Forecasting Electricity Consumption And Its Relationship With Climate Change In Pekanbaru City

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Abstract*–Global warming which results in climate change resulting in an increase in air temperature and rainfall is a major problem in the world, especially Pekanbaru City. The significant increase in air temperature and rainfall recently has resulted in increased electricity consumption in Pekanbaru City. So forecasting air temperature, rainfall, and electricity consumption as well as the relationship between each of these variables is needed so that in the future society can adapt and mitigate. The aim of this research is to predict changes in air temperature, rainfall, and electricity consumption and to find out how much influence air temperature and rainfall have on electricity consumption in Pekanbaru City. In predicting related variables, the method used is decomposition model forecasting and to determine the relationship between each variable, multiple linear regression analysis is used. The graph of forecast results for 2023 – 2027 shows a decreasing trend in air temperature and electricity consumption, while rainfall experiences an increasing trend. The regression results show that the effect of changes in air temperature and rainfall simultaneously on electricity consumption is 3.5%, then the results of the F test and t-test show an insignificant effect of changes in air temperature and rainfall on electricity consumption.

Keywords: Decomposition, Multiple Linear Regression, Forecasting, Electricity Consumption

I. INTRODUCTION

The need for electrical energy plays an important role in supporting the productivity of society and industry. Along with increasing population growth and development progress, the need for electrical energy continues to increase. This is proven in data related to climate change and electricity consumption which generally increases every period. So it is clear that electrical energy plays an important role in human life and development. There are many factors that influence the demand and consumption of electrical energy so climate change is a factor that cannot be ignored in its impact on electricity consumption.

Climate change is one of the most pressing global problems today. Greenhouse gas emissions covering the earth result in the trapping of the sun's heat. This then causes global warming. Climate change is characterized by increasing global temperatures, changes in rainfall patterns, and rising sea levels. Among the various impacts it causes, climate change can affect electricity demand and consumption[1].

Rising global temperatures can cause increased electricity consumption for various purposes. One example is the use of air conditioning which aims to maintain and condition indoor air temperature. Because higher temperatures can make a person feel uncomfortable and require the use of electrical equipment to cool the room. The increasing use of water pumps also affects the demand for electrical energy. This is because the need for clean water is increasingly scarce due to increasing global temperatures[2][3].

Increased rainfall makes temperatures cooler. This can make people feel uncomfortable and want to warm themselves. To warm themselves, people tend to use room heaters. Another example is the textile industry requires equipment to dry products and the food industry to dry food. Due to changes in rainfall, these industries are required to use more electricity to dry their products[2][3].

Indonesia is very vulnerable to the impacts of climate change, especially changes in air temperature and rainfall. This is because Indonesia has a warm and humid tropical climate, and has a large coastal area. People who depend on electrical energy tend to use more electricity due to high air temperatures. Based on research conducted by the University of Indonesia, an increase in global temperature of 1°C can cause an increase in household electricity consumption in Indonesia by 2.5%. An increase in global temperature of 2°C can cause an increase in household electricity consumption in Indonesia by 5%. Other research shows that climate change has a significant influence on household electrical energy consumption in Banten Province, both partially and simultaneously. Other research shows that as air temperature changes increase by 1 °C, electrical energy consumption in East Kalimantan generally increases by 9,851 MW[4][5][6].

The reciprocal relationship between air temperature and rainfall clearly influences electricity consumption in Indonesia. As the air temperature rises, rainfall will decrease. Conversely, as rainfall increases, the air temperature will decrease. Based on previous research, temperature comfort standards for humans in Indonesia, which are guided by SNI 03-6572-2001, recommend a comfortable temperature of 22.8° - 25.8°C TE (Effective

Temperature). The range of values can be simplified to a range between 23°C TE to 26°C TE[7].

Pekanbaru City has experienced significant climate change in the last few periods, followed by an increase in electricity consumption. It was noted that electricity consumption reached an average of 160.53 GWh, followed by air temperature and rainfall of 26.78 °C and 286.5 mm in 2022. Meanwhile, in 2021 electricity consumption will be average131.79 GWh followed by air temperature and rainfall of 26.91 °C and 262.42 mm. It is feared that the high difference in the value of electricity consumption in the last 2 years will continue to increase in subsequent periods. Based on previous research, increasing air temperature and rainfall have a positive effect on electricity consumption, resulting in increased electrical energy consumption. However, the results of this research showed that the effect was not significant.[8][9][10].

Based on these problems, further research is needed regarding the influence of climate change on electricity consumption and its forecasting in Pekanbaru City. The development of this research is to use data from all sectors related to the use of electrical energy, not only in the household sector. This is due to the high temperature and rainfall in Pekanbaru City in recent periods. The aim of this research is to predict changes in air temperature, rainfall, and electricity consumption and determine the relationship between each of these variables. Forecasting variables use the decomposition method, while to find out the relationship between each variable, the multiple linear regression method is used. The data used in this research is secondary data obtained from BPS Pekanbaru City for 2018 - 2022. The problem limitation of this research is that it only knows how much influence air temperature and rainfall variables have on electricity consumption in Pekanbaru City and does not discuss these variables other things that might affect electricity consumption.

II. Basics of Theory

A. Climate change

Climate change is a change in the physical conditions of the earth's atmosphere, such as the distribution of temperature and rainfall, and has a broad impact on various areas of human life. This change does not occur instantly but over a long period of time. LAPAN (National Institute of Aeronautics and Space) defines climate change as a change in the average of one or more weather components in certain areas. The term global climate change refers to climate changes that occur in all regions of the earth. The IPCC (Intergovernmental Panel on Climate Change) states that climate change refers to changes in average or statistically significant climate conditions at a location over a long period of time (usually decades or more). It is furthermore clear that climate change can be caused by internal natural processes, external forces, or human activities that continually change atmospheric composition and land use.[1].

B. Electricity Consumption

Electrical energy is one of society's most important needs. Almost every activity carried out uses electrical energy, both household and industrial. The need for electrical energy is proportional to the increase in population, and as the population increases, the need for electrical energy also increases. In addition, climate change has a positive impact on electrical energy consumption. This is proven by the many related studies that discuss this issue[6].

C. Relationship between Climate Change and Electricity Consumption

There is a close relationship between climate change and electricity consumption. Climate change causes global temperatures to increase, thereby causing an increase in electricity demand. This is because people need more energy to cool their homes and businesses. Global electricity consumption will increase by 2.2% every year in 2050. This increase is largely influenced by the increasing demand for electricity from various sectors. This was conveyed by the International Energy Agency (IEA) in its report regarding the impact of climate change on energy demand[11].

Rapidly increasing demand for cooling equipment in developing countries is a major contributor to the growth in electricity demand, and climate change is exacerbating the need for cooling. In emerging markets, demand for refrigeration means electricity demand is increasing, adding 2,800 TWh to global electricity demand by 2050 in STEPS. This increase in electricity consumption will have a negative impact on the environment. This is because traditional power plants, such as coal and oil power plants, produce greenhouse gas emissions that contribute to climate change[11].

Of all global electrical energy, commercial and residential buildings account for more than half. As the use of coal, oil, and natural gas for heating and cooling systems continues, greenhouse gas emissions resulting from commercial and residential buildings are having a significant impact. Soaring energy demand for heating and cooling systems with an increase in the number of air conditioning users, as well as increased use of electrical energy for lighting, appliances, and connected devices, has resulted in an increase in energy-related carbon dioxide emissions from buildings in recent years. To overcome this problem, a transition to clean energy is needed. Clean energy, like renewable energy, does not produce greenhouse gas emissions. By switching to clean energy, we can reduce the impact of climate change on electricity consumption[12].

D. Adaptation and Mitigation

The negative impact of climate change on the survival of humans and other living creatures is very large and requires efforts to overcome it. Climate change mitigation and climate change adaptation is one of the efforts to overcome unavoidable climate change events. In short, mitigation measures refer to preventive measures against increasing greenhouse gases, while adaptation measures refer to measures to adapt to conditions resulting from climate change. Climate change adaptation and climate change mitigation measures can be implemented in various areas of life, such as agriculture, forestry, fisheries, and maritime affairs. Examples of climate mitigation and adaptation efforts that can be implemented include reducing the use of carbon fuels, avoiding burning wood, reducing the use of natural gas, utilizing climate and weather information, increasing body resilience, improving the environment, improving irrigation systems, and other actions[13].

E. Decomposition Method

Decomposition is a time series data analysis approach technique to identify the components that influence each data value. The decomposition method separates three basic components, namely trend, cyclical component, and seasonal component. Trend factors represent behavior in data that may increase or decrease over time. Cyclical factors represent increases or decreases over a period of time. Seasonal factors are periodic fluctuations over a certain period of time caused by various factors. The difference between seasonality and cycle is that seasonal factors repeat themselves at regular intervals, such as years, months, or weeks, while periodic factors have longer periods, and those periods change from period to period. The steps in forecasting using the decomposition method are[14]:

1. Time Series Plot Actual Data

The grouped data is entered into a Minitab worksheet. The data is then displayed in a time series graph and then processed according to the needs of the research.

2. Trend Component Decomposition Analysis

A trend is a pattern that provides information about an object in the form of an increase or decrease that occurs over a long period of time (for example several years). This can happen due to technology, population behavior patterns, and so on.

3. Seasonal Variation Component Decomposition Analysis

Seasonality is a pattern of increase or decrease that occurs periodically (usually within one year). This can happen due to weather patterns, holiday patterns, and so on.

4. Cyclical Component Decomposition Analysis

A cycle is a pattern of increases or decreases that repeats and impacts over a short period of time (e.g. weeks to years). This can be caused by various economic and political problems.

5. Irregular Component Decomposition Analysis

Irregularities are patterns that are irregular, unsystematic, short-lived, and non-repeating. This can be caused by unexpected events such as war or natural phenomena.

6. Forecasting Results

The processed data is presented in the form of tables and graphs. In situations where the seasonal influence is greater than the random component, decomposition provides more meaningful prediction results than non-seasonal methods.

A good forecast is a forecast that has the lowest MAPE (Mean Absolute Percentage Error) value with the following criteria[15]:

MAPE value <10% = Very Good Forecasting
MAPE Value 10% - 20% = Good Forecasting
MAPE Value 20% - 50% = Sufficient Forecasting
MAPE value >50% = Inaccurate Forecasting

F. Multiple Linear Regression Method

Multiple linear regression is an analysis technique that describes the relationship between two or more variables that give rise to cause and effect. The multiple linear regression method is a regression analysis with several independent variables[13].

Multiple linear regression is a method of making predictions that involves two or more variables, the independent variable and the dependent variable. These variables are interrelated and have a cause-and-effect relationship. The regression method describes the relationship between these variables. The steps in multiple linear regression consist of:[16]:

1. Normality test

Normal distribution analysis is a preliminary analysis and is a prerequisite for whether a statistical analysis technique can be used to test a hypothesis.

In this study, data normalization was carried out based on the Normal PP Plot and *One-Sample Kolmogorov-Smirnov Test* using the SPSS program.

In the Normal PP Plot, data can be declared to be normally distributed if the distribution of the data is in the form of points that are close together or coincide with a straight line. On One-Sample Kolmogorov-Smirnov Test, data is normally distributed if the value Asymp. Sig. (2 - tailed) > 0.05[17].

2. F-test and t test

a) F test

The F test is used to find out how much influence the independent variable has on the independent variable simultaneously. The steps in carrying out the F Test on SPSS are as follows[17]:

1) Determine H0 and H1
H0: $\beta 1 = \beta 2$
H1: $\beta 1 \neq \beta 2$
2) Make decisions

b) t-test

The t-test is used to find out how much influence the independent variable has on the independent variable partially. The steps in carrying out the t-test in SPSS are as follows[17]:

1) Determine H0 and H1
H0: $\beta = 0$
H1: $\beta \neq 0$
2) Make decisions

G. Hypothesis

A hypothesis or assumption is a statement, conclusion, or logical conclusion about a population. In statistics, a hypothesis is a statement about a population parameter. These population parameters represent the variables that exist in the population, calculated using sample statistics. Therefore, research that always requires a hypothesis is quantitative research. On the other hand, qualitative research does not necessarily require a hypothesis. Even so, most of it is still hypothetical. Therefore, researchers must formulate or have formed research hypotheses before entering the field[18].

Based on the description, a hypothesis can be formulated that changes in air temperature and rainfall will influence changes in electricity consumption in Pekanbaru City.

III. Method and Design

A. Research sites

The research is located in Pekanbaru City with the type and source of data coming from the Pekanbaru City Central Statistics Agency. The city of Pekanbaru was chosen because previous research showed insignificant results regarding the influence of climate change on electricity consumption. Apart from that, due to climate change which has increased in recent years, further research is needed.

B. Types of research

The type and type of research data used is quantitative research. Quantitative research is a type of research that produces discoveries that can be achieved (obtained) using statistical procedures or other means of quantification (measurement).

The data forecasting used is multivariate decomposition. The decomposition method is a method of approaching time series data analysis to identify component factors that influence each value of the data. The data analysis used is multiple linear regression analysis using the enter method. Multiple linear regression serves to see the influence that occurs between the independent variable X_1 (temperature), and X2 (rainfall) to the dependent variable Y (Electricity Consumption). Multiple linear regression was also used to determine what factors greatly influence electricity consumption in households and businesses in Pekanbaru City.

C. Research Stages

In this research, what will be discussed a lot is the results of forecasting air temperature, rainfall, and electricity consumption as well as the influence of air temperature and rainfall on electricity consumption. The data used in this research is data for the last 5 years. In the research process, the research was carried out in the following stages:

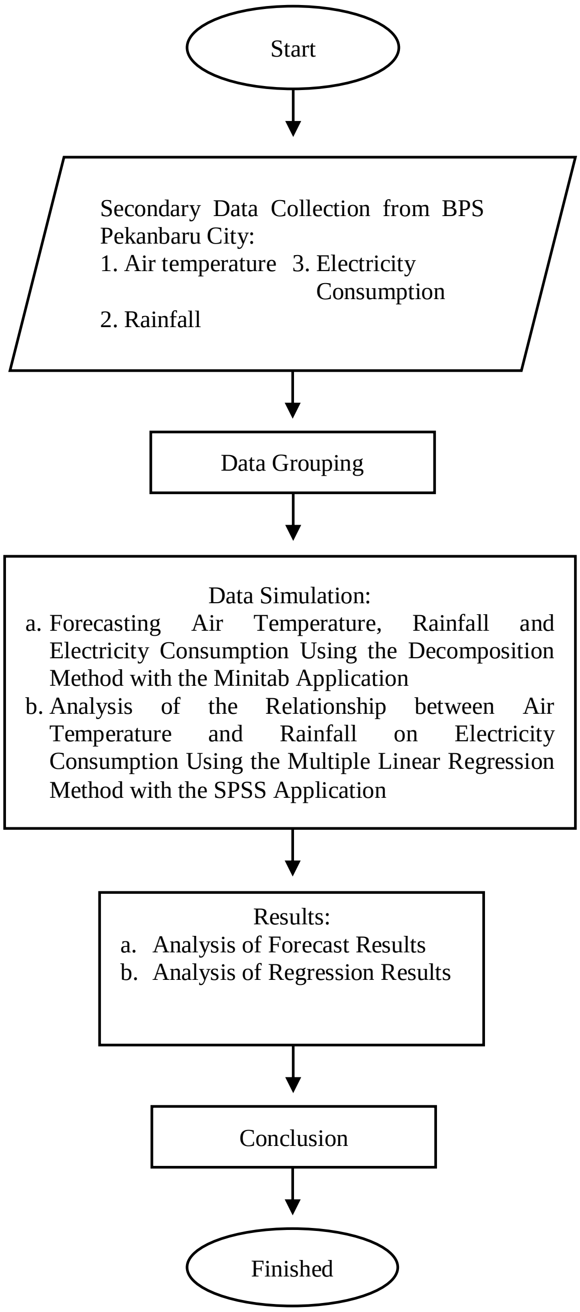

Figure 1 Research Flowchart

Based on Table 1, during the last 5 years, the air temperature in Pekanbaru City has been on average 26.19 °C, the average rainfall value 224.13 mm, and the average electricity consumption is 150,943GWh.

1. Secondary Data Collection from BPS Pekanbaru City

Table 1 Variable Data Collection

Year	Month	Temperature (°C)	Rainfall (mm)	Electricity Consumption (GWh)
2018	1	26.7	68	150.25
	2	27	142	146.79
	3	27.1	309	162.09
	4	27.8	161	163.24
	5	27.7	249	171.31
	6	27.8	260	154.01
	7	27.6	125	167.82
	8	27.9	108	168.1
	9	27.4	113	166.07
	10	26.8	298	154.74
	11	27.1	333	149.92
	12	27.2	522	150.75
2019	1	26.9	163	149.21
	2	27.3	105	140.4
	3	27.8	96	161.2
	4	28	282	149.88
	5	28.2	163	160.84
	6	27.6	323	140.41
	7	27.8	74	157.87
	8	28	43	160.77
	9	27.5	55	156.97
	10	27	208	157.07
	11	26.9	316	151.04
	12	26.6	178	151.94
2020	1	22.2	161.7	155.37
	2	22.5	30.2	148.9
	3	22.8	96.7	158.55
	4	23	341.6	139.15
	5	23	246	148.01
	6	22.3	196.8	147.05
	7	22.2	109.2	151.92
	8	22.4	198.3	153.19
	9	22.2	53.5	148.66
	10	22	195.3	153.19
	11	22.6	432.8	148.66
	12	22.2	104.8	153.37
2021	1	25.9	326.1	125.53
	2	27	96.9	118.67
	3	26.6	357.2	132.31
	4	27	409.9	130.37
	5	27.4	258.8	130.95
	6	27.3	207	135.27
	7	27.4	91.3	136.32
	8	26.8	199.1	131.17
	9	26.6	310.8	129.55
	10	27.3	343.2	139.37
	11	27	342.4	135.11
	12	26.6	206.3	136.9
2022	1	26.5	299	155.77
	2	26.3	291	142.3
	3	27.5	214	165.05
	4	27.2	417	163.4
	5	27.7	295	159.53
	6	26.8	268	163.3
	7	27	285	165.72
	8	26.8	184	165.31
	9	26.7	179	161.33
	10	26.3	473	163.72
	11	26.6	190	158.95
	12	26	343	161.97

2. Data Grouping

Table 2 Variable Data Grouping

X1	X2	Y1
26.7	68	150.25
27	142	146.79
27.1	309	162.09
27.8	161	163.24
27.7	249	171.31
27.8	260	154.01
27.6	125	167.82
27.9	108	168.1
27.4	113	166.07
26.8	298	154.74
27.1	333	149.92
27.2	522	150.75
26.9	163	149.21
27.3	105	140.4
27.8	96	161.2
28	282	149.88
28.2	163	160.84
27.6	323	140.41
27.8	74	157.87
28	43	160.77
27.5	55	156.97
27	208	157.07
26.9	316	151.04
26.6	178	151.94
22.2	161.7	155.37
22.5	30.2	148.9
22.8	96.7	158.55
23	341.6	139.15
23	246	148.01
22.3	196.8	147.05
22.2	109.2	151.92
22.4	198.3	153.19
22.2	53.5	148.66
22	195.3	153.19
22.6	432.8	148.66
22.2	104.8	153.37
25.9	326.1	125.53
27	96.9	118.67
26.6	357.2	132.31
27	409.9	130.37
27.4	258.8	130.95
27.3	207	135.27
27.4	91.3	136.32
26.8	199.1	131.17
26.6	310.8	129.55
27.3	343.2	139.37
27	342.4	135.11
26.6	206.3	136.9
26.5	299	155.77
26.3	291	142.3
27.5	214	165.05
27.2	417	163.4
27.7	295	159.53
26.8	268	163.3
27	285	165.72
26.8	184	165.31
26.7	179	161.33
26.3	473	163.72
26.6	190	158.95
26	343	161.97

In order to clarify data based on data type, first the data is grouped. The influential (independent) variable is called variable X and the variable that is influenced (dependent) is called variable Y. So electricity consumption is variable Y, air temperature is variable X1 and rainfall is variable X2.

3. Data Simulation

a. Forecasting Air Temperature, Rainfall and Electricity Consumption Using the Decomposition Method with the Minitab Application

The steps taken in predicting air temperature, rainfall, and electricity consumption using the decomposition method are:

1. Determine the time series plot of actual data
2. Analyze the decomposition of trend components
3. Analyze the decomposition of seasonal variation components
4. Analyze the decomposition of cyclical components
5. Analyzing the decomposition of irregular components

b. Analysis of the Relationship between Air Temperature and Rainfall on Electricity Consumption Using the Multiple Linear Regression Method with the SPSS Application

The steps taken in determining the relationship of related variables using the multiple linear regression method are to carry out a normality test as well as the F test and t-test. Analysis of the regression results will be presented in section

4. Results

a. Analysis of Forecast Results

Forecasting results are presented in the form of graphs and tables. The graph shows a plot in the form of actual data, fits, trends, and forecasts, then the MAPE, MAD, and MSD values. The table shows the forecast results of air temperature, rainfall, and electricity consumption.

b. Analysis of Regression Results

The regression results are presented in table form which shows the relationship between variables simultaneously and partially. Simultaneously the variable relationships are shown in the Model Summary and ANOVA tables. Partially the variable relationships are shown in the Coefficient table.

IV. Results and Discussion

A. Data Simulation

1. Forecasting Air Temperature, Rainfall and Electricity Consumption Using the Decomposition Method with the Minitab Application

a. Time Series Plot Actual Data

Based on the capital forecasting image using seasonal data for 2018 - 2022. Graphs of Temperature, Rainfall, and Electricity Consumption values are presented respectively in Figures 1, 2, and 3.

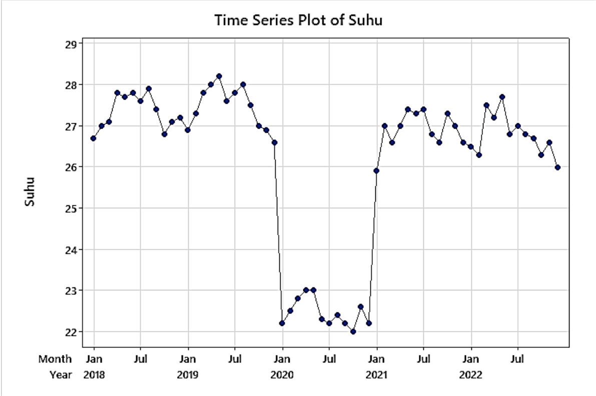

Figure 2 Time Series Plot of Temperature

Based on the graph, the data period used experienced fluctuations up and down. During 60 periods, air temperature reached the highest value in May 2019 and the lowest value in October 2020.

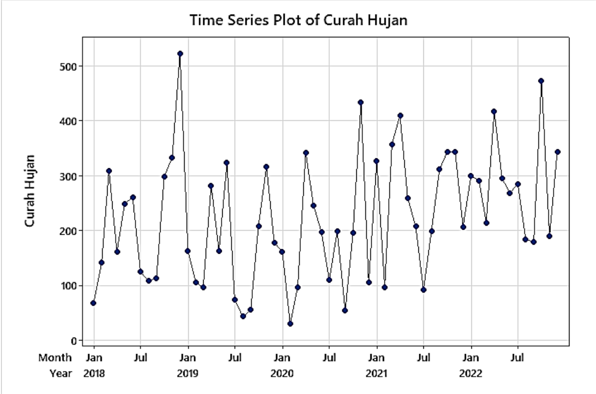

Figure 3 Time Series Plot of Rainfall

Based on the graph, the data period used experienced fluctuations up and down. During 60 periods, rainfall reached the highest value in December 2018 and the lowest value in February 2020.

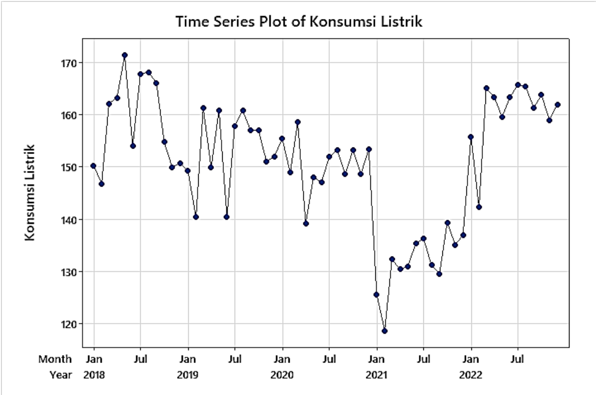

Figure 4 Time Series Plot of Electricity Consumption

Based on the graph, the data period used experienced fluctuations up and down. Over 60 periods, electricity consumption reached its highest value in May 2018 and its lowest value in February 2021.

b. Trend Component Analysis

Based on data analysis, a linear trend equation was obtained for monthly data on air temperature, rainfall, and electricity consumption, respectively, as follows:

$$Y_t = 26.609 - 0.0137_t \quad (1)$$
$$Y_t = 166 + 2.383_t \quad (2)$$
$$Y_t = 154.95 - 0.1307_t \quad (3)$$

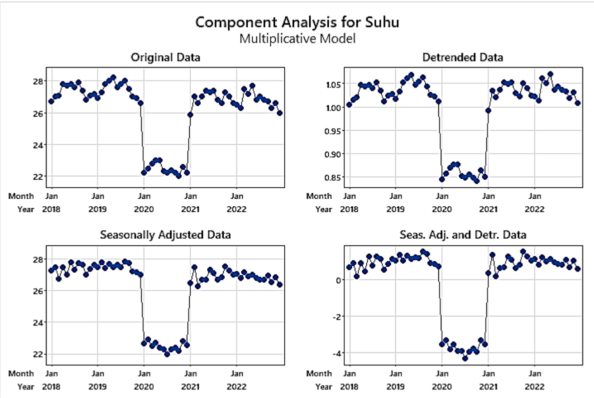

Figure 5 Component Analysis for Temperature

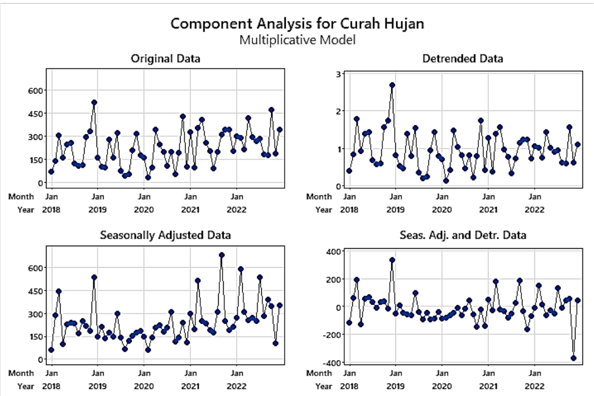

Figure 6 Component Analysis for Rainfall

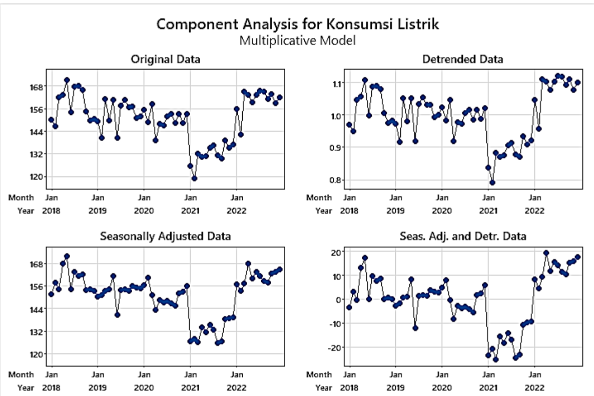

Figure 7 Component Analysis for Electricity Consumption

Figures 5, 6, and 7 show component analysis of actual data, non-trend data, seasonal data adjustments, and a combination of seasonal data adjustments and non-trend data.

c. Seasonal Variation Component Decomposition Analysis

Based on the analysis results, the decomposition of the components of seasonal variations in air temperature, rainfall, and electricity consumption is obtained as follows:

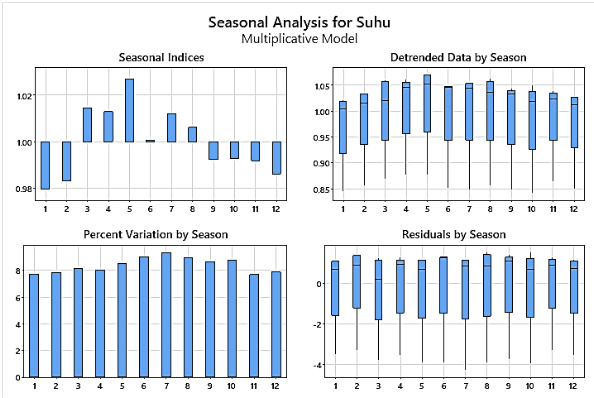

Figure 8 Seasonal Analysis for Temperature

Based on the image, the average seasonal air temperature index values are obtained as follows:

Table 3 Seasonal Air Temperature Index

Period	Index	%	Note.
1	0.97968	98%	-2%
2	0.98331	98%	-2%
3	1.01441	101%	1%
4	1.01295	101%	1%
5	1.02698	103%	3%
6	1.00073	100%	0%
7	1.01214	101%	1%
8	1.00618	101%	1%
9	0.99243	99%	-1%
10	0.99295	99%	-1%
11	0.99195	99%	-1%
12	0.9863	99%	-1%

So it can be seen that the fifth month has the highest seasonal pattern at 103%, 3% greater than the expected seasonal index. Meanwhile, the first and second months were the lowest at 98%, 2% smaller than the expected season index. In general, from the first to the twelfth month the seasonal index is around the expected value and does not experience significant fluctuations.

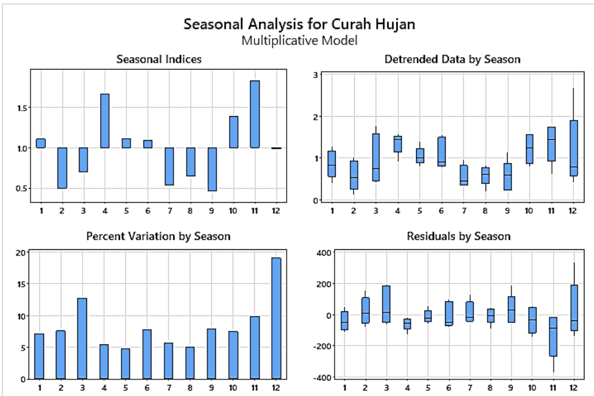

Figure 9 Seasonal Analysis for Rainfall

Based on the image, the average seasonal rainfall index values are obtained as follows:

Table 4 Seasonal Rainfall Index

Period	Index	%	Note.
1	1.10463	110%	10%
2	0.49556	50%	-50%
3	0.70046	70%	-30%
4	1.65982	166%	66%
5	1.10526	111%	11%
6	1.09118	109%	9%
7	0.53379	53%	-47%
8	0.6522	65%	-35%
9	0.46082	46%	-54%
10	1.38396	138%	38%
11	1.82938	183%	83%
12	0.98294	98%	-2%

So it can be seen that the eleventh month has the highest seasonal pattern at 183%, 83% greater than the expected seasonal index. Meanwhile, the ninth month was the lowest at 46%, 54% smaller than the expected season index.

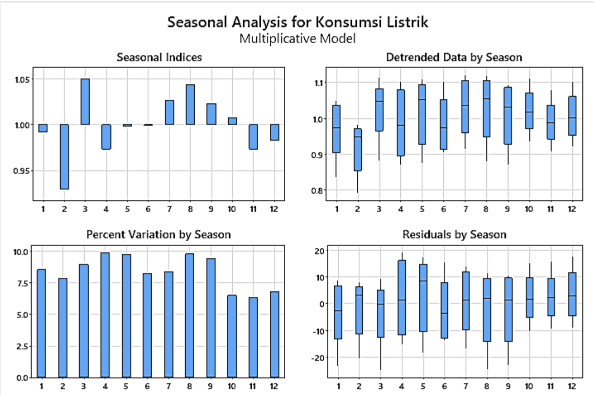

Figure 10 Seasonal Analysis for Electricity Consumption

Based on the image, the average seasonal rainfall index values are obtained as follows:

Table 5 Seasonal Index of Electricity Consumption

Period	Index	%	Note.
1	0.99212	99%	-1%
2	0.92948	93%	-7%
3	1.05033	105%	5%
4	0.97346	97%	-3%
5	0.99824	100%	0%
6	0.9991	100%	0%
7	1.02671	103%	3%
8	1.04373	104%	4%
9	1.02341	102%	2%
10	1.00722	101%	1%
11	0.97332	97%	-3%
12	0.98287	98%	-2%

So it can be seen that the third month has the highest seasonal pattern at 105%, 5% greater than the expected seasonal index. Meanwhile, the second month was the lowest at 93%, 7% smaller than the expected season index.

d. Cyclical Component Decomposition Analysis

Cyclical effects are defined as wave-like fluctuations around a trend. Periodic patterns are difficult to model over time because they are usually neither stable nor fixed. Wave-like fluctuations that rise and fall along a trend rarely repeat at fixed time intervals, and the strength of the fluctuations tends to vary.

e. Irregular Component Decomposition Analysis

Irregular components indicate conditions that vary over time or tend to change after other components are removed. This component is called the remainder or error.

2. Analysis of the Relationship between Air Temperature and Rainfall on Electricity Consumption Using the Multiple Linear Regression Method with the SPSS Application

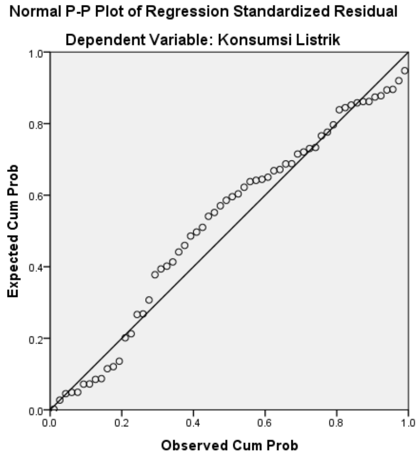

Figure 11 Normal P –P Plot

The image shows the results of the variable data normality test using the PP Plot in the SPSS program. Based on the results obtained, it can be concluded that the data is normally distributed.

Table 6 *One-Sample Kolmogorov-Smirnov Test*

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residuals
N		60
Normal Parameters, b	Mean	.0000000
	Std. Deviation	11.97585057
Most Extreme Differences	Absolute	.108
	Positive	,068
	Negative	-.108
Statistical Tests		.108
Asymp. Sig. (2-tailed)		.077c

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Based on the table, the Asymp value is obtained. Sig. (2 - tailed) of 0.077. Based on these values, it can be concluded that the data is normally distributed.

B. Results

1. Analysis of Forecast Results

Forecasts of air temperature, rainfall, and electricity consumption for 60 periods from 2023 – 2027 are obtained by multiplying the four components, namely seasonal, cyclical, and irregular trends for each month. Forecasting results are presented in the form of graphs and tables. The graph shows a plot in the form of actual data, fits, trends, and forecasts, then the MAPE, MAD, and MSD values. The table shows the forecast results of air temperature, rainfall, and electricity consumption.

The plot graph of forecasting results is shown in the following figure:

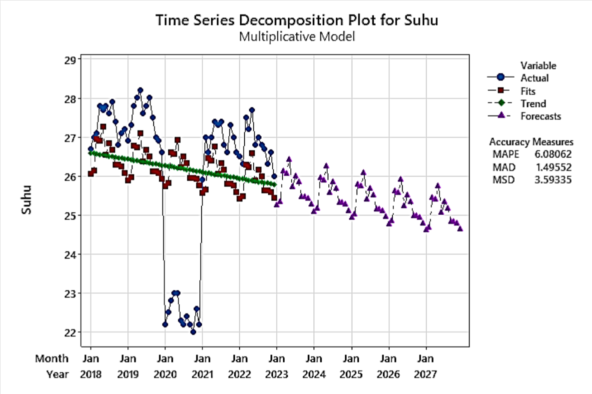

Figure 12 Time Series Decomposition Plot for Temperature

Based on the forecasting results, the MAPE value for air temperature is 6.08% with a decreasing trend. This indicates that the forecasting is accurate with a downward trend.

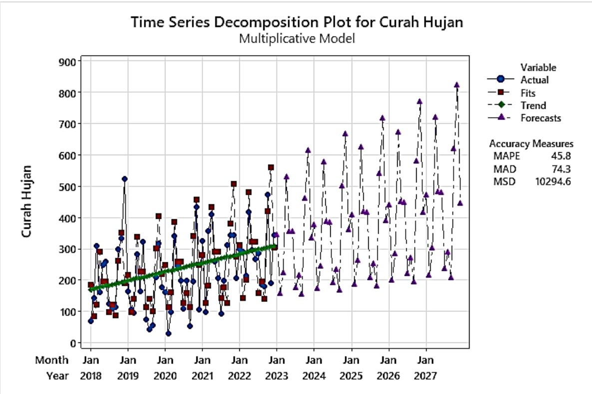

Figure 13 Time Series Decomposition Plot for Rainfall

Based on the forecasting results, the rainfall MAPE value is 45.8% with an increasing trend. This indicates that the forecast is reasonable with an increasing trend.

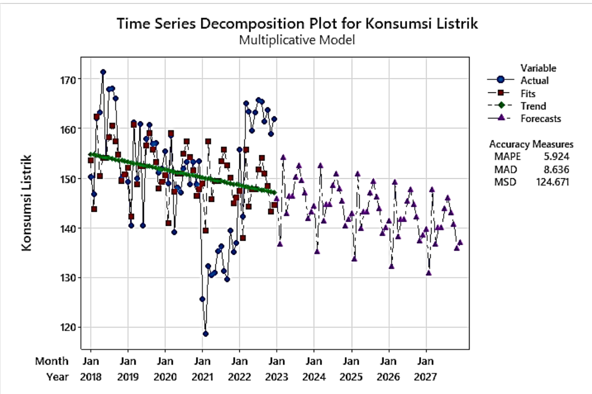

Figure 14 Seasonal Analysis for Electricity Consumption

Based on the forecasting results, the MAPE value for electricity consumption is 5.92% with a decreasing trend. This indicates that the forecasting is accurate with a downward trend.

Based on the image, the forecasting results for 60 periods 2023 – 2027 are presented in the following table:

Table 7 Forecasting Results

Forecasting Results for 2023 - 2027				
Year	Month	Temperature (°C)	Rainfall (mm)	Electricity Consumption (GWh)
2023	1	25.24838	343.8811	145.8232
	2	25.32863	155.4533	136.4949
	3	26.11565	221,396	154.1048
	4	26.06421	528.5792	142.7001
	5	26.41104	354.6103	146.2023
	6	25.72231	352.6951	146.1968
	7	26.00161	173.8049	150.1038
	8	25.83472	213.9141	152.4556
	9	25.46816	152.2399	149.3536
	10	25.46788	460.5187	146.8593
	11	25.42853	613.0934	141.7895
	12	25.27006	331.7607	143.0515
2024	1	25.08705	375.4676	144.2677
	2	25.16671	169.6237	135.0376
	3	25.9486	241.4253	152.4581
	4	25.8974	576.0411	141.1738
	5	26.24192	386.2147	144.6372
	6	25.55751	383.8971	144.6304
	7	25.83493	189.0684	148.4941
	8	25.66902	232.5635	150.8191
	9	25.30473	165.4167	147.7491
	10	25.30436	500.0926	145.2801
	11	25.26518	665.4039	140.2635
	12	25.10765	359.8674	141.5105
2025	1	24.92572	407.0542	142.7122
	2	25.00478	183.7941	133.5803
	3	25.78155	261.4546	150.8113
	4	25.73059	623.5029	139.6476
	5	26.07281	417.8192	143,072
	6	25.39272	415.0991	143.0639
	7	25.66826	204.3319	146.8843
	8	25.50333	251.2129	149.1827
	9	25.1413	178.5936	146.1445
	10	25.14084	539.6665	143.7009
	11	25.10183	717.7144	138.7375
	12	24.94523	387.9741	139.9695
2026	1	24.76439	438.6408	141.1567
	2	24.84285	197.9645	132.123
	3	25.6145	281.4839	149.1645
	4	25.56378	670.9647	138.1213
	5	25.90369	449.4236	141.5069
	6	25.22792	446.3011	141.4975
	7	25.50158	219.5954	145.2746
	8	25.33764	269.8624	147.5463
	9	24.97787	191.7704	144.5399
	10	24.97733	579.2404	142.1217
	11	24.93848	770.0249	137.2114
	12	24.78281	416.0808	138.4285
2027	1	24.60306	470.2274	139.6013
	2	24.68092	212.1349	130.6657
	3	25.44745	301.5133	147.5178
	4	25.39697	718.4265	136.5951
	5	25.73457	481,028	139.9418
	6	25.06312	477.5031	139,931
	7	25.33491	234,859	143.6649
	8	25.17194	288.5118	145.9099
	9	24.81444	204.9472	142.9354
	10	24.81381	618.8143	140.5425
	11	24.77513	822.3354	135.6854
	12	24.62039	444.1876	136.8875

Based on the forecasting results table, the air temperature values obtained in December 2023 and 2027 are respectively 25.27006°C and 24.62039°C. The difference in values obtained is 0.64967°C which shows a decline in value within 5 years. Rainfall in December 2023 and 2027 respectively of 331.7607 mm and 444.1876 mm. The difference in value obtained is 112.4269 mm which shows an increase in value in 5 years. Electricity consumption in December 2023 and 2027 is 143.0515 GWh and 136.8875 GWh respectively. The difference in value obtained is 6.164 GWh which shows a decrease in value in 5 years.

Based on the forecasting results that have been obtained, the MAPE results for air temperature and electricity consumption are below 10%, which shows that the forecasting is very good. Compared with previous research, forecasting using the decomposition method is considered to be equally effective as the forecasting method in previous research. This is because the MAPE value resulting from this research using the decomposition method is 6.08% for air temperature and 5.92% for electricity consumption. Meanwhile, the MAPE produced by previous research using the ARIMA method was 2.11% (Balikpapan), 3.02% (Samarinda), and 3.02% (Berau) for air temperature and 11.9% for electricity consumption in East Kalimantan.[6].

2. Analysis of Regression Results

Table 8 Model Summary

Model Summary b					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.187a	,035	,001	12.18414	,644

a. Predictors: (Constant), Rainfall, Temperature
b. Dependent Variable: Electricity Consumption

The table shows the results of the correlation coefficient of 0.187 and the coefficient of determination value of 0.035. Based on the results obtained, simultaneously (simultaneously) the air temperature and rainfall variables influence the electricity consumption variable by 3.5%. Meanwhile, 96.5% is influenced by other factors.

Table 9 ANOVA

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	307,445	2	153,723	1,035	.362b
	Residual	8461.839	57	148,453		
	Total	8769.284	59			

a. Dependent Variable: Electricity Consumption
b. Predictors: (Constant), Rainfall, Temperature

The table shows the sig value. 0.362, which shows that simultaneously the air temperature and rainfall variables do not have a significant effect on the electricity consumption variable in Pekanbaru City. This is in accordance with the condition that if the sig value. < 0.05, then simultaneously the independent variable does not have a significant effect on the dependent variable.

Compared with previous studies, the independent variable has differences where the independent variable has an insignificant influence in Pekanbaru City. This difference can be caused by many factors, one of which is the comparison of the number of customers.

Table 10 *Coefficients*

Coefficients						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	137,569	21,352		6,443	,000
	Temperature	,662	,818	.106	,809	,422
	Rainfall	-.018	.014	-.167	- 1,276	,207

a. Dependent Variable: Electricity Consumption

The table shows the sig value. The air temperature and rainfall variables are respectively 0.422 and 0.207, which shows that partially the air temperature and rainfall variables do not have a significant effect on the electricity consumption variable in Pekanbaru City. This is in accordance with the provision that if the sig value is <0.05, then partially the independent variable does not have a significant effect on the dependent variable. Based on the coefficients table, the following regression equation is obtained:

$$Y = 137.569 + 0.662X_1 - 0.018X_2 \qquad (4)$$

The interpretation of the equation is:

a. The regression coefficient value for the air temperature variable in the regression equation shows a value of 0.662, which means that if the value of the rainfall variable is constant, while the value of the air temperature variable increases by 1°C, then electrical energy consumption increases by 0.662 GWh. In other words, the higher the air temperature, the more electricity consumption will increase.
b. The regression coefficient value for the rainfall variable in the regression equation shows a value of 0.018, which means that if the value of the air temperature variable is constant, while the rainfall variable increases by 1mm, then electrical energy consumption decreases by 0.018 GWh or 18 MWh. In other words, the higher the rainfall, and the lower the electricity consumption will be.

Compared with previous studies, the results of research in Pekanbaru City are different from previous studies. The difference is in the significance value of the influence of the independent variable on the dependent variable. Previous research had a significant influence, while research conducted in Pekanbaru City had an insignificant influence. This can happen due to many factors. One example is the difference in the number of customers in Pekanbaru City with case studies from previous research. As the number of customers increases, the influence of the independent variables will become greater. Pekanbaru City has 485,736 customers, while Banten Province has the number of customers 3,496,958 subscribers. This is of course a determining factor in the results of research in Pekanbaru City compared to previous research considering the large difference in the number of customers from the two case studies[5].

V. Conclusion

Based on research results, forecasting results of air temperature, rainfall and electricity consumption in Pekanbaru City show various trend patterns. Based on the graph, air temperature experiences a decreasing trend from 2023 – 2027. Rainfall experiences an increasing trend from 2023 – 2027. Electricity consumption experiences a decreasing trend from 2023 – 2027. The MAPE value for air temperature was 6.08%, rainfall was 45.8% and electricity consumption was 5.92%. Based on the forecast results table, it is found that the difference in values for air temperature, rainfall, and electricity consumption in December 2023 and 2027 respectively is 0.64967°C,112.4269 mm, and 6.164 GWh. Based on the research that has been carried out, the results show that air temperature and rainfall influence electricity consumption in Pekanbaru City. However, the effect is only 3.5%, which shows an insignificant effect. This is not in accordance with previous research which shows the significant influence of climate in Banten Province. This could be caused by many factors, one of which is the difference in the number of customers in the two case studies.The results obtained show that with each increase in temperature is 1°C, then electrical energy consumption increases by 0.662 GWh. In other words, the higher the air temperature, the more electricity consumption will increase. Meanwhile, for every 1mm increase in rainfall, electrical energy consumption decreases by 0.018 GWh or 18 MWh. In other words, the higher the rainfall, the lower the electricity consumption.

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