 2019, and it will contribute 11.19% to the GDP in 2019 or equivalent to Rp11,694,991.75 million, and then will be 13% or up to Rp24,708,830.62 million in 2030. This achievement will be the highest compared to the other sectors. The contribution to GDP in 2030 will be followed by the construction sector up to 11.99% or Rp22,787,730.52 million. The accommodation and food service sector will contribute 10.71% to the GDP or up to Rp20,364,034.10 million in 2030 will exceed the contribution of the manufacturing sector that will contribute up to 10.70% Rp20,339,644.51 million.

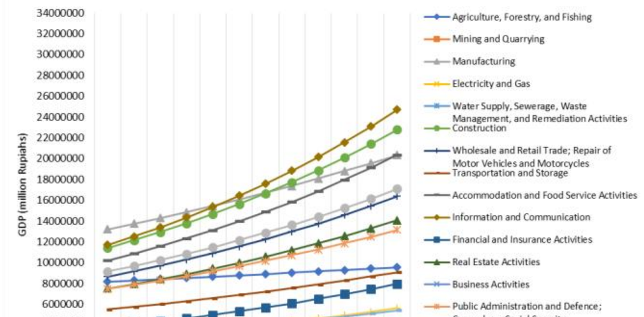

Figure 3. Forecast of GDP components in BAU scenario

The forecast in the MOD scenario in Figure 4 shows that the information and communication sector will grow by 8.28% in 2021. It will be the most significant contributor, up to 18.67% or equivalent to Rp33,422,807.21 million in 2030. The construction sector will also exceed the manufacturing sector's contribution in 2026 and will be the second-largest contributor to the GDP, up to 11.42% or Rp20,449,280.39 million in 2030. As the third-largest contributor, the manufacturing sector will contribute 9.85% or Rp17,627,861.67 million in 2030.

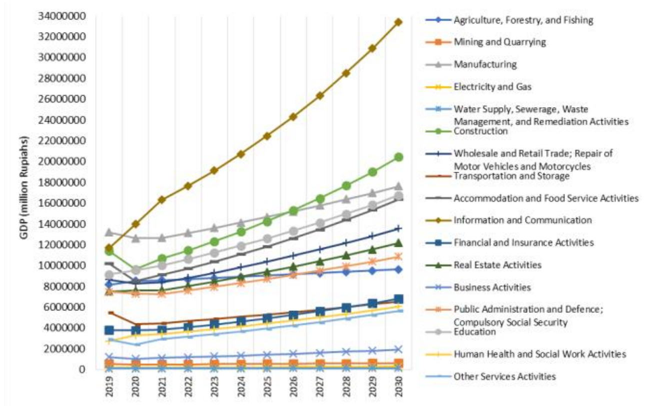

Figure 4. Forecast of GDP components in MOD scenario

OPT scenario in Figure 5 shows that the components of GDP will grow by a certain value to hit the baseline of the BAU scenario. The information and communications sector will remain the most significant contributor to the GDP from 2019-to 2030. The construction sector will take second place in 2027, exceeding the manufacturing sector.

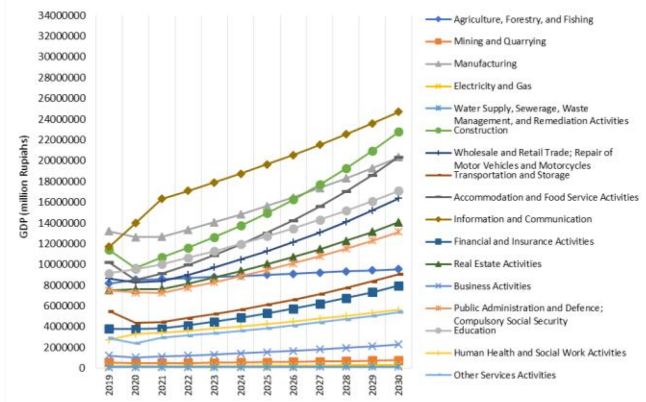

Figure 5. Forecast of GDP components in OPT scenario

3.3. Energy Intensity

The economic sectors of GDP are grouped into the format of group tariff structures, as shown in Table 4. The energi intensity for the household sector is based on the ratio between the energy consumption of the household sector and the number of households. For other sectors, the energy intensity is defined as the amount of consumed energy per unit of GDP.

Table 4. Classification of GDP components by electricity sector

Electricity Sectors	Components of GDP
Industry	**Manufacturing**
Business	Agriculture, Forestry, and Fishing
	Mining and Quarrying
	Electricity and Gas
	Water Supply, Sewerage, Waste Management, and Remediation Activities
	Construction
	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
	Transportation and Storage
	Accommodation and Food Service Activities
	Information and Communication
	Financial and Insurance Activities
	Real Estate Activities
	Business Activities
Social	Education
	Human Health and Social Work Activities
Public	Public Administration and Defence; Compulsory Social Security

The growth of households determines the growth of electricity consumption for the household sector, while GDP growth determines electricity consumption growth for other sectors. Therefore, the energy intensity for the BAU scenario can be determined in Table 5. The energy intensity for the MOD and OPT scenarios is given with the same criteria to see how extent the electricity demand can be affected by economic growth. The energy intensity for MOD and OPT scenarios is given in Table 6.

Table 5. Energy Intensity by sector in BAU scenario

Year	Energy Intensity (kWh/household)	Energy Intensity (kWh/million Rupiah)			
	Household	Industry	Business	Social	Public
2019	1,382	19.92	10.94	22.38	17.04
2020	1,388	19.79	11.29	22.84	16.86
2021	1,395	19.65	11.64	23.3	16.67
2022	1,401	19.52	12.01	23.78	16.49
2023	1,407	19.39	12.38	24.27	16.31
2024	1,414	19.25	12.77	24.77	16.13
2025	1,421	19.12	13.17	25.28	15.96
2026	1,427	18.99	13.58	25.8	15.78
2027	1,434	18.86	14.01	26.33	15.61
2028	1,440	18.74	14.45	26.87	15.44
2029	1,447	18.61	14.9	27.42	15.27
2030	1,454	18.48	15.37	27.98	15.11

Table 6. Energy intensity by sector in MOD and OPT scenario

Year	Energy Intensity (kWh/household)	Energy Intensity (kWh/million Rupiah)			
	Household	Industry	Business	Social	Public
2019	1,382	19.92	10.94	22.38	17.04
2020	1,418	19.37	10.13	18.42	17.77
2021	1,415	20.95	9.47	18.23	17.60
2022	1,422	21.00	9.62	18.50	17.44
2023	1,430	21.04	9.76	18.78	17.28
2024	1,437	21.09	9.91	19.05	17.12
2025	1,445	21.13	10.07	19.33	16.96
2026	1,452	21.18	10.22	19.62	16.81
2027	1,460	21.22	10.38	19.91	16.65
2028	1,468	21.27	10.53	20.20	16.50
2029	1,475	21.31	10.69	20.50	16.35
2030	1,483	21.36	10.86	20.81	16.20

3.4. Electricity Demand

A. BAU Scenario

Figure 6 shows the electricity demand throughout the 2019-2030 period. In 2019, the household sector dominated electricity use up to 53.82% of total electricity, equal to 1,682.74 GWh. The share of the business sector was recorded at 25.17% of total electricity or 786.78 GWh, while the energy share of the industrial, social, and public sectors in 2019 was in the amount of 8.41% (263 GWh), 8.52% (266.53 GWh) and 4.08% (127.43 GWh), respectively.

The final electricity demand in 2030 is projected to reach 5,301.58 GWh, where the business sector will dominate the energy use in SRY, up to 38.81% of total electricity or equivalent to 2,057.70 GWh. The business sector demand is projected to grow by between 9.00-9.24%. On the other hand, the household sector will only dominate energy use until 2029, surpassing the business sector in 2030. The demand for the household sector in 2030 will reach 2,033.83 GWh or 38.36% of total electricity, and it will grow by approximately 1.68% every year.

The demand for the social sector is expected to grow by 8.21-8.23% over the 2019-2030 periode, and the energy share will be 11.99% or equal to 635.50 GWh. The growth rate of the industrial sector will be at a 3.30% pace for the period to 375.92 GWh in 2030. The public sector will only grow at a 4.12% pace, and the electricity demand will reach 198.64 GWh in 2030.

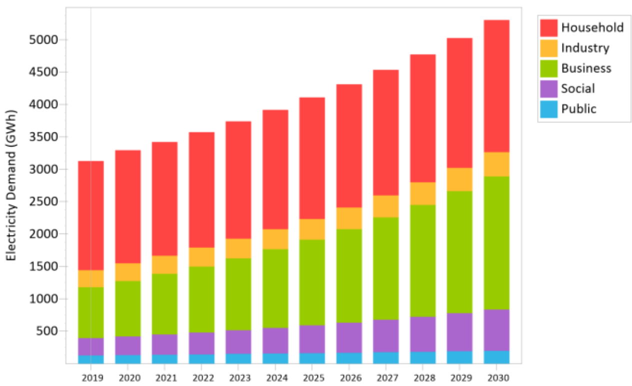

Figure 6. Forecast of electricity demand in BAU scenario

B. MOD Scenario

The projected electricity demand in the MOD scenario shown in Figure 7 is influenced by the contraction of GDP in 2020, which shows the shifting pattern in the electricity sector. The final electricity demand is predicted to reach 4,489.11 GWh in 2030 at a growth rate between 3.69-4.49%. The household sector will grow by approximately 1.74%. Moreover, the electricity demand of the household sector will dominate the energy use in SRY up to 46.21%, or equivalent to 2,074.42 GWh.

The business sector will be the second-largest to dominate 30.89% of total electricity or 1,386.57 GWh in 2030. The electricity demand of the social sector will reach 475.37 GWh in 2030, and the energy share will be 10.59% of the total electricity. The electricity demand for the industrial sector will grow at a 3.6% pace to reach 376.50 GWh in 2030, and the energy share will be 8.39% of total electricity. The public sector will have the least influence on electricity demand, which is expected to use 3.93% of total energy or 176.25 GWh in 2030.

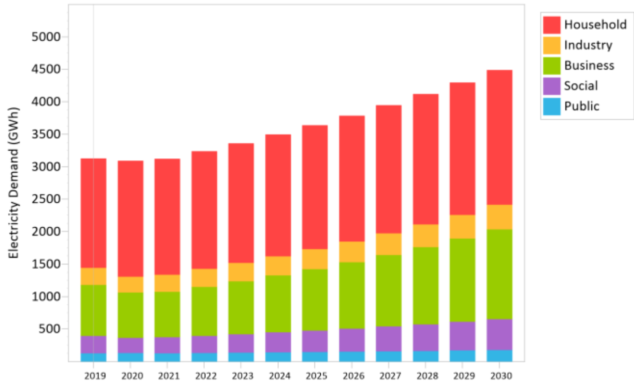

Figure 7. Forecast of electricity demand in MOD scenario

C. OPT Scenario

In the OPT scenario shown in Figure 8, the projected electricity demand is influenced by the economic recovery of GDP that will hit the baseline of the BAU scenario in 2030. The household sector will remain the largest demanding sector over the 2019-2030 periode, with 44.63% of total electricity. The electricity demand for the business sector will gradually grow by 8.23-8.68%, and the energy share will rise to 31.28%, or equal to 1,453.72 GWh in 2030.

The energy use of the social sector will be 10.17% or 472.54 of total energy, and the growth rate will remain at 7.53% for the projected period. The industrial sector is expected to reach 434.42 GWh in 2030, and the energy share will gradually increase to 9.35%. The public sector will use 4.58% of total energy or 213.02 GWh in 2030, expanding by approximately 5.81% annually.

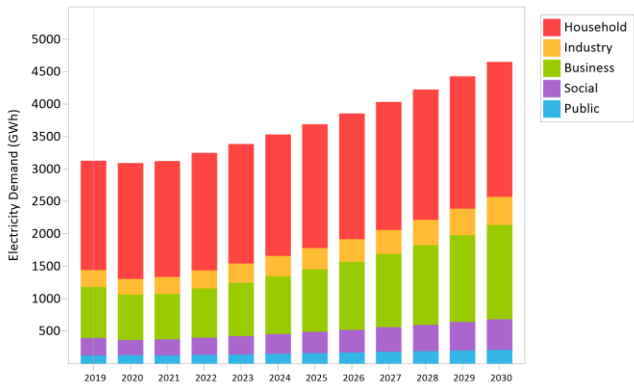

Figure 8. Forecast of electricity demand in OPT scenario

D. Total Electricity Demand by Scenario

The projected electricity demand in BAU, MOD, and OPT scenarios, as shown in Figure 9, will reach 5,301.58 GWh, 4,489.11 GWh, and 4,648.12 GWh in 2030, respectively. The growth rate of the BAU scenario will be in the amount of between 3.89-5.49% from 2019 to 2030.

On the other hand, the growth rate of OPT scenario is expected to be higher than the MOD scenario due to the implication of economic recovery. The electricity demand in the MOD scenario will grow by between 3.69-4.49%, while in OPT scenario, it will grow by 4.03-4.96%. Albeit relatively insignificant, there is a rise in the electricity demand in OPT scenario due to the encouragement of economic recovery.

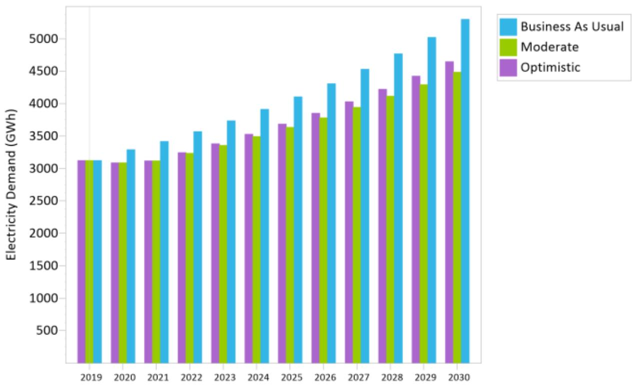

Figure 9. Forecast of total electricity demand by scenario

E. Household Sector

Figure 10 shows that the household sector in the MOD and OPT scenario is projected to rise by 1.53% in 2022, and it will grow by 1.74% over the 2019-2030 period. The electricity demand for MOD and OPT scenarios has exceeded the baseline of the BAU scenario, and it will remain the largest energy-demanding sector for the period. However, the projected electricity demand of the household sector in three scenarios indicates the declining energy share. One factor is slow population growth compared to the growth rate of other sectors.

Figure 10. Forecast of electricity demand in the household sector

F. Industrial Sector

Figure 11 shows that the implication of economic recovery in OPT scenario will boost the growth of the industrial sector. The annual growth rate in the MOD and OPT scenarios rose by 8.57% in 2021. However, the growth rate in OPT scenario is expected at 5.63% because of the encouragement of economic recovery in every sector of GDP. The electricity demand will grow by approximately 3.96% per year in the MOD scenario. The electricity demand in OPT scenario will be 15.56% higher than in the BAU scenario in 2030. At the same time, the difference in electricity demand between the MOD and BAU scenarios will not be significant. However, in 2030 the demand in the MOD scenario will exceed 0.15% of the demand in the BAU scenario.

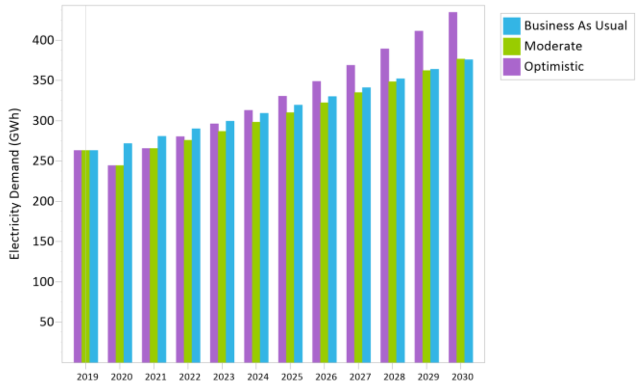

Figure 11. Forecast of electricity demand in the industrial sector

G. Business Sector

In Figure 12, the electricity demand in the MOD and OPT scenarios will not reach the baseline of the BAU scenario over the 2019-2030 period. The electricity demand in the BAU scenario will gradually grow by 9.00-9.24%, reaching 2,057.70 GWh. Meanwhile, the MOD and OPT scenario growth is expected at 7.73-8.05% and 8.23-8.68%, respectively. The electricity demand in the OPT scenario will reach 1,453.72 GWh or 29.35% lower than the BAU scenario, while the demand in the MOD scenario will reach 1,386.57 GWh or 32.62% lower BAU scenario.

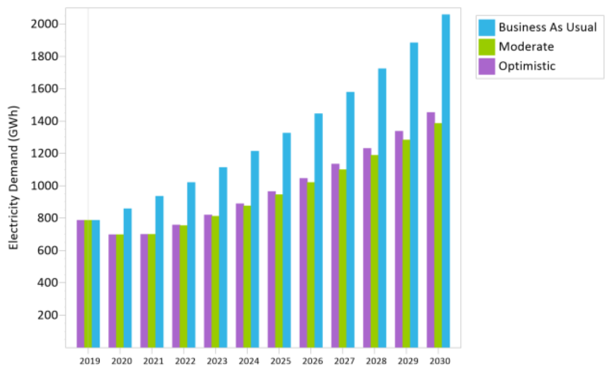

Figure 12. Forecast of electricity demand in the business sector

H. Social Sector

The BAU, MOD, and OPT scenario electricity demand will reach 635.50 GWh, 475.37 GWh, and 472.54 GWh. The demand in the BAU scenario will grow by between 8.21-8.23% for 2019-2030, while the growth in the MOD and OPT scenarios is expected at 7.61% and 7.54%, respectively. The increase in electricity demand for the social sector in the MOD scenario is influenced by GDP's health and education sectors.

An increase in the health sector will affect the more than the education sector in the social sector. The rise in the health sector will boost, influencing more in the MOD scenario more than in the OPT scenario. Figure 13 shows the bar chart of electricity demand in the social sector.

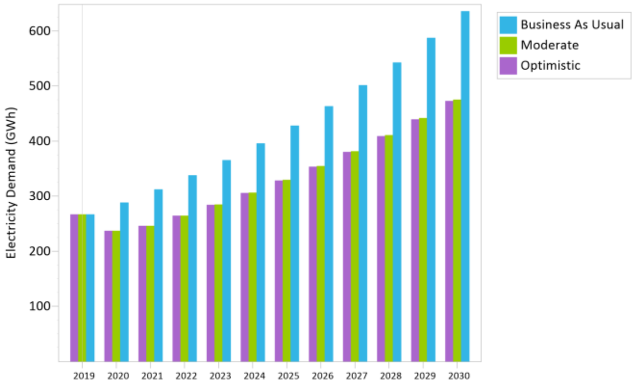

Figure 13. Forecast of electricity demand in the social sector

I. Public Sector

The OPT scenario's electricity demand will exceed the BAU scenario's baseline in 2026, as shown in Figure 14, while in the MOD scenario, it will not hit the baseline of the BAU scenario. The electricity demand in BAU, MOD, and OPT scenarios will be 198.64 GWh, 176.25 GWh, and 213.02 GWh, respectively. The economic recovery of the GDP will boost the growth of electricity demand up to 5.81%. In contrast, the growth in the MOD scenario is expected to range between 3.60-3.61%, and the growth in BAU is approximately 4.12% from 2019-to 2030. The OPT and BAU scenario range will exceed 7.24% higher for OPT scenario. The demand in the MOD scenario will be 11.27% lower than in the BAU scenario.

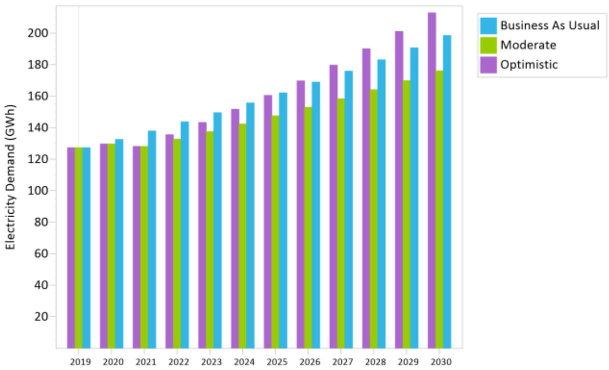

Figure 14. Forecast of electricity demand in the public sector

4. Conclusion

The electricity demand in BAU, MOD, and OPT scenarios will reach 5,301.58 GWh, 4,489.11 GWh, and 4,648.12 GWh. The implication of economic recovery in the OPT scenario will increase electricity demand which will be 3.42% higher in 2030 than in the MOD scenario. The electricity demand of the household sector in the MOD and OPT scenarios will be 2% higher than the baseline of the BAU scenario. The electricity demand of the industrial sector in the MOD scenario will be 0.15% higher than the BAU scenario in 2030, while the demand in the OPT scenario will significantly exceed 15.56% higher than the baseline. The electricity demand for the business sector in the MOD and OPT scenario will be 32.62% and 29.53% lower than the baseline. The electricity demand of the social sector in the MOD and OPT scenario will also be 25.20% and 25.64% lower than the baseline. The electricity demand of the public sector in the MOD scenario will be 11.27% lower than the baseline of the BAU scenario. However, it will be 7.24% higher than the baseline in the OPT scenario.

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