



Factors Affecting Urban and Rural Household Electricity Demand in South Sulawesi Province, Indonesia

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ABSTRACT

This study aims to analyze the factors influencing household electricity demand in urban and rural areas of South Sulawesi Province. The seven independent variables used in this study include electricity price, household income, number of family members, electronic device ownership, education level, number of rooms, and a dummy variable for urban-rural areas. The analysis method used was multiple linear regression with a quantitative approach based on data from 400 household respondents. The results show that household income, number of family members, electronic device ownership, number of rooms, education level, and the dummy variable for urban-rural areas have a positive and significant effect on electricity consumption. Conversely, electricity price has a significant negative effect. This finding indicates that household economic and physical characteristics are more important determinants of electricity demand than social factors. This study recommends electricity tariff policies tailored to household socioeconomic conditions and improved energy access and education, especially in rural areas.

Keywords: Electricity Demand, Household, Urban, Rural Areas

JEL Classifications: C13, Q40, R21

1. INTRODUCTION

Electricity is a crucial element in supporting modern society. Its existence not only supports domestic activities but also serves as a key driver of social, economic, and technological development. In today's digital era, the need for electricity has increased significantly because almost all societal activities, from lighting and communication to production and mobility, depend on electrical energy. On the other hand, the distribution and access to electricity are uneven, particularly when viewed from the differences between urban and rural areas (Damanhuri, 2021; World Bank, 2020). This is also reflected in South Sulawesi Province, which boasts quite complex geographic, social, and economic diversity (South Sulawesi Provincial Communication and Informatics Office, 2022).

Household electricity demand in South Sulawesi continues to increase in line with dynamic economic and demographic

growth. The province consists of 24 regencies/cities, reflecting the diverse characteristics of urban and rural areas (Central Bureau of Statistics 2023). In large cities like Makassar, Parepare, and Palopo, household electricity consumption tends to be high due to higher incomes, high population density, and modern lifestyles. Meanwhile, in rural areas like East Luwu, Enrekang, and the Selayar Islands, electricity consumption patterns differ due to various factors, including limited infrastructure, affordability, and purchasing power.

The disparity between urban and rural household electricity consumption is an important issue that requires further in-depth study (Harwanto, 2020; UNDP Indonesia, 2021). Electricity demand is closely related to structural and contextual aspects such as household income, electricity prices, electronic equipment ownership, house size, education level, and perceptions of energy efficiency. Therefore, a scientific approach is needed that can

comprehensively explain variations in household electricity demand based on empirical data (Hadi, 2019).

According to demand theory, electricity consumption, as a normal good, tends to increase with rising income and changes in consumer preferences (Nugraha, 2019; PLN, 2023). This can be observed in urban environments, where people tend to own more electronic devices and use electricity more intensively, including for air conditioners, water heaters, double-door refrigerators, digital televisions, and other smart devices (Todaro and Smith, 2020). On the other hand, rural communities have limited access and ability to purchase electrical equipment, which causes their consumption levels to be lower (Sari and Pratama 2021).

Besides income, electricity prices are also a significant determinant of demand. In Indonesia, the majority of people still receive government subsidies on electricity tariffs, particularly for 450 VA and 900 VA units. This subsidy policy has a significant impact on electricity consumption by lowering utility costs and providing consumption incentives (Yusuf and Resosudarmo, 2015). However, not all households receive subsidies equally, and the effectiveness of electricity subsidies in various regions—particularly rural areas—remains a matter of debate in national energy policy studies.

Other equally important factors include demographics, such as the number of family members, the age of the head of the household, and education level. Households with larger families tend to consume higher electricity due to additional needs such as lighting, cooling, and cooking appliances. Furthermore, education level and awareness of energy efficiency also influence consumption behavior. Households with better knowledge of energy conservation tend to be more prudent in their electricity use and choose energy-efficient appliances (Amin, 2020).

It's also important to highlight the role of infrastructure in driving electricity consumption. In urban areas, the PLN electricity distribution network is widespread and stable, so residents experience no obstacles in accessing energy. However, in rural areas, many areas still rely on local diesel generators or are not yet fully electrified. This situation makes comparing electricity demand more complex, as supply constraints also influence actual demand (Prasetyo, 2023).

Government policies in developing the energy sector through the national electrification program have succeeded in significantly increasing the electrification ratio. According to data from the Ministry of Energy and Mineral Resources. (2023), the national electrification ratio has reached 99.63%. However, some areas in Eastern Indonesia, including South Sulawesi, still experience delays in electricity access due to geographical challenges (Ministry of Energy and Mineral Resources, 2023; IEA, 2022; Akhmad et al., 2019). This impacts rural communities' limited access to reliable and affordable electricity, which in turn influences their behavior and patterns of electricity demand.

Technological advancements and the digitalization of households also contribute to new variables in understanding electricity

demand. Households today use electricity not only for basic needs, but also to support productive activities such as home businesses, working from home, and even online learning. This digitalization is certainly more widespread in urban areas, while rural areas still face barriers to accessing technology and other supporting infrastructure (Handayani, 2019).

The geographical conditions of South Sulawesi Province, consisting of coastal areas, lowlands, and hills, result in uneven electricity distribution. Some inland and island areas still rely on alternative energy sources such as solar cells or generators. The local government and PLN (State Electricity Company) have undertaken various initiatives to expand electricity coverage, including through the Village Electricity (Lisdes) program. However, numerous challenges remain, including technical, financial, and social challenges (Ridwan and Iskandar, 2021; Setiawan, 2018).

In the context of sustainable development, energy efficiency and carbon emission reduction are national priorities. Household consumption behavior needs to be directed toward more economical and environmentally friendly patterns (Sudrajat, 2021). This can only be achieved with a good understanding of the factors influencing electricity demand, so that policy interventions can be tailored to the characteristics of each region (Hadi, 2019). This research is expected to provide input for the development of evidence-based policies in the household energy sector, particularly in the context of the urban-rural divide in South Sulawesi.

Therefore, this research is important to answer several fundamental questions, such as: What are the main factors influencing household electricity demand in urban and rural areas of South Sulawesi? Are there significant differences between the two? How do income, electricity prices, and family size influence demand? And more importantly, how can the results of this research be used to formulate equitable, efficient, and sustainable energy policies?

This research will employ a quantitative approach through primary data collection using a household survey. Linear or logistic regression analysis will be used to measure the influence of independent variables such as income, family size, education level, electricity prices, and electronic device ownership on the dependent variable, electricity consumption. The research will also consider the spatial dimension through comparisons across districts/cities in South Sulawesi.

Against this background, this research is expected to provide theoretical and practical contributions to household energy studies. The theoretical contribution lies in the development of a contextualized electricity demand model for urban and rural areas, while the practical contribution is in the form of recommendations for household energy policies that adapt to the socioeconomic characteristics of the community. Therefore, the results of this research can serve as an important reference for energy planning in South Sulawesi Province and serve as a baseline for similar studies in other regions in Indonesia.

2. LITERATURE REVIEW

Household electricity demand is a key issue in energy economics, especially in developing countries like Indonesia. Electricity, as an economic good, plays a crucial role in supporting modern household life. From a microeconomic perspective, electricity demand is influenced by several key factors, such as electricity price, income, family size, education level, household size, ownership of electronic equipment, and geographic location (World Bank, 2021). The theory of demand for consumption of normal goods such as electricity indicates that it increases with income (Sloman, 2018). In the context of South Sulawesi, there is a disparity between household electricity consumption in urban and rural areas. Urban areas have higher electricity consumption due to better infrastructure, higher incomes, and modern lifestyles that tend to use more electronic devices (Romadhoni and Akhmad, 2020).

Electricity demand theory refers to a consumption model that explains how economic factors influence the amount of electricity consumed by households. Electricity demand is elastic with respect to several variables, particularly income and price. According to Samuelson and Nordhaus (2009), changes in electricity prices will lead to changes in consumption, but the elasticity tends to be low, especially for basic needs.

In households, electricity is used for various purposes, from lighting and cooling to cooking and entertainment. Therefore, according to UNDP Indonesia (2021), electricity demand is influenced by: Electricity Price, Household Income, Number of Family Members, Head of Household Education Level, Electronic Equipment Ownership, Number of Rooms, and the Urban-Rural Dummy Variable.

Income is one of the strongest factors influencing household electricity demand. A study by the Ministry of Energy and Mineral Resources (2021) showed that electricity consumption in households with monthly expenditures of more than IDR 5 million is significantly higher than that of households with expenditures of less than IDR 2 million. This is supported by research by Purnomo (2020), which found that the income elasticity of household electricity consumption in Indonesia is around 0.6—meaning that every 10% increase in income leads to a 6% increase in electricity consumption.

Electricity prices also play a significant role, although household electricity consumption for basic needs tends to be inelastic. This is because households still require electricity for lighting and other essential needs. However, for secondary needs such as air conditioning or water heating, price changes are more pronounced (IEA, 2022; Lee et al., 2011).

Electricity tariffs in Indonesia are classified based on power capacity. Households with 450 VA and 900 VA power receive subsidies, resulting in lower electricity costs. Urban households generally use higher power (1300 VA and above), which is not subsidized, causing differences in response to prices (PLN, 2022; Akhmad, 2015).

The number of family members directly impacts electricity consumption. The more people in a household, the greater the electricity demand for lighting, fans, refrigerators, and other household appliances. Research by Ridwan and Iskandar (2021) found that an increase in the number of family members correlates with a 15 kWh increase in electricity consumption per month (Karim et al., 2021).

Households with multiple electronic devices tend to consume more electricity. In urban areas, households generally own more appliances, such as air conditioners, refrigerators, flat-screen TVs, washing machines, microwaves, and computers. In rural areas, ownership of electronic devices is still limited, resulting in lower electricity consumption (Ministry of Energy and Mineral Resources, 2021).

Geographical factors and regional status significantly influence electricity demand. In cities, electricity infrastructure is more established, distribution networks are more extensive, and communities have good access to electricity. In rural areas, there are still areas without adequate electricity, especially in mountainous or remote areas, such as parts of Enrekang or North Toraja (PLN RUPTL, 2023).

Urbanization in South Sulawesi has led to a surge in electricity demand. Migration from rural to urban areas has increased the number of urban households and increased the electricity load. Urbanization has also driven higher and more complex energy consumption patterns (Todaro and Smith, 2020).

3. RESEARCH METHODS

This research was conducted in South Sulawesi Province, which consists of 24 regencies/cities. This region has diverse geographic and demographic characteristics, encompassing urban areas such as Makassar, Pare-pare, and Palopo, as well as rural areas in various regencies such as Bone, Enrekang, Gowa, and Bulukumba. This location was selected based on the consideration that South Sulawesi Province is one of the provinces with significant growth in household electricity consumption, both in urban and rural areas (Central Bureau of Statistics, 2023).

Furthermore, the disparity in electricity consumption between urban and rural households in this province is interesting for further study. Differences in socioeconomic aspects, infrastructure, and electrification levels provide a strong foundation for exploring various factors influencing household electricity demand. Location selection significantly determines the social and economic context in the analysis of household electricity consumption (Sovacool, 2012).

3.1. Data Collection Techniques

The data collection technique in this study was conducted through a questionnaire. The questionnaire was used to collect primary data from household respondents. The questionnaire was designed with a Likert scale of 1-5 to measure respondents' perceptions of variables such as electricity price, household income, number of family members, education level of the head of household, ownership of electronic devices, and number of rooms.

Complementary interviews were conducted with key informants such as regional PLN officials and village/sub-district officials to obtain an overview of electricity distribution and the barriers faced by households in accessing electricity, particularly in rural areas.

3.2. Population and Sample

The population in this study comprised all households across urban and rural areas in South Sulawesi Province. According to Central Bureau of Statistics (2023), there are over 2 million households in this region, with approximately 55% in rural areas and the remainder in urban areas. Population determination in energy studies must take into account geographic distribution and electrification levels (Bhattacharyya, 2011).

The sampling technique used stratified random sampling based on two major strata: urban and rural households. Furthermore, districts/cities were randomly selected from each stratum, and within each district/city, several sub-districts were selected proportionally. Stratification allows for valid comparisons between heterogeneous population groups (Neuman, 2014).

Sample size was determined using the Slovin formula: Where: N = total households (2,000,000), e = margin of error (5%). Thus, a total sample of 400 households was divided proportionally between urban and rural areas. The Slovin formula is suitable for use in large populations to determine sample size efficiently (Umar, 2013).

3.3. Analysis Method

To analyze the influence of factors on household electricity demand, a Multiple Linear Regression model was used. Multiple linear regression analysis is widely used in energy demand studies because it can explain multivariate relationships between variables (Gujarati and Porter, 2009), with the general formula:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \epsilon$$

Where:

X_1 = Electricity price per kWh

X_2 = Household income

X_3 = Number of family members

X_4 = Ownership of electronic devices

X_5 = Education level

X_6 = Number of rooms

X_7 = Dummy variable for city/village, where city is assigned a value of 1 and village is assigned a value of 0.

Y = Household electricity demand (kWh/month)

ϵ = Error term

Classical assumption testing is necessary to ensure the results are accurate. regression meets the BLUE (Best Linear Unbiased Estimator) rules, Gujarati, 2011).

4. RESEARCH RESULTS AND DISCUSSION

4.1. Respondent Characteristics

This study involved 400 households, spread across urban and rural areas in South Sulawesi Province. 200 respondents came

from urban areas, while the remainder came from rural areas. Data were collected through questionnaires and interviews, then analyzed using descriptive statistics and multiple linear regression.

Based on the survey results, the majority of respondents had a high school education or equivalent (42%), and only 12% had pursued higher education. The majority of respondents were self-employed (34%) and farmers (27%), with an average monthly income of IDR 2,500,000. The most common electronic appliances used were televisions, rice cookers, and fans. Socioeconomic characteristics such as education and income are important predictors in energy demand studies (Bhattacharyya, 2011).

Household electricity consumption in urban areas averages 110 kWh per month, while in rural areas it is around 78 kWh per month. This difference is influenced by the level of electronic device ownership, economic activity, and accessibility to electricity services. Most rural households use electricity for lighting, while urban households also use electricity for electronic devices, entertainment, and productivity support. Access to and use of electricity are influenced not only by supply but also by socio-cultural needs (Sovacool, 2012).

4.2. Model Estimation Results

The results of the model estimation of factors influencing urban and rural household electricity demand in South Sulawesi Province can be seen in Table 1.

The results of the model estimation of Factors Influencing Urban and Rural Household Electricity Demand in Sulawesi Province show a coefficient of determination (R^2) of 0.882. This indicates that the explanatory variables—electricity price, household income, number of family members, education level of the head of household, electronic equipment, number of rooms, and a city/village dummy—collectively explain 88.20% of the fluctuation in household electricity demand at a significance level (α) of 0.0001, indicated by an F value of 187.17, as seen in Table 1.

The model estimation results indicate that electricity price (X_1) has a significant negative effect on household electricity demand. The negative coefficient indicates that when electricity prices increase, household electricity demand decreases. This is in accordance with the law of demand. A coefficient of -0.018 means that if electricity prices increase by Rp100, electricity consumption decreases by 1.8 kWh, all other things being equal.

Household income (X_2) has a positive and significant effect on household electricity demand in South Sulawesi Province. The significant positive coefficient indicates that higher household income leads to higher electricity consumption. Electricity consumption is a normal good. For every Rp100,000 increase in income, electricity consumption increases by 6.5 kWh.

The model estimation results also show that the number of household members (X_3) has a positive and significant effect on household electricity demand. A significant positive coefficient indicates that households with more members tend to have higher electricity needs due to increased household activities. Each

Table 1: Estimation results of factors influencing urban and rural household electricity demand in south sulawesi province

Model	Unstandardized coefficients		T	Significance	R ²	F
	B	Standard error				
(Constant)	150.25	15.612	-2.312	0.022	0.882	187.17
Electricity price (X ₁)	-0.018	0.026	4.987	0.000		
Income (X ₂)	0.065	0.0013	2.115	0.036		
Number of family members (X ₃)	0.341	0.844	2.432	0.017		
Education (X ₄)	0.212	0.523	5.672	0.000		
Electronic equipment (X ₅)	0.456	0.911	1.997	0.048		
Number of Rooms (X ₆)	0.188	0.798	3.331	0.001		
City-Village Dummy (X ₇)	0.726	2.983	-2.312	0.022		

additional family member increases electricity consumption by approximately 0.341 kWh.

The education level of the head of the household has a positive and significant effect on household electricity demand in South Sulawesi Province. A positive coefficient on education level can increase awareness and use of technological devices, thereby increasing electricity consumption. Each additional year of education leads to an increase in household electricity consumption of 0.212 kWh.

The number of electronic appliances (X₅) has a positive and significant effect on household electricity demand in South Sulawesi Province. This coefficient is the highest among all variables, at 0.453. This indicates that owning more electronic devices is directly proportional to electricity consumption. For example, the addition of one electronic appliance (air conditioner, refrigerator, etc.) will increase household electricity consumption in South Sulawesi Province by 0.453 kWh.

The model estimation results also show that the number of bedrooms in a household (X₆) has a positive effect on household electricity consumption in South Sulawesi Province. A positive coefficient indicates that homes with more bedrooms tend to have higher electricity consumption due to the greater number of facilities and lighting fixtures. Each additional bedroom increases household electricity consumption by 0.188 kWh.

The estimation results also show that the dummy variable has a positive and significant effect on household electricity consumption in South Sulawesi Province. A positive and significant coefficient indicates that the dummy variable has a value of 1 for urban areas and 0 for rural areas. A coefficient of 0.726 means that urban households consume 0.726 kWh more electricity than rural households, assuming other variables remain constant.

4.3. Discussion of Research Findings

The regression results indicate that electricity prices have a negative effect on household electricity consumption, especially in rural areas. A negative regression coefficient indicates that price increases will lead to a decrease in demand. This finding supports the theory of demand, which states an inverse relationship between price and quantity demanded (Mankiw, 2012). Electricity demand elasticity is higher among low-income consumers due to limited purchasing power (Filippini and Pachauri, 2004). In rural areas, the prepaid system implemented by PLN also encourages households to be more economical. This system allows consumers to control

consumption according to their economic means (Chakravarty et al., 2013).

Household income has a positive effect on electricity demand. Households with higher incomes tend to consume more electricity because they can afford electronic equipment and afford sustainable energy consumption. This aligns with the findings of Reiss and White (2005) that income is the most consistent factor explaining variations in electricity consumption between households. Household economic well-being directly impacts energy consumption patterns, including electricity (Bhattacharyya, 2011). However, the effect of income also interacts with education. High-income households with a high level of education tend to be more conscious of energy efficiency (Czajkowski et al., 2014).

The number of family members is directly proportional to electricity consumption. The larger the family, the greater the need for lighting, electronic devices, and daily activities that require electricity. This also supports the study by Lopes et al. (2016) that household demographic factors such as family size influence energy use. However, this study also shows that the effectiveness of per capita consumption decreases with increasing family size due to the efficiency of shared electrical appliances. Economies of scale in large households can reduce per capita consumption, even if total consumption increases (IEA, 2019).

The education of the household head is positively correlated with energy efficiency awareness. Households with higher levels of education tend to manage electricity use wisely, use energy-efficient appliances, and turn off electrical appliances when not in use. This supports the findings of Czajkowski et al. (2014) and the World Bank (2020) that education plays a crucial role in shaping sustainable consumption patterns. Investing in household energy education can be an efficient strategy for managing national energy demand (IEA, 2019). Education also plays a role in selecting electronic appliances with energy-efficient labels and in accessing information about government subsidies or efficiency programs.

Ownership of electronic appliances has been shown to be a very significant variable in determining electricity demand. Households with a greater number of electronic appliances, especially high-power appliances such as washing machines, water dispensers, and air conditioners, have significantly higher electricity consumption. "Modernization of household lifestyles drives energy consumption due to the increasing number and types of electronic devices" (Sovacool and Dworkin, 2015). Interestingly, the data shows that ownership of electronic devices is higher in urban areas.

Meanwhile, in rural areas, consumption of electronic devices is limited to basic needs, such as lighting, fans, and televisions. This indicates that the level of technology adoption is still an obstacle for households in rural areas.

The number of rooms is used as a proxy for the size and luxury of a home. Homes with more rooms typically consume more electricity because they require lighting and may have air conditioning or fans in each room. Regression results indicate that the number of rooms has a positive and significant effect on electricity demand. This effect is greater in urban areas because homes generally have more additional electricity-based facilities. This finding is consistent with research by Hidayat and Darmawan (2017), which indicates that homes with a large number of rooms tend to have higher electricity consumption.

The results show a significant difference in household electricity consumption levels between urban and rural areas. Households in urban areas consume an average of 110 kWh per month, while those in rural areas consume only around 78 kWh per month. This aligns with findings by Sovacool (2012), which stated that access to and quality of energy infrastructure are key determinants of electricity consumption levels. Limited infrastructure in rural areas, such as unstable electricity supply, the lack of electricity connections in some remote areas, and low income levels, contribute to low consumption. Conversely, urban areas with better access to energy resources and higher incomes tend to exhibit greater consumption. The disparity in energy consumption between urban and rural areas reflects inequalities in access and economic development (World Bank, 2020).

5. CONCLUSION AND RECOMMENDATIONS

This study shows that all seven variables analyzed significantly influence household electricity demand, both in urban and rural areas of South Sulawesi. Household income, number of family members, electronic device ownership, education level, number of rooms, and the urban-rural dummy variable have a positive and significant effect on increasing household electricity consumption. Conversely, electricity price has a significant negative effect, meaning that increasing electricity prices tend to decrease household electricity consumption.

This study concludes that there are differences in the determinants of electricity consumption between urban and rural areas. In urban areas, electronic device ownership, household income, and number of rooms are the main factors driving high electricity consumption. On the other hand, in rural areas, the number of family members and education level have a greater contribution. Interestingly, the effect of electricity price tends to be weaker in rural areas, possibly due to the low elasticity of demand due to dependence on electricity for basic needs.

This study emphasizes the importance of infrastructure and socioeconomic factors in explaining variations in household electricity demand in South Sulawesi. Household income is

the most significant variable, indicating that purchasing power significantly determines electricity consumption capacity. The number of rooms and electronic devices reflects the quality of infrastructure and household stability, which directly increases electricity consumption. Education level also proved to have a positive effect, especially in more informed households that tend to use more electronic devices. Electricity price remains a controlling variable, but its effect is more pronounced in low-income groups. The urban-rural dummy is significant, indicating that urban households tend to have higher electricity consumption due to access and lifestyle. This study suggests the importance of a progressive electricity tariff policy and increasing electricity access in rural areas.

The government and PLN are advised to implement a progressive electricity tariff scheme that takes into account household income and the number of electronic devices. Households with high consumption and higher incomes are charged higher tariffs, while low-income groups receive equitable subsidies. This can maintain electricity affordability while encouraging energy efficiency.

It is necessary to improve electricity access and education on energy use in rural areas. Local governments should promote programs to promote energy efficiency and efficiency, especially for households with low education and large families, to ensure optimal electricity use.

Subsidized housing development programs or livable home renovations should consider energy efficiency aspects, such as the number of rooms and the number of electronic devices used. Incentives for the use of energy-efficient electronic devices are crucial, particularly in urban areas with high electricity demand.

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