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Rainy and Dry Seasons Impacts on Electricity Demand in Indonesia

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Abstract
Electricity consumption has become an integral part of daily life, playing a key role in supporting various aspects of human life. North Aceh Regency, a tropical region in Indonesia, experiences significant seasonal fluctuations between the rainy and dry seasons. This research aims to investigate and analyze the impact of these seasonal differences on electricity consumption patterns by consumers in the region, using the IBM SPSS statistical method. Monthly electricity consumption data from consumers in North Aceh Regency over a specific period were collected and analyzed using IBM SPSS software. Descriptive statistical analysis, hypothesis testing, and regression models were employed to identify significant differences in electricity consumption between the rainy and dry seasons, as well as to understand the factors influencing consumption patterns. The analysis results indicate a significant difference in electricity consumption between the rainy and dry seasons in North Aceh Regency. The dry season tends to show an increase in electricity consumption, possibly related to factors such as the use of air conditioning and additional lighting.

Keywords:
Electrical Energy Demand; Weather Changes; Linear Regression Method;

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INTRODUCTION

The demand for electricity in Indonesia continues to increase due to economic growth, population growth, and increased purchasing power [1][2][3][4]. Indonesia has a unique climate due to its tropical location and position between the Pacific and Indian Oceans, which affects climate. Therefore, Indonesia has three types of climate patterns: monsoon, equatorial, and local [5][6]. During prolonged dry seasons, the temperature increases, requiring electronic devices such as air conditioning (AC) or fans to cool the room [7]. The use of AC is one of the causes of increased electricity consumption. Electric consumption forecasting is needed to ensure continuity of service due to increased electricity demand [8][9].

Electricity consumption forecasting is vital in planning electricity production, as it is the starting point in production planning [10][11][12][13]. Overproduction is wasteful or costly for companies, while underproduction allows competitors to enter the market. Therefore, predicting electricity demand is crucial in developing an electricity system in a particular area or region [14][15].

The North Aceh Regency, located in a tropical region, experiences significant seasonal changes between the rainy and dry seasons [16]. These climate variations can impact the electricity consumption patterns and needs among electricity consumers [17][18].

This study aims to analyze the influence of the differences between the rainy and dry seasons on electricity consumption among consumers in North Aceh Regency. By understanding the variability in electricity consumption patterns during different seasons, this research is expected to provide valuable insights for energy management in the region [19][20].

Although many studies have examined factors influencing electricity consumption, [21] the lack of focus on seasonal variations in the context of tropical regions has motivated this research. By understanding how electricity consumption fluctuates during the rainy and dry seasons, we can identify potential strategies for more effective energy management [22].

In this article, the author presents the influence of climate on electricity demand and forecasts the electricity needs for the next six years in North Aceh Regency during the dry and rainy seasons using IBM SPSS software with a stepwise method in multiple linear regression [23][24]. The data used includes weather data from BMKG Indrapuri, North Aceh, as well as electricity load data from PLN (State Electricity Company) North Aceh.

The results of this research are expected to contribute to our understanding of the factors influencing electricity consumption, especially in the context of seasonal variations in tropical regions. These findings can serve as a foundation for the development of more adaptive and sustainable energy policies, providing practical guidance for consumers and electricity service providers in dealing with dynamic changes in energy consumption.

This research is relevant not only for providing new insights into electricity consumption but also for serving as a basis for further consideration of energy efficiency, sustainability, and energy resource management in regions with significant seasonal variations.

METHOD

The analysis of this research is based on monthly electricity consumption data from consumers in North Aceh Regency during a specific period, namely the data from 2017, 2018, and 2019. The population data for this study were obtained from BMKG Indrapuri and electricity load data from PLN (State Electricity Company) North Aceh. Temperature and humidity data were measured three times a day at 07:00, 13:00, and 18:00 and later divided by 3 for the daily results. The types and sources of data used in this research are secondary and quantitative. The methodology includes descriptive statistical analysis and multiple linear regression models using IBM SPSS software to understand the differences in electricity consumption between the rainy and dry seasons and the factors that may influence it.

The SPSS software is an application program that features advanced statistical data analysis capabilities. SPSS has a data management system in a graphical environment using descriptive menus and simple dialog boxes, making it easy to operate and understand. SPSS is one of the most popular and widely used application programs by analysts and researchers for processing statistical data [25][26].

Based on weather and power data, where the population values are averaged and divided into 16 months for the rainy season and another 16 months for the dry season, to ascertain that the population data of weather and power can be processed with multiple linear regression, it is necessary to undergo classical assumption tests as follows:

a. Normality Test
b. Autocorrelation Test
c. Multicollinearity Test
d. Heteroskedasticity Test

After conducting classical assumption tests, the analysis of the data continued using multiple linear regression analysis with the stepwise method [27][28][29] to examine the extent of influence between independent variables X1 (temperature), X2 (air humidity), X3 (rainfall), X4 (sunshine duration), X5 (wind speed) on the dependent variable Y1 (electric consumption). The aim is also to determine which season significantly influences electricity consumption among electric customers in North Aceh Regency. Subsequently, the determination coefficient (R2) and correlation coefficient values were calculated [29].

The coefficient of determination in multiple linear regression, often referred to as R2, is a measure of how well the variability of the dependent variable can be explained by the regression model. The coefficient of determination ranges from 0 to 1, and the closer it is to 1, the better the regression model can explain the data variation.

Regression analysis is a statistical tool that explains the relationship pattern (model) between two or more variables [11][30]. In regression analysis, there are two types of variables namely, the response variable is also called the dependent variable, namely the variable whose existence is influenced by other variables and is denoted by Y. And the independent variable, namely the independent variable (not influenced by other variables) and denoted by X [31]. The research flowchart is presented in Figure 2.

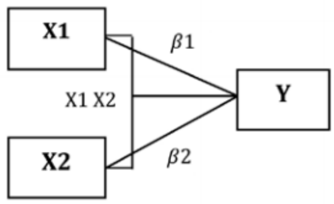

Figure 1. The paradigm of multiple linear regression analysis.

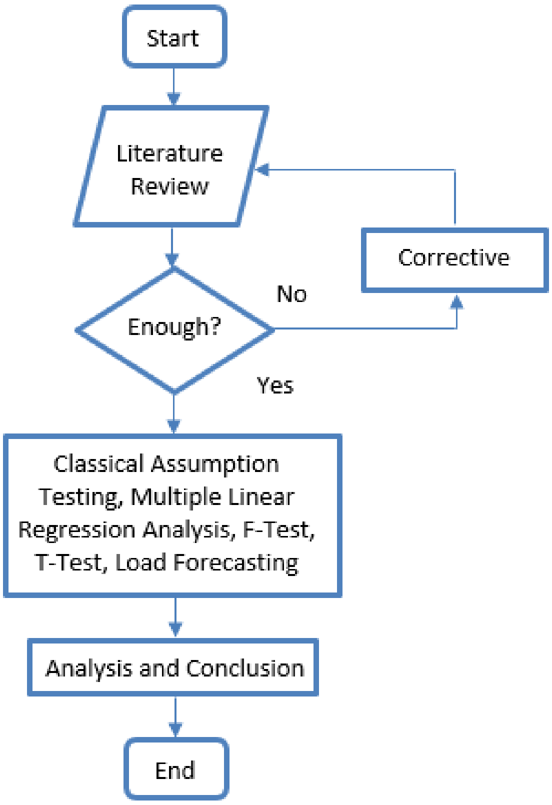

Figure 2. Research flowchart

RESULTS AND DISCUSSION

In the regressed data, the authors grouped the dry season and rainy season data, each of which amounted to 18 months from the previous 3 years (2020, 2021 and 2022), the dry season is seen from the lowest rainfall in each month which can be seen in table 1 and vice versa in the rainy season data contained in table 2.

Table 1. The dry season data table is seen from the lowest rainfall for 3 years.

No	Years	Months	Y	X1	X2	X3	X4	X5
1	2020	Maret	19048	30.8	84	31.66	57	3.7
2	2020	April	18540	31.2	85	23	67	3.8
3	2020	Juni	20360	31.9	84	11	66	4.2
4	2020	Juli	20096	32.1	82	19	65	4.2
5	2020	Oktober	19916	30.9	86	21.66	58	3.7
6	2020	November	18941	30.1	88	24.33	49	3.6
7	2021	Februari	17971	31.1	83	21	69	4.3
8	2021	Maret	21047	32	82	27	78	4
9	2021	Juni	22024	32.6	81	17	56	3.6
10	2021	Juli	21976	32.4	80	10	63	3.9
11	2021	Agustus	22282	32.2	82	25.33	65	3.3
12	2021	Desember	20294	30.4	86	0	48	3.7
13	2022	Januari	21842	31.2	87	13.33	69	4.5
14	2022	Februari	20119	31.6	82	14.33	79	3.4
15	2022	Maret	23846	32.4	80	13.33	84	3.7
16	2022	April	23391	32.8	81	15	69	4.1
17	2022	Juni	23565	32.6	83	26.66	58	3.3
18	2022	Juli	23479	32.8	80	18	71	3.7

Table 2. Table of rainy season data in view of the highest rainfall for 3 years.

No	Years	Months	Y	X1	X2	X3	X4	X5
1	2020	Januari	18019	29.5	87	39.33	41	4
2	2020	Februari	16982	30.3	85	37	63	4.4
3	2020	Mei	19917	32.2	84	39	57	3.7
4	2020	Agustus	19549	31.7	83	50.33	54	3.8
5	2020	September	19006	30.7	86	36.33	53	3.7
6	2020	Desember	18669	29.8	88	53	38	3.8
7	2021	Januari	19044	30.3	87	32.66	46	3.8
8	2021	April	21274	32.5	83	34.66	66	3.6
9	2021	Mei	22601	31.8	85	57.66	62	4
10	2021	September	21341	31.3	84	29.33	50	3.7
11	2021	Oktober	21174	30.6	87	45.66	48	3.2
12	2021	November	20268	30.7	88	47	47	3.1
13	2022	Mei	25173	32.2	83	40.33	64	3.9
14	2022	Agustus	23697	32.8	81	27	72	4.1
15	2022	September	23024	31.5	86	35.66	45	4
16	2022	Oktober	22524	30.3	88	41.33	45	2.8
17	2022	November	22389	30.5	88	36.66	50	4
18	2022	Desember	22405	30.4	86	42.66	50	4.9

Note: Y = PLN monthly load X1= Temperature
X2 = Humidity X3 = Rainfall
X4 = Length of Sunlight X5 = Wind Speed

1. Data Normality Test

a. Dry season data normality test

The regression model is said to be normally distributed if the value is asymp. Sig (2-tailed) is greater than the significance value of 0.05, so the data is normally distributed. Conclusion: Regression Model is normally distributed.

Table 3. Kolmogrov Smirnov test table

		Unstandardized Residual
N		18
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	1126.328528
Most Extreme Differences	Absolute	.107
	Positive	.087
	Negative	-.107
Test Statistic		.107
Asymp. Sig. (2-tailed)		.200 [c,d]

b. Rainy season data normality test

The regression model is said to be normally distributed if the value is asymp. Sig (2-tailed) is greater than the significance value of 0.05, so the data is normally distributed.

Table 4. Kolmogrov Smirnov test table

		Unstandardized Residual
N		18
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	1792.608437
Most Extreme Differences	Absolute	.107
	Positive	.094
	Negative	-.107
Test Statistic		.107
Asymp. Sig. (2-tailed)		.200 [c,d]

2. Dry Season Linear Regression

Table 5. Table Description of the Stepwise Method

Model	Variable Entered	Variables Removed	Method
1	Temperature		Stepwise (criteria: Probability-of-F-to-enter <= 0.050. Probability-of-F-to-remove>=0.100).

Table 5 describes the method used in multiple linear regression using the stepwise method.

a. F test

F table = (k; n-k)

Note: k = Number of Variable X

n = Number of Samples

F table = (k; n-k)

= (5; 18-5)

= (5; 13)

= 3.03.

Then, the critical F-value at a significance level of 0.05 is obtained as 3.03. Based on the output above, it is known that the Sig value of the simultaneous influence of variable X on Y is 0.000 < 0.05, and the calculated F-value is 26.896 > the critical F-value of 3.03, indicating that there is a simultaneous influence of variable X on Y.

Table 6. Table Description of the Stepwise Method

Model	Sum.of Square	df	Mean Square	F	Sig.
1 Regression	36253159.744	1	36253159.744	26.896	0.000
Residual	21566471.201	16	1347904.450		
Total	57819630.944	17			

b. T test

T table = T (∝ / 2; n-k-1)

Note: k = Number of variables

∝ = 0.05

n = Number of Samples

T table = T (∝ / 2; n-k-1)

= (0.025; 12)

= 2.1788

Based on the output above, it is known that the Sig value for the effect of variable X1 partially on Y is equal to 0.000 <0.05 and the value of T count is 5.186> T table 2.1788, so it is concluded that it can reject H0, which means that there is an influence of variable X1 partially on Y.

Table 7. Coefficient Table

	Unstadarized Coefficients		Stadarized Coefficients			Collinearity Statistics	
Model	B	Std.Error	Beta	T	Sig.	Tolerance	VIF
1 (Constant)	-33841.186	10586.021		-3.197	0.006		
Suhu	1729.782	333.540	0.792	5.186	0.000	1.000	1.000

c. Coefficient of Determination

Table 8. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate	Durbin-Watson
1	0.792	0.627	0.604	1160.993	1.412

So from Table 8 by looking at the adjusted R2 value of the coefficient of determination (R2) the temperature obtained = 0.604. This means that the effect of temperature in the dry season in the last 3 years can explain 60.4% of the dependent variable (the loading capacity of the North Aceh Regency) while the remaining 39.6% is influenced by other things.

d. Correlation Test

The temperature correlation value is 0.792, which means that the positive strong correlation value means that if the value of the X1 variable is high, the Y value will be high. The correlation value for humidity is -0.583, which means that the value of the strong negative correlation means that if the value of the variable X2 is high, the value of the variable Y will be low. While other variables the sig (1-tailed) value is greater than 0.05, which indicates that the variable is uncorrelated.

Table 9. Correlation Table

m	Power load	Temperature	Air humidity	Rainfall	Length of solar irradiation	Wind speed	
Pearson corelation	Power load	1000	.792	-.583	-.197	.300	-.210
	Temperature	.792	1.000	-.865	-.034	.475	-.073
	Air humidity	-583	-.865	1.000	-.057	1.000	.219
	Rainfall	-197	-.034	.057	1.000	-.004	-.254
	Length of solar irradiation	300	475	-.551	-.004	1.000	.219
	Wind speed	-210	-.073	.130	-254	219	1.000
Sig. (1-tailed)	Power load		.000	.006	217	113	201
	Temperature	000		.000	447	023	387
	Air humidity	006	000	.	412	009	303
	Rainfall	217	447	412		494	154
	Length of solar irradiation	113	023	009	494		191
	Wind speed	201	387	303	154	191	

3. Rainy Season Linear Regression

Table 10. Table Description of the Stepwise Method

Model	Variable Entered	Variables Removed	Method
1	Suhu		Stepwise (criteria: Probability-of-F-to-enter <= 0.050. Probability-of-F-to-remove>=0.100).

Table 10 describes the method used in multiple linear regression using the stepwise method.

a. F test

Table. 11 Tabel Anova

Model	Sum of Square	df	Mean Square	F	Sig.
1 Regression	25197329.274	1	25197329.274	7.380	0.015
Residual	54628565.170	16	3414285.323		
Total	79825894.444	17			

F table = (k; n-k)
Note: k = Number of Variable X
n = Number of Samples
F table = (k; n-k)
= (5; 18-5)
= (5; 13)
= 3.03

Then the F table value is obtained with a significance level of 0.05 is 3.03. Based on the output above, it is known that the Sig value for the effect of variable X simultaneously on Y is 0.015 <0.05 and the value of F count is 7.380> F table 3.03, which means that there is an effect of variable X simultaneously on Y.

b. T Test

Table 12. Coefficient Table

	Unstadarized Coefficients		Stadarized Coefficients			Collinearity Statistics	
Model	B	Std.Error	Beta	T	Sig.	Tolerance	VIF
1 (Constant)	-18175.342	14407.949		-1.261	0.225		
Suhu	1259.546	463.646	0.562	2.717	0.015	1.000	1.000

T table = T (∝ / 2; n-k-1)
Note: k = Number of variables
∝ = 0.05
n = Number of Samples
Thus, T table = T (∝ / 2; n-k-1)
= (0.025; 12)
= 2.1788

Based on the output above, it is known that the Sig value for the effect of the X1 variable partially on Y is 0.015 <0.05 and the T value is 2.717> T table 2.1788, so it is concluded that it can reject H0, which means that there is a partial influence of the X1 variable on Y.

c. Coefficient of Determination:

Table 13. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of The Estimate	Durbin-Watson
1	0.582	0.316	0.273	1847.774	0.533

So from Table 13 by looking at the adjusted R2 value of the coefficient of determination (R2) the temperature obtained = 0.273. This means that the effect of temperature in the dry season in the last 3 years can explain 27.3% of the dependent variable (the loading capacity of the North Aceh Regency) while the remaining 72.7% is influenced by other things.

d. Correlation Test
Based on the output to the side, it can be seen that only the temperature that is correlated with a sig (1-tailed) value is smaller than 0.05 where: The temperature correlation value is 0.562, which means that the positive strong correlation value means that if the value of the X1 variable is high, the Y value will be high. While other variables the sig (1-tailed) value is greater than 0.05, which indicates that the variable is not correlated.

Table 14. Correlation Table

		Power load	Temperature	Air humidity	Rainfall	Length of solar irradiation	Wind speed
Pearson corelation	Power load	1000	.562	-.308	-.103	.346	-.007
	Temperature	.562	1.000	-.865	-.213	.792	-.021
	Air humidity	-308	-.853	1.000	-.325	-.833	-.292
	Rainfall	-.103	-.213	.325	1.000	-.255	-.124
	Length of solar irradiation	.346	.792	-.833	-.255	1.000	.258
	Wind speed	-.007	-.021	.292	-.124	.258	1.000
Sig. (1-tailed	Power load		.008	.106	.342	.080	.489
	Temperature	.008		.000	.198	.000	.467
	Air humidity	.106	000	.	.094	000	.120
	Rainfall	.342	.198	.094	.	.154	.312
	Length of solar irradiation	.080	.000	.000	.154	.	151
	Wind speed	.489	.467	.120	.312	.151	.

4. Forecasting Using Linear Equations

The following are the results of the forecast values for the dry season and the rainy season in the next 6 years (2023, 2024, 2025, 2026, 2027, and 2028) by looking at the equation of the SPSS output or it can be defined in the month period, namely 19.20, …., 54. The results of the forecasts that have been obtained are:

a. Forecasting for the dry season

Table 15. Table of Forecasting Coefficients

	Unstadarized Coefficients		Stadarized Coefficients		
Model	B	Std.Error	Beta	T	Sig.
. (Constant)	18406.033	557.288		33.028	0.000
t	277.359	51.485	0.803	5.387	0.000

Obtainedthe equation Yt= 18.406,033 + 277,359 t
Calculations are made to predict the demand for electrical energy in the dry season for the next 6 years (2023 to 2028).
Y = 18,406,033 + 277,359 (19, 20, … up to 54)

b. Forecasting for the rainy season

Table 16. Table of Forecasting Coefficients

	Unstadarized Coefficients		Stadarized Coefficients		
Model	B	Std.Error	Beta	T	Sig.
1 (Constant)	17809.418	638.323		27.900	0.000
t	330.330	58.971	0.814	5.602	0.000

Obtained the equation Yt=17,809,418 + 330,330 t
Calculations are made to predict the demand for electrical energy in the rainy season for the next 6 years (2023 to 2028).
Y = 17,809,418 + 330,330 (19, 20, … up to 54)
So that the load demand forecasting can be as follows:

Table 17. Table of Average Electric Energy Demand per month in the Dry and Rainy Season

Years	Average Electric Energy Needs per month in the Dry Season	Average Electric Energy Needs per month in the Rainy Season
2023	24369,2515 kW	24911,513 kW
2024	26033,4055 kW	26893,493 kW
2025	27697,5595 kW	28875,473 kW
2026	29361,7135 kW	30857,453 kW
2027	31025,8675 kW	32839,433 kW
2028	32690,0215 kW	34821,413 kW

CONCLUSION

The conclusion from this study is that the weather factor that has the most influence on electricity load in North Aceh Regency in 2020, 2021 and 2022 is temperature, which can be seen from the correlation value (r) which is 79.2% for the dry season and 56.2% for the rainy season. The rainy season and the season that has the most influence on the electricity load in North Aceh District in 2020, 2021 and 2022 is the dry season, which can be seen from the adjusted R2 value = 60.4% for the dry season while the rest is influenced by other things and adjusted R2 = 27.3% for the rainy season while the rest is influenced by other things. The percentage increase in demand for electrical energy in the dry season is 47% until 2028 and the percentage increase in electricity demand in the rainy season is 42% until 2028.

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