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ELECTRICAL ENERGY CONSUMPTION FOR RURAL RESIDENCES IN THE FUTURE

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Abstract

Shelter is a primary need for everyone to take shelter from all circumstances, therefore that shelter must fulfill the need for electricity for daily activities. The need for electricity is predicted to continue to increase every year. Access to electricity will have a positive impact, for example, improving the standard of living of the population. However, many villages in Indonesia are still experiencing poverty. Therefore, the government implemented the 35,000 MW power plant procurement program to overcome the poverty problem. This paper aims to evaluate and analyze the electrical energy provided to the needs of the village community itself in a bottom-up way, namely determining peak loads, electricity consumption, reliability of electricity distribution systems, community characteristics, predicting electricity demand, to determine suitable renewable energy plants developed in ruralareas in North Sumatra. One of the uses of electrical energy must be regulated as well as possible so that there is no waste in its use, but still comfortable and safe to use. In addition, comparative studies and influencing factors are analyzed with the dependent variable determined in the form of household electrical energy demand, and the independent variableconsists of the intensity of electrical energy users and the number of equipment used in the residence. The proposed research method is descriptive quantitative and comparative. Analysisand evaluation model with multiple linear regression with the help of SPSS software. Comparative research results show that the demand for electrical energy there are differences between urban and rural areas. The results of the *t-test (partial)* showed that the intensity of the use of electrical energy, and the amount of equipment used have a positive and significant effecton household electricity demand. The results of the *F test* (simultaneous) obtained the intensityof electricity use, the number of equipment used and the number of family members have a positive effect on household electrical energy demand.

Keywords: Intensity of Electricity Use, Number of Appliances Used, Number of Family Members, 't-test and 'F' test.

JEL Classification: O4, O5

1. INTRODUCTION

The government is committed to making the best efforts for the equitable distribution of rural electricity for the realization of equitable energy. Based on the Village Potential (BVP) data issued by the Central Bureau of Statistics (CBS) in 2014 (Suman Kharel and Rajan Binayak Pasa, 2021), there are around 2,500 villages in Indonesia that do not enjoy access to electricity at all. Most of these villages are located in theeastern part of Indonesia, namely Papua and West Papua Provinces. The best effort to electrifyrural areas is that by 2019, 2500 villages have been electrified. According to the Minister of Energy and Mineral Resources (MEMR) number 3440/K/21/MEM/2012 on various occasions, electricity must beenjoyed by all levels of society

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at affordable rates, including those living in rural areas. To realize these ideals, efforts to electrify the community continue to be carried out by the Government through three approaches. First, the expansion of the electricity network through PT PLN's (Persero) rural electricity program.

This is developed mainly when the community or load is near the electricity system. The development of transmission network interconnections is carried out to get a better load (Imadadullah, Basem Alamri, Md Alamgir Hossain, M S Jamil Asghar., 2021), (Hesam Mazaheri, Hossein Ranjbar, Hossein Saber, Moein Moeini-Aghtaie., 2021). Second, for people who live in rural areas, scattered and far from PLN's electricity installations, the way the Government does is to provide pre-electrification, through the distribution of Energy-Saving Solar Lights (ESSL) (A Amo-Aidoo, E N Kumi, O Hensel, J K Korese, B Sturm., 2022). This program is stipulated in Presidential Regulation 47/2017 on the Provision of ESSL for Communities that Have Not Gained Access to Electricity. In 2017, the Government targeted the distribution of 95,729 LTSHE packages to the 6 easternmost provinces of Indonesia, namely West Nusa Tenggara, East Nusa Tenggara, Maluku, North Maluku, Papua, and West Papua. Meanwhile, in 2018 the Ministry of Energy and Mineral Resources also proposed funds for the implementation of ESSL distribution in 15 provinces. Third, for people who livefar from PLN electricity installations, but live together in one area, the way to electrify them isto develop *micro grids-off grids.*

The government through the business of supplying small-scale electricity by the Minister of Energy and Mineral Resources Regulation38/2016. With this regulation, people living in undeveloped, remote villages, and outermost or border islands can be electrified by other business entities such as Regional Owned Enterprises (ROE), the private sector, and cooperatives that are given separate business areas by the Government. This rural electrification acceleration program utilizes the use of new renewable energy sources (RES) as a source of electrical energy (Moses jeremiah Basara Kabeyi and Oludolapo Akanni Olanrewaju, 2022).

Indonesia has a rural electrification ratio of 99.48%, a significant increase from 2014's 84%. This figure has exceeded the 2015-2019 National Medium-Term Development Plan (NMDP) target of 96%. However, 433 villages in Indonesia have not been electrified including Papua (325 villages), West Papua (102 villages), East Nusa Tenggara (5 villages), and Maluku (1 villages). The government has also developed a strategy to fulfill all electricity needs in the country. The Coordinating Minister for Human Development and Culture (CMHDC) recommends meeting electricity needs by utilizing alternative energy that is adjusted to the availability of budget needs and village characteristics, both Human Resources (HR), geography, and availability of energy sources. Relevant ministries/agencies including Relevant Ministries/Institutions include Energy, Human Resources, State Electricity Company, Ministry of Development of Disadvantaged Villages and Transmigration, and private development partners must also work together to maximize efforts to utilizealternative energy for electricity that is appropriate based on characteristics to increase the Rural Electrification Ratio.

ISSN 1533-9211

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The government has directed that State Electricity Company in the future must dare to shift its power plants not onlyrelying on coal but also New Renewable Energy (NRE) such as hydro power, biothermal, or biomass as an alternative to electricity development. It is indeed a little more expensive but inthe future direction, the use of NRE can be utilized properly. I think our targetfor the utilization of NRE will be exceeded. In addition, the Government considers it necessaryto identify villages that have not been electrified. It is also important to record which villages are close to electrified villages and the distance between houses between residents so that the government can determine the right technological strategy approach. It is important whether it is by extending the electricity network or building mini grades, such as micro-hydro, diesel power, or distribution of electric tubes equipped with battery charging stations (Ramadoni Syahputra and Indah Soesanti, 2021).

In everyday life, electricity has an important role in providing energy supply as a source of lighting and running various businesses and human activities. Electricity is the only energy capable of carrying out all operational activities, where energy is a natural resource needed in human life and also in development, especially for industrialization activities. Grellier (2008) (Philippe Grellier et al, 2008), explain that electricity demand is the total use of household electricity consumption is considered at the level of consumer satisfaction, and many electrical devices are used as a resultof increased income. Along with the development of the Indonesian economy plus the industrial revolution, the standard of human life has also increased, ultimately affecting the increase in electricity demand and electricity consumption per capita, (Xiaoming Kan, Lina Eichenberg, Fredrik Hedenus., 2021). It is one of the impacts of increasing electricity demand in various provinces in Indonesia,

The increase in the number of households in North Sumatra Province is one of the factors that increase electricity demand both urban and rural. The number of urban households is more than rural households, in 2018 The number of households in North Sumatra City reached 141,877 people far greater than the West Tanjung Jabung Regency which has a small household population of only 82,235 thousand people in 2018 (BPS Statistics Indonesia, 2019). Making cities the center of the economy where complete facilities, availability of infrastructure, easy to get adequate electricity services make cities densely populated and inversely proportional to rural areas that lack infrastructure so that they are less attractive for residence. Household electricity demand is influenced by factors such as the number of family members, the number of appliances used, and the intensity of electricity use (Zhifeng Guo, Kaile Zhou, Chi Zhang, Xinhui Lu, Wen Chen, Shanlin Yang., 2018), (Vladimir Durisic, Suncica Rogic, Julija Cerovic Smolovic,Milena Radonjic., 2020). This study assumes that there are factors that play a role in it so that the demand for electricity in the household sector is high. As described above, the formulation of the problemthat can be drawn is how the characteristics of rural and urban household electricity users (respondents) in North Sumatra Province, whether there are differences in urban and rural household electricity demand, and what factors affect the demand for electrical energy in ruraland urban areas in North Sumatra Province. The purpose of this study is to identify the characteristics of household electrical energy demand (respondents), analyze the differences, and analyze the factors that affect the electricity demand of rural and urban households in NorthSumatra Province.

The Seybold Report
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2. METHODS

Some of the empirics used for research include calculating the number of respondents, population size, and percentage of error allowed as follows;

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

Where;

n sample size/number of respondents,

N= population size

e= percentage error allowed, usually e=0.1 (10%).

The data used in this study are primary data obtained from surveys, which are direct observations of the research location. To take a sample, the Slovin formula is used in equation (1). To determine the characteristics of urban and rural household electrical energy users in North Sumatra Province, the following formula is used:

$$x = \frac{\sum x^i}{n} \quad (2)$$

Where:

x = Average

$\sum x^i$ = Frequency

n = Number of respondents

To find a comparative test (t-test), use a two-part test (t-test) with the formula:Where;

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\frac{S_1}{\sqrt{n_1}} + \frac{S_2}{\sqrt{n_2}}} \quad (3)$$

$\bar{x}_1$ = average of sample 1

$\bar{x}_2$ = sample mean 2

S1 = Standard deviation of sample 1

S2 = Standard deviation of sample 2

$n1$ = number of samples 1

$n2$ = number of samples 2

r = Correlation between two samples

The Seybold Report
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Furthermore, to see whether there is an effect of electricity use intensity, the number of equipment users used on household electricity demand in urban and rural areas in North Sumatra Province. Analysis and evaluation methods with multiple regression and Ordinary Least Square (OLS) using SPSS. The equation model is as follows (Springer-Verlag, 2008):

$$Y_k / d_i = \beta_0 + \beta_1 IPL_i + \beta_2 PDN_i + \beta_3 JAE_i + \beta_4 LBR_i - \beta_5 JAK_i + e_i \quad (4)$$

Where:

Yk/di = urban and rural household electricity demand (rupiah)a = constant

β = regression coefficient

$IPLLi$ = electricity usage intensity (hour)

$PDNi$ = revenue (million)

$JAEi$ = number of electronic devices (units)

$LBRi$ = house building area (square meters)

$JAKi$ = number of family members (people)

ei = 5% error term

2.1 Classical assumption test

2.1.1 Normality test

The test results are to see whether in a multiple regression model the two variables, namelythe independent variable and the dependent variable, are normally distributed or not. Having normally distributed data or close to normal is a good multiple regression model. The Kolmogorov-Smirnov test is used to detect data normality so that it can be used as a guideline for decision-making (Jamal I Daoud, 2017). If the *sig value* or probability value <0.05, the distribution is abnormaland if the sig value or probability value> 0.05, the distribution is normal.

2.1.2 Multicolonierity test

The test used to determine whether the regression model has a correlation between independent variables or not is multicollinearity testing. The absence of a high correlation between the independent variables can only be said to be a good model. How to detect the presence or absence of multicollinearity in a regression model can be seen through the tolerance value and the variance inflation factor (VIF) value. Tolerance measures the variability of selected independent variables which cannot be explained by other independent variables. Multicollinearity can see the tolerance value and variance inflation factor (VIF). If the tolerance value> 0.10 and the VIF value <10, it can be concluded that the regression model is said to be free from multicollinearity (Lubna Amro, Frank Konietschke, 2019).

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.10559640

2.1.3 Heteroscedasticity test

Heteroscedasticity is a test used to see if, in the regression model, there is an inequality of variance from the residuals of one observation to another. Homoscedasticity is a good regression model or it can be said that heteroscedasticity does not occur. The following heteroscedasticity test uses the graphical method, by paying attention to the pattern of the graph points from the regression. With the basis for decision-making, namely, if certain patterns, such as existing points form a certain regular pattern (wavy, widening, then narrowing), then heteroscedasticity occurs (one of the factors that cause simple linear regression models to be inefficient and accurate, also resulting in the use of the maximum likelihood method in estimating regression parameters (coefficients) will be disrupted). If there is no clear pattern, such as the dots spreading above and below the number 0 on the *Y* axis, then there is no heteroscedasticity (Roger Koenker, 1981).

2.2 Hypothesis testing

2.2.1 Statistical F test

According to (Ana Lopez-Cheda, and Yingwei Peng, 2023), the Simultaneous test is a test used to seeif there is a joint influence between the Independent variable and the dependent variable. For the F_{test}, the basis for decision-making is, if the sig. value is <0.05, or $F_{count} > F_{tabel}$, then *Ha is* accepted and *Ho is* rejected, meaning that there is a significant relationship between variable X and variable Y and if the sig value is> 0.05, or Fcount< Ftabel, then *Ha is* rejected and *Ho* is accepted, meaning that there is no significant relationship between variable *X* and variable *Y*. The formula used is:

$$F_{tabel} = F(k;n-k) \quad (5)$$

2.2.2 Statistical t-test

According to (Ana Lopez-Cheda, Yingwei Peng, 2023), the partial test is a test used to test the independent variable and whether it has an influence or not on the Dependent variable. With a confidence level of 95%, $\alpha = 0.01$. The basis for making the t-test decision is if the sig value <0.05, or $t_{count} > t_{table}$, then *Ha is* accepted and *Ho is* rejected, meaning that there is a significant effect of variable *X* on variable *Y*. And if the sig value>0.05, or tcount< table, then *Ha is* rejected and *Ho* is accepted, meaning that there is no effect of variable *X* on variable *Y*. The formula used is: $t_{tabel} = t(\alpha/2;n-k-1)$

2.2.3 Coefficient of determination (R^2)

The value (R^2) is used to pay attention to how much influence the independent variable has on the dependent variable. That is the variables of electricity use intensity, income, number of electronic devices, house building area, and number of family members and affect household electricity demand in urban and rural areas in North Sumatra Province. An R^2 valueclose to one means that the independent variables convey almost all the information needed topredict the dependent variables. Conversely, if R^2 is small or close to zero, it means that the ability of the independent variables to explain the variance of the dependent variable is very limited

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.10559640

(Springer-Verlag, 2008).

3. RESULTS AND DISCUSSION

3.1 Characteristics of respondents

Characteristics of urban and rural respondents by age. Characteristics of respondents by age, in urban areas, the head of household has an average age of 40 years and in rural areas themselves the head of household has an average age of 41 years. Characteristics of urban and rural respondents by gender. Characteristics of respondents based on gender, for urban areas the average male gender is 94 household heads with a percentage of 94%, and in rural areas, the average male gender is 56 household heads with a percentage of 83.6%. Characteristics of urban and rural respondents based on latest education. Characteristics of respondents based on their latest education, for urban areas, the average high school graduate (HSG) is 48 household heads, and in rural areas, the average high school graduate (HSG) is 40 household heads.

Characteristics of urban and rural respondents by occupation. Characteristics of respondents based on occupation, in urban areas the average number of 41 household heads working in other occupations, and in rural areas the average number of 45 household heads working in the agricultural sector.

Characteristics of urban and rural respondents based on electricity users. Characteristics of respondents based on electricity users, for urban areas the average respondent uses prepaid electricity (tokens) totaling 76 household heads and in rural areas the average respondent uses prepaid electricity (tokens) totaling 67 household heads.

Characteristics of urban and rural respondents based on installed electric power. Characteristics of respondents based on installed electric power, for urban areas, many respondents use 900-1.300 VA electric power totaling 54 household heads, and in rural areas, the average respondent uses 900-1.300 VA electric power totaling 43 household heads.

Characteristics of urban and rural respondents based on home ownership. Characteristics of respondents based on home ownership, in urban areas the average respondent owns his own house totaling 80 household heads, and in rural areas, the average respondent owns his own house totaling 60 household heads.

Characteristics of urban and rural respondents based on the number of family members. Characteristics of respondents based on the number of family members, for urban areas the average family member is 3 people totaling 34 household heads and rural areas have an average family member of 4 people totaling 20 household heads.

Characteristics of urban and rural respondents based on the size of the house. Characteristics of respondents based on the size of the house, urban areas have an averageof 56 square meters, and rural areas have an average house size of 6 square meters.

Characteristics of urban and rural respondents based on income. Characteristics of respondents based on income, for urban areas have an average income of 1.877 million and rural areas have an average income of 2.674 million.

The Seybold Report
ISSN 1533-9211
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Characteristics of urban and rural respondents based on the number of electronic devices. Characteristics of respondents based on the number of electronic devices, in urban areas households have an average of 9 units of electronic devices, and in rural areas, households have an average of 9 units of electronic devices.

Characteristics of urban and rural respondents based on the intensity of electricity use. Characteristics of respondents based on the intensity of electricity use, urban households have an average intensity of electricity use of 49 hours, and rural households have an average intensity of electricity use of 38 hours.

Characteristics of urban and rural respondents based on electricity consumption. Characteristics of respondents based on electricity consumption, urban areas have an average electricity consumption of 145 rupiah, and rural areas have an average electricity consumption of 199 rupiah.

3.2 Comparative test results (t-test)

This study explains the results of the comparative test (t-test) to compare the average value between two groups of mutually independent variables, how to calculate the average of two mutually independent groups (Comparative test) is done using IBM SPSS software. Based on calculations using IBM SPSS software, the results can be seen, namely:

Table 1: Comparative test results

		Mean	Std. Deviation	Std. error mean	95% Confodence interval of the difference		T	Df	One-side p	Two-side p
					Lower	Upper				
Pair 1	Rural-urban	43074.63	107049.452	13078.172	16963.21	69186.04	3.294	66	0.001	0.002

From Table 1, it shows the significant results of the Two-Sided t-test p (2-tailed) where 0.002<0.05, in addition to the results of t_{count} and t_{table}, where t_{count} (3.294) >t_{table} (2.000), so the hypothesis $H0$ is rejected and the hypothesis Ha is accepted. Signaling the electricity demand of urban and rural households has a difference.

Average results of comparative test (t-test)

Table 2: Urban and rural t-test results

		Mean	N	Std. deviation	Std. error mean
Pair 1	Urban	147223.88	100	55107.284	6732.426
	Rural	190298.51	67	78450.335	9584.234

In addition, it can also be seen in Table 2, that the average value of urban electricity demand is 147223.88 while rural 190298.51. This explains that the average value (Mean) of rural areas is much greater than urban areas, seeing this it can be concluded that the level of demand (consumption) of household electricity in rural areas is higher than the demand (Consumption) of electricity in urban areas.

The Seybold Report
ISSN 1533-9211
DOI: 10.5281/zenodo.10559640

3.3 Multiple regression analysis results

This study explains the results of the estimation based on the factors that affect the electricity demand of urban and rural households in North Sumatra Province, these factors include the intensity of electricity use, income, the number of electronic devices, the size of the house and the number of family members. Calculating and analyzing the relationship and influence between these variables is done using IBM SPSS software with the OLS (Ordinary Least Square)method and multiple linear regression analysis. Based on calculations using IBM SPSS software. Based on Table 3, the regression equation model was obtained as follows

The following:

Yk/di = -26558.102 + 470.281IPL+ 0.032PDN + 5616.356JAE + 997.293LBR-1578.711JAK

Table 3: **Linear regression**

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	-26558.102	16437.457		-1.616	0.108
	IPL	470.281	235.523	0.103	1.997	0.048
	PDN	0.032	0.005	0.466	6.829	0.000
	JAE	5616.356	1903.932	0.201	2.950	0.004
	LBR	997.293	258.977	0.242	3.851	0.000
	JAK	-1578.711	3671.896	-0.027	-0.430	0.668

Source: Data processed 2022

3.4 Classical assumption test

Based on the results of normality testing, the value of Asymp. Sig (2-Tailed) 0.2276 is greater than 0.05 so it can be said that the data is normally distributed. The results of multicollinearity testing show that the independent variables have a Tolerance Value above 0.1 and VIF less than 10, so there is no multicollinearity between the independent variables in the regression model. The results of the heteroscedasticity test show the scatterplot graph analysis wherethere is no clear pattern, along with points that spread above and below the number 0 on the Yaxis, so it is stated that the data in this study does not occur heteroscedasticity.

3.5 F-statistic test results

From Table 4, the sig value for the effect of IPL, PDN, JAE, LBR, and JAK based simultaneously on Y is 0.001<0.05 and the value of f_{count} 52.205>f_{table} 2.27 then shows simultaneously that the intensity of electricity use, income, number of electronic devices, house building area and number of family members together influence the demand or electricity consumption of urban and rural households in North Sumatra province.

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Table 4: F-statistic results

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	511768139012.631	5	102353627802.526	52.205	<.001[b]
	Residual	315655214280.781	161	1960591393.048		
	Total	827423353293.412	166			

3.6 Results of the t-statistic test

It can be seen that the variable intensity of electricity use has a significant level of 0.048 <0.05, it can be seen that partially it has a positive and significant effect on the demand or electricity consumption of urban and rural households in North Sumatra province. The income variable has a significant level of 0.000<0.05, it can be seen that partially it has a positive and significant effect on the demand or consumption of electricity for urban and rural households in North Sumatra province.

Table 5: Results of t-statistics

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-26558.102	16437.457		-1.616	0.108
	IPL	470.281	235.523	0.103	1.997	0.048
	PDN	0.03214	0.004706	0.466	6.829	0.000
	JAE	5616.356	1903.932	0.201	2.950	0.004
	LBR	997.293	258.977	0.242	3.851	0.000
	JAK	-1578.711	3671.896	-0.027	-0.430	0.668

For the variable number of electronic devices has a significant level of 0.004<0.05, it can be seen that partially the variable number of electronic devices has a positive and significant effect on the demand or electricity consumption of urban and rural households in North Sumatra province. The variable area of the house has a significant level of 0.000<0.05, it can be seen that partially the variable area of the house has a positive and significant effect on the demand or electricity consumption of urban and rural households in North Sumatra province. Variable The number of family members has a significant level of 0.668>0.05 from these results it can be seen that partially the number of family members does not have a positive and significant effect on the demand or electricity consumption of urban and rural households in North Sumatra province.

3.7 Coefficient of Determination (R^2)

The magnitude of the coefficient of determination (R^2) is 0.607, which explains that the percentage of influence of independent variables (intensity of electricity use, income, number of electronic devices, house building area, and number of family members) on the dependent

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variable (household electricity demand) is 60.7%. While the remaining 39.3% is explained by other variables outside the study.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusion

According to the characteristics of respondents, namely urban and rural household electricity demand in North Sumatra Province, 100 respondents and rural 67 respondents with a total of 167 respondents. Characteristics of respondents based on the average house building area of urban 56 m^2 and rural 63 m^2, the average income of urban 1.877 million and rural average 2.674 million, the average number of electronic devices urban 9 units and rural average 9 units. With an average intensity of urban electricity use of 49 hours and rural with an average of 38 hours, the average urban electricity consumption of 145 thousand, and rural with an average electricity consumption of 199 thousand. From the results of the comparative test (t-test) urban and rural household electricity demand has a difference, where the average value of urban household electricity demand amounted to 147223.88 and rural 190298.51. This indicates that the level of electricity demand of rural households is higher than that of urban households. Based on the results of the study the variable intensity of electricity use (IPL), income (PDN), the number of electronic devices (JAE), and the building area of the house (LBR) positively and significantly affect the electricity demand of urban and rural households. While the variable number of family members (JAK) has a negative and insignificant effect on the electricity demand of urban and rural households in north Sumatra Province.

4.2 Suggestion

Increasing the diversity of characteristics possessed by urban and rural households must be reproduced to increase household electricity demand. In addition, PLN North Sumatra Province must also provide the availability of electricity so that urban and rural households canincrease their electricity demand. The electricity demand of rural and urban households has a difference, the low demand for electricity in the city is influenced by the low level of electricityconsumption, so city households must increase their income level so that they can increase their household electricity consumption in the future. From the results of the study, the numberof family members has a negative and insignificant effect this occurs because the increase in the number of family members does not cause household electricity demand to rise. So for thisvariable number of family members must pay more attention to the age of family members andalso family members who reside in the family, so that the results can later be positiveand significant.

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