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Determinants Of Energy Poverty In West Sumatra

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Abstract

Energy poverty remains one of the development challenges faced by various regions in Indonesia, including West Sumatra Province. Although access to electricity has continued to improve, some households still face difficulties in obtaining and adequately using modern energy services. This study aims to examine how household characteristics, regional characteristics, and economic conditions affect energy poverty among households in West Sumatra Province. This study employs a quantitative approach using data from the 2020 National Socioeconomic Survey (Susenas). Energy poverty is measured using the Multidimensional Energy Poverty Index (MEPI), while the factors influencing energy poverty are analyzed using a probit regression model. The findings indicate that household characteristics, residential location, and economic conditions significantly affect the likelihood of households experiencing energy poverty. Households headed by individuals with higher levels of education, those living in urban areas, and those with higher household expenditures are less likely to experience energy poverty. In contrast, households with a larger number of members are more likely to experience energy poverty. These findings indicate that reducing energy poverty requires more than simply improving access to modern energy services. It also requires improvements in human capital, more equitable regional development, and stronger household economic conditions. Therefore, policies addressing energy poverty should adopt a comprehensive and multidimensional approach to ensure more effective and targeted interventions.

Keywords: Energy Poverty, MEPI, Probit Model, Household, West Sumatra

INTRODUCTION

Energy is an essential need for households, supporting education, health, employment, and economic productivity. However, the availability of energy does not

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necessarily ensure that all households can obtain sufficient, safe, clean, and affordable energy services. This condition is commonly referred to as energy poverty. The issue is complex because it involves various aspects, including economic conditions, household characteristics, and residential location. Education is one of the household characteristics associated with the ability to access and utilize modern energy. Previous studies by Nepal et al. (2025), Zetara and Hartono (2023), and Sothea Oum (2019) have demonstrated a relationship between education and energy poverty (Nur et al., 2024). Households with higher levels of education generally have greater capacity to obtain and utilize modern energy services effectively.

The number of household members may also influence energy requirements. The larger the number of people living in a household, the greater the amount of energy required for lighting, cooking, and other daily activities. Rizal et al. (2024) found that larger households tend to face a higher risk of energy poverty (Nur, Hartono, Dartanto, & Ml, 2024). This finding indicates that household demographic characteristics may affect their ability to meet energy needs.

Furthermore, the gender of the household head may influence how households access and utilize energy. Ng et al. (2026) found differences in energy use based on household-head characteristics in Zambia. Male-headed households with higher levels of education and income tend to use electricity as their primary energy source, whereas female-headed households are more likely to use firewood or charcoal as energy sources.

Energy poverty is also closely related to regional characteristics. Differences in infrastructure, electricity-grid access, availability of clean fuels, and geographical conditions create disparities in households' ability to access modern energy between urban and rural areas. Nur et al. (2024) showed that geographical location influences energy poverty in Indonesia, while Hartono, Dartanto, and Gultom (2024) emphasized the important role of geographical factors in multidimensional energy poverty (Nur et al., 2024). Yaqin et al. (2023) also demonstrated that changes in energy prices may affect urban and rural areas differently.

From an economic perspective, the resources available to households are associated with their ability to meet energy needs. Azhary and Irfan (2025) stated that per capita income has a negative effect on energy poverty, whereas income inequality has a positive effect. These findings suggest that better economic conditions can improve people's ability to meet their energy needs. In this study, household economic

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conditions are represented by household expenditure, which reflects the extent to which households are able to fulfill various basic needs, including energy consumption.

Previous studies indicate that energy poverty is influenced by household characteristics, regional location, and economic conditions. However, differences in social, economic, geographical, and infrastructure conditions mean that findings from one region may not necessarily represent conditions in another region. Therefore, a study specifically examining the various factors associated with energy poverty in West Sumatra Province is necessary.

West Sumatra Province continues to experience disparities in energy use across its regencies and cities. Some areas still rely considerably on traditional fuels, whereas urban areas have greater access to modern energy. This condition indicates that energy poverty in West Sumatra is not merely related to a lack of electricity, but also to households' ability to obtain clean and modern energy, as well as to socioeconomic and residential-location factors.

Based on these conditions, this study examines the determinants of household energy poverty in West Sumatra Province. The study considers several factors, including the educational attainment of the household head, household size, and gender of the household head. It also considers regional characteristics, particularly whether a household resides in an urban or rural area. In addition, household expenditure is incorporated as an economic factor. Energy poverty is measured using the Multidimensional Energy Poverty Index (MEPI), while the Probit model is employed to analyze the factors affecting the probability of a household experiencing energy poverty.

This study is expected to provide empirical evidence regarding the factors influencing household energy poverty in West Sumatra. The findings may also serve as a reference for policymaking, particularly in improving energy access, enhancing educational quality, strengthening household economic conditions, and promoting equitable distribution of energy infrastructure.

LITERATURE REVIEW

Multidimensional Poverty Theory

Energy poverty can be understood as one form of multidimensional poverty that is not determined solely by income, but also by household limitations in obtaining safe, clean, and affordable energy services (Tri et al., 2023). According to Zulkifli et al. (2023), multidimensional poverty encompasses various forms of deprivation in economic, social, and environmental aspects. Okushima also explains that energy poverty includes the

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dimensions of energy availability and affordability (Nepal et al., 2025). This indicates that energy poverty is influenced by various factors, including economic, social, demographic, and regional conditions. Therefore, its measurement cannot rely on a single indicator.

To provide a more comprehensive representation of this condition, the Multidimensional Energy Poverty Index (MEPI) approach is employed. MEPI considers various forms of energy deprivation experienced by households. It can be used to identify households experiencing energy poverty while also determining the dimensions contributing to such conditions. Therefore, this study employs MEPI as a measure of household energy poverty in West Sumatra Province.

Capability Approach

According to Amartya Sen's Capability Approach, individual well-being should not be assessed solely based on income and ownership of assets, but also on people's capabilities and freedom to achieve the kind of life they value (Rama et al., 2025). In the context of energy, the availability of modern energy can support households in carrying out educational activities, maintaining health, working, and increasing productivity. Conversely, limited access to energy can restrict households' opportunities to achieve greater well-being.

Nepal et al. (2025) demonstrated a relationship between education and energy, as energy limitations can hinder educational opportunities, while low levels of education may increase the risk of energy poverty. Rizal et al. (2024) also found that households with limited energy access in Indonesia experience various forms of deprivation in the utilization of modern energy, particularly in cooking, which may affect health and quality of life (Nur, Hartono, Dartanto, & Ml, 2024). Therefore, improving access to modern energy is important for expanding household capabilities to achieve a more decent standard of living and reducing energy poverty.

Energy Ladder Theory (Leach, 1992)

Leach (1992), through the Energy Ladder Theory, explains that household welfare conditions may influence the choice of energy sources used. As economic conditions improve, households tend to shift from traditional fuels, such as firewood and charcoal, toward more modern and cleaner energy sources, such as LPG and electricity (Ng et al., 2026). Changes in energy use are not determined solely by income but are also influenced by education, energy availability, and infrastructure support.

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Regional differences may also influence patterns of energy use. Urban households generally have easier access to modern energy because they benefit from better infrastructure compared with rural households. Nevertheless, the transition between energy sources does not always occur completely, as some households continue to use several energy sources simultaneously, a practice known as fuel stacking. This condition indicates that energy use is also influenced by household habits, user preferences, and the availability of energy sources in the surrounding environment.

RESEARCH METHODS

Research Design

This study employs a quantitative explanatory research design to examine the determinants of multidimensional energy poverty in West Sumatra. A quantitative approach enables objective measurement of variables using numerical data and statistical analysis, while the explanatory design aims to identify the causal relationship between socioeconomic, demographic, and geographic factors and household energy poverty (Sugiyono, 2023). The Multidimensional Energy Poverty Index (MEPI) is applied to measure both the incidence and intensity of energy deprivation, and the Probit regression model is used to estimate the probability of households experiencing energy poverty.

Research Setting and Period

The study was conducted in West Sumatra Province, Indonesia, using secondary data obtained from the 2020 National Socioeconomic Survey (SUSENAS) published by Statistics Indonesia (BPS). SUSENAS was selected because it provides nationally representative household-level data with comprehensive socioeconomic and demographic information. The analysis focuses on the 2020 survey year.

Data Type and Source

This research uses quantitative secondary data collected from the 2020 SUSENAS database. The dataset contains information on household characteristics, education, expenditure, residential location, electricity access, and cooking fuel, which are required to construct the MEPI and analyze its determinants. SUSENAS is considered a reliable source due to its standardized methodology and broad population coverage across Indonesia.

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Operational Definition of Variables

The dependent variable is Multidimensional Energy Poverty (MEPI), measured using the Alkire–Foster methodology. Households are classified as energy poor when their weighted deprivation score is 0.33 or higher, following Nussbaumer et al. (2012) and Koomson & Danquah (2017). The MEPI is calculated as:

$$MEPI=H\times A$$

Where:

H = Headcount ratio (proportion of energy-poor households)

A = Average deprivation share (intensity of energy poverty)

The independent variables include:

Variable	Measurement
Education	Years of schooling (interval)
Household size	Number of household members (ratio)
Gender of household head	Dummy (1 = male, 0 = female)
Rural residence	Dummy (1 = rural, 0 = urban)
Household expenditure	Monthly expenditure in Indonesian Rupiah (ratio)

Data Collection Technique

Data were collected by accessing and extracting the official SUSENAS 2020 dataset from Statistics Indonesia (BPS). The relevant household variables were selected, verified, and transformed into research variables. The dependent variable was generated from the MEPI calculation, while the independent variables were derived from demographic, socioeconomic, and geographic information contained in the survey.

Data Analysis Technique

The analysis was conducted in two stages using quantitative statistical methods.

MEPI Analysis

The first stage calculates the Multidimensional Energy Poverty Index (MEPI) using the Alkire–Foster approach. Equal weights are assigned to each deprivation indicator, household deprivation scores are computed, and a 0.33 cutoff is applied to

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identify energy-poor households. The resulting MEPI ranges from 0 to 1, with higher values indicating greater energy deprivation.

Probit Regression Analysis

The second stage examines the determinants of energy poverty using a binary Probit regression model, since the dependent variable is dichotomous (1 = energy poor; 0 = not energy poor). The model is expressed as:

$$P(Yi=1)=\Phi(\beta0+\beta1X1+\beta2X2+\beta3X3+\beta4X4+\beta5X5)$$

Where:

Y = Household energy poverty status

Φ = Standard normal cumulative distribution function

X_1–X_5 = Education, household size, gender, rural residence, and household expenditure

The model is estimated using Maximum Likelihood Estimation (MLE). Statistical significance is evaluated through the z-test at the 5% significance level, and marginal effects are calculated to interpret the change in the probability of energy poverty resulting from changes in each explanatory variable.

RESEARCH RESULTS AND DISCUSSION

Overview of the Research Object

The study analyzed 11,305 households in West Sumatra Province using data from the 2020 National Socioeconomic Survey (Susenas). Energy poverty was measured using the Multidimensional Energy Poverty Index (MEPI) based on two indicators: access to electricity and the use of clean cooking fuels. Each indicator was assigned an equal weight of 0.5, with a deprivation cut-off of 0.33.

The results show that 23.25% of households experienced energy poverty, while 76.75% were not classified as energy-poor. The average intensity of deprivation among energy-poor households was 52.53%, resulting in an MEPI value of 0.1221. These findings indicate that although most households had access to modern energy services, a considerable proportion still experienced deprivation in at least one energy dimension.

The distribution of deprivation scores further shows that 76.75% of households had a score of 0, indicating no deprivation. Meanwhile, 22.07% had a score of 0.5 and 1.18% had a score of 1, both of which were classified as energy-poor because their scores exceeded the 0.33 cut-off. This indicates that most energy-poor households experienced deprivation in only one dimension, particularly in the use of clean cooking fuels.

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Overall, the findings suggest that energy poverty in West Sumatra is not only related to electricity access but also to the availability and use of clean cooking energy. Therefore, efforts to reduce energy poverty should also consider improving access to affordable and clean cooking fuels, particularly among vulnerable households. These findings provide the basis for further analysis of the factors associated with household energy poverty using the Probit regression model.

RESEARCH RESULTS

Multicollinearity Test

Before estimating the Probit regression model, a multicollinearity test was conducted to assess the potential correlation among the independent variables. Multicollinearity was evaluated using the Tolerance and Variance Inflation Factor (VIF) values. A model is generally considered free from serious multicollinearity when the Tolerance value is greater than 0.10 and the VIF value is below 10.

Table 1. Multicollinearity Test Results

Variable	Tolerance	VIF	Conclusion
Household Expenditure	0.782604	1.28	No multicollinearity
Household Size	0.811644	1.23	No multicollinearity
Education of Household Head	0.841200	1.19	No multicollinearity
Urban Residence	0.894594	1.12	No multicollinearity
Gender of Household Head	0.895446	1.12	No multicollinearity
Mean VIF		**1.19**	

Source: Authors' calculation based on Susenas 2020 data, 2026.

As shown in Table 1, all independent variables have Tolerance values above 0.10 and VIF values below 10. The VIF values range from 1.12 to 1.28, with a mean VIF of 1.19. These results indicate that there is no evidence of serious multicollinearity among the explanatory variables. Therefore, all independent variables can be retained in the Probit regression model.

Probit Regression Results

A Probit regression model was estimated to examine the association between household characteristics and the probability of experiencing energy poverty in West

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Sumatra Province in 2020. The dependent variable is binary, taking a value of one when a household is classified as energy poor and zero otherwise. The model includes the education level of the household head, household size, gender of the household head, urban residence, and household expenditure as explanatory variables. Robust standard errors were used to account for potential heteroskedasticity.

Table 2. Probit Regression Estimates of Factors Associated with Household Energy Poverty

Variable	Coefficient	Robust SE	z-statistic	p-value	Significance
Education of Household Head	-0.1910573	0.0119208	-16.03	0.000	Significant
Household Size	0.0687476	0.0111934	6.14	0.000	Significant
Gender of Household Head	-0.0544235	0.0369244	-1.47	0.141	Not significant
Urban Residence	-0.3534043	0.0303843	-11.63	0.000	Significant
Household Expenditure	-1.57×10^{-7}	1.39×10^{-8}	-11.26	0.000	Significant
Observations	11,305				
Pseudo R^2	0.1296				
Prob > χ^2	0.0000				

Source: Authors' calculation based on Susenas 2020 data, 2026.

The likelihood-ratio test indicates that the Probit model is jointly significant (Prob > χ^2 = 0.0000). The model has a Pseudo R^2 of 0.1296, indicating that the explanatory variables collectively contribute to explaining variation in the probability of household energy poverty.

Education of the household head has a negative and statistically significant coefficient (β = -0.1911; $p < 0.001$). This finding indicates that higher educational attainment is associated with a lower probability of experiencing energy poverty. Education may improve access to employment opportunities, income-generating activities, and knowledge related to energy use and household resource management.

Household size has a positive and statistically significant coefficient (β = 0.0687; $p < 0.001$). This result suggests that larger households tend to have a higher probability

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of experiencing energy poverty. An increase in household members may increase energy requirements for electricity, cooking, lighting, and other household activities.

When these additional energy requirements are not accompanied by sufficient economic resources, household vulnerability to energy poverty may increase.

The coefficient for the gender of the household head is negative but statistically insignificant ($\beta = -0.0544$; $p = 0.141$). Thus, there is insufficient statistical evidence to conclude that the gender of the household head is associated with the probability of household energy poverty. This finding suggests that other socioeconomic and household characteristics may be more relevant in explaining energy poverty than the gender of the household head.

Urban residence has a negative and statistically significant coefficient ($\beta = -0.3534$; $p < 0.001$). This result indicates that households living in urban areas tend to have a lower probability of experiencing energy poverty than households living in rural areas, with rural households serving as the reference category. The difference may be related to better access to electricity infrastructure, modern energy sources, distribution networks, and economic opportunities in urban areas.

Household expenditure also has a negative and statistically significant coefficient ($\beta = -1.57 \times 10^{-7}$; $p < 0.001$). The negative coefficient indicates that households with higher expenditure tend to have a lower probability of experiencing energy poverty. Higher household expenditure may reflect greater economic capacity to afford electricity, cooking fuels, and other energy-related necessities.

Marginal Effects

Because Probit coefficients cannot be directly interpreted as changes in probability, marginal effects were estimated to provide a more intuitive interpretation of the magnitude of the associations between the explanatory variables and the probability of household energy poverty.

Table 3. Average Marginal Effects of the Probit Model

Variable	Marginal Effect (dy/dx)	Robust SE	z-statistic	p-value	Significance
Education of Household Head	-0.0512412	0.0031316	-16.36	0.000	Significant

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Household Size	0.0184380	0.0029491	6.25	0.000	Significant
Gender of Household Head	-0.0145963	0.0099068	-1.47	0.141	Not significant
Urban Residence	-0.0947823	0.0080517	-11.77	0.000	Significant
Household Expenditure	-4.20×10^{-8}	3.52×10^{-9}	-11.95	0.000	Significant
Observations	**11,305**				

Source: Authors' calculation based on Susenas 2020 data, 2026.

The marginal effects provide a clearer interpretation of the magnitude of the estimated relationships. Education of the household head has a marginal effect of -0.0512 and is statistically significant ($p < 0.001$). This indicates that a one-unit increase in the education variable is associated with approximately a 5.12 percentage-point reduction in the probability of household energy poverty, holding other variables constant.

Household size has a positive marginal effect of 0.0184 ($p < 0.001$). Thus, an additional household member is associated with an approximately 1.84 percentage-point increase in the probability of experiencing energy poverty, ceteris paribus. This finding reinforces the role of household energy demand and resource constraints in explaining energy poverty.

The marginal effect of household head gender is -0.0146 but statistically insignificant ($p = 0.141$). Therefore, although the estimated direction is negative, there is insufficient statistical evidence to establish a systematic relationship between household head gender and energy poverty.

Urban residence has a marginal effect of -0.0948 and is statistically significant ($p < 0.001$). Holding other variables constant, households living in urban areas have an estimated probability of experiencing energy poverty that is approximately 9.48 percentage points lower than that of rural households. This result highlights the importance of spatial disparities in energy access and infrastructure.

Household expenditure has a negative and statistically significant marginal effect of -4.20×10^{-8} ($p < 0.001$). The magnitude should be interpreted according to the original unit of household expenditure. The negative sign indicates that greater household expenditure is associated with a lower probability of energy poverty, reflecting the importance of household economic capacity in meeting energy needs.

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Overall, the marginal effects indicate that education, urban residence, and household expenditure are associated with lower probabilities of energy poverty, whereas larger household size is associated with a higher probability. Among the statistically significant variables, urban residence has the largest marginal effect in absolute terms, suggesting that the urban-rural divide is an important factor associated with household energy poverty in West Sumatra.

Probit Model Classification

The predictive performance of the Probit model was further evaluated using a classification table. The classification results compare the observed energy poverty status of households with the status predicted by the estimated model.

Table 4. Classification Results of the Probit Model

Classification Measure	Value
Number of observations	11,305
True Positive (TP)	282
False Positive (FP)	2,346
False Negative (FN)	162
True Negative (TN)	8,515
Sensitivity	63.51%
Specificity	78.41%
Positive Predictive Value (PPV)	10.73%
Negative Predictive Value (NPV)	98.13%
Correctly Classified	77.82%

Source: Authors' calculation based on Susenas 2020 data, 2026.

The classification results show that the model correctly identifies 282 households experiencing energy poverty (true positives) and 8,515 households not experiencing energy poverty (true negatives). However, 2,346 households are incorrectly classified as energy poor (false positives), while 162 energy-poor households are not identified by the model (false negatives).

The model has a sensitivity of 63.51%, indicating that it correctly identifies approximately two-thirds of households that actually experience energy poverty. Its specificity is higher at 78.41%, indicating a stronger ability to correctly identify households that do not experience energy poverty.

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The PPV is relatively low at 10.73%, meaning that only a small proportion of households predicted to be energy poor are actually classified as energy poor. In contrast, the NPV is 98.13%, indicating that the model is highly accurate when predicting that a household does not experience energy poverty. The overall percentage of correctly classified observations is 77.82%.

The relatively low PPV should be interpreted in light of the substantial imbalance between the two outcome categories. Of the 11,305 households, 444 households (3.93%) are classified as energy poor, while 10,861 households (96.07%) are classified as non-energy poor. Consequently, overall classification accuracy alone should not be interpreted as evidence of strong predictive performance. The classification results should instead be considered alongside the Probit coefficients, marginal effects, and statistical significance of the model.

Overall, the Probit estimation provides evidence that household education, household size, residential location, and household expenditure are significantly associated with the probability of energy poverty, whereas the gender of the household head is not statistically significant. The marginal effects further demonstrate that urban residence and education are associated with meaningful reductions in the probability of energy poverty, while larger household size is associated with an increased probability. These findings highlight the importance of socioeconomic conditions and spatial disparities in understanding household energy poverty in West Sumatra.

RESEARCH DISCUSSION

Household Energy Poverty in West Sumatra

The Multidimensional Energy Poverty Index (MEPI) indicates that household energy poverty in West Sumatra Province remained a relevant socioeconomic issue in 2020. The estimated MEPI was 0.1221, derived from a Headcount Ratio (H) of 23.25% and an Average Intensity of Deprivation (A) of 52.53%. This means that approximately 23.25% of households experienced energy poverty, while energy-poor households experienced deprivation in approximately 52.53% of the energy-related indicators considered in this study.

Although the overall MEPI value indicates a relatively low level of energy poverty, the proportion of households experiencing energy deprivation remains substantial. The findings suggest that energy poverty should not be understood solely as a problem of energy supply or electricity availability. It also involves households' ability to obtain and use adequate, clean, safe, and affordable energy services. In particular, deprivation

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related to clean cooking fuels remains an important concern. This finding indicates that improvements in electricity access do not necessarily eliminate other dimensions of household energy poverty.

The distribution of deprivation further shows that 76.75% of households were not classified as energy poor, while 23.25% experienced deprivation in at least one of the selected energy indicators. The remaining energy deprivation is likely to be associated with differences in socioeconomic capacity and geographic conditions. Rural households may face greater difficulties in accessing modern energy infrastructure, while households with limited economic resources may have difficulty affording cleaner energy sources even when such sources are physically available.

These findings reinforce the multidimensional nature of energy poverty. Household economic capacity, educational attainment, and residential location may jointly determine the ability of households to obtain modern energy services. Therefore, reducing energy poverty in West Sumatra requires policies that address not only energy infrastructure but also the socioeconomic conditions that determine households' capacity to utilize modern energy.

Education of the Household Head and Energy Poverty

The Probit estimation shows a negative and statistically significant relationship between the education of the household head and the probability of household energy poverty. The marginal effect indicates that a one-unit increase in the education variable is associated with approximately a 5.12 percentage-point reduction in the probability of experiencing energy poverty, holding other variables constant.

This finding suggests that education is an important socioeconomic factor associated with households' ability to satisfy their energy needs. Higher educational attainment may provide household heads with better access to information, employment opportunities, and income-generating activities. These advantages can increase households' ability to afford electricity, clean cooking fuels, and other modern energy services.

The result is consistent with the Human Capital Theory proposed by Becker, which considers education as an investment that enhances individual productivity, skills, and earning potential. Higher educational attainment may improve employment opportunities and income, thereby increasing household capacity to afford modern energy services. The finding is also consistent with the Capability Approach developed by Amartya Sen, which emphasizes that well-being depends not only on income but also

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on individuals' capabilities to access opportunities and achieve desirable living conditions. Education can expand these capabilities by improving access to information, employment, and essential services, including modern energy.

The finding is further consistent with the Energy Ladder perspective, which suggests that improvements in socioeconomic conditions are generally associated with a transition from traditional energy sources toward cleaner and more modern alternatives. Households with better educational and economic resources may therefore be better positioned to adopt modern energy sources.

Empirically, this result is consistent with Nur, Hartono, Dartanto, and Gultom (2024), who found that higher educational attainment of the household head was associated with lower energy poverty in Indonesia. Similar evidence has been reported by Nguyen and Nasir (2021), indicating that education can improve households' capacity to access cleaner energy. Therefore, the negative association identified in this study supports the hypothesis that education is an important determinant of household energy poverty.

Household Size and Energy Poverty

Household size has a positive and statistically significant association with the probability of energy poverty. The estimated marginal effect indicates that an additional household member is associated with an approximately 1.84 percentage-point increase in the probability of experiencing energy poverty, ceteris paribus.

The positive relationship can be explained by the increasing energy requirements associated with larger households. Additional household members may increase demand for electricity, cooking fuel, lighting, and other household energy services. When household resources do not increase proportionally with household size, the additional energy burden may reduce the ability of households to maintain adequate access to modern energy.

This finding is consistent with the multidimensional perspective of energy poverty proposed by Nussbaumer, Bazilian, and Modi (2012), which recognizes household characteristics as important determinants of energy deprivation. Larger households may face greater resource constraints because available income must be allocated among more household members and a greater number of basic needs.

The result is also compatible with the Capability Approach. From this perspective, a household's ability to achieve adequate living conditions depends on the resources available relative to its needs. An increase in household size may increase the resources

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required to achieve an adequate level of energy consumption. If economic resources remain limited, household capabilities to obtain modern energy services may consequently decline.

The finding is consistent with Nur, Hartono, Dartanto, and Gultom (2024), who reported a positive association between household size and energy poverty in Indonesia. This suggests that household size should be considered when designing energy poverty interventions, particularly for households with relatively large numbers of members.

Gender of the Household Head and Energy Poverty

In contrast to the other socioeconomic characteristics, the gender of the household head does not have a statistically significant association with household energy poverty. Although the estimated marginal effect is negative, its p-value exceeds the 5% significance threshold. Therefore, the study does not provide sufficient statistical evidence that household head gender systematically differentiates the probability of experiencing energy poverty.

The absence of a statistically significant relationship suggests that gender alone may not adequately capture the socioeconomic mechanisms underlying energy poverty. Household access to modern energy may instead depend more strongly on economic resources, educational attainment, household composition, and residential location.

This finding differs from Nur, Hartono, Dartanto, and Gultom (2024) and Nepal et al. (2025), who identified a significant relationship between household head gender and energy poverty. The difference may be explained by variations in geographical context, socioeconomic conditions, measurement approaches, and model specifications. In the present study, the effect of gender is estimated while controlling for education, household size, residential location, and household expenditure. Once these characteristics are taken into account, gender is no longer statistically significant.

The finding therefore suggests that energy poverty policies in West Sumatra should not rely solely on the gender of the household head as a targeting criterion. Greater attention should be directed toward socioeconomic and spatial characteristics that demonstrate stronger empirical associations with energy poverty.

Residential Location and Energy Poverty

Residential location exhibits a negative and statistically significant association with energy poverty. The marginal effect indicates that households living in urban areas

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have an approximately 9.48 percentage-point lower probability of experiencing energy poverty than households living in rural areas, holding other characteristics constant.

Among the significant explanatory variables, residential location has the largest marginal effect in absolute terms. This finding highlights the importance of the urban-rural divide in explaining energy poverty in West Sumatra. The lower probability of energy poverty among urban households may be related to differences in infrastructure, energy distribution networks, access to electricity, availability of LPG, and economic opportunities. Urban households generally have greater proximity to energy infrastructure and commercial markets, while rural households may face geographical barriers and higher costs associated with energy distribution.

This finding is consistent with the multidimensional perspective of energy poverty, in which residential location represents an important contextual factor affecting access to essential energy services. It also supports the findings of Nur, Hartono, Dartanto, and Gultom (2024), who reported that rural households in Indonesia were more vulnerable to energy poverty than urban households.

The result has important policy implications for West Sumatra. Energy poverty reduction should therefore include efforts to improve energy infrastructure and distribution in rural areas, expand reliable electricity access, improve the availability of clean cooking fuels, and develop locally appropriate alternative energy sources. Addressing spatial disparities is particularly important because improvements in household income alone may not fully eliminate energy deprivation when physical access to energy infrastructure remains limited.

Household Expenditure and Energy Poverty

Household expenditure has a negative and statistically significant association with the probability of energy poverty. The negative sign indicates that households with greater expenditure capacity tend to have a lower probability of experiencing energy poverty.

The result can be interpreted economically as evidence that household purchasing capacity is closely related to the ability to obtain modern energy services. Households with greater economic resources are more capable of paying electricity bills, purchasing clean cooking fuels, and using energy-consuming household appliances. Conversely, households with limited expenditure capacity may be more likely to rely on less expensive traditional fuels or reduce energy consumption to accommodate financial constraints.

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This finding is consistent with the multidimensional conception of energy poverty, in which economic deprivation is an important component of limited access to adequate energy services. It is also consistent with previous evidence indicating that better-off households are generally less vulnerable to energy poverty because they have greater financial capacity to adopt modern energy sources.

The marginal effect of household expenditure is numerically small because expenditure is measured in monetary units. Therefore, the magnitude should be interpreted according to the unit of measurement rather than viewed in isolation. Nevertheless, the statistically significant negative relationship confirms that household economic capacity remains an important factor associated with energy poverty.

The finding suggests that energy poverty policies should be complemented by broader socioeconomic interventions. Employment creation, income enhancement, support for household businesses, and targeted energy assistance can improve households' capacity to afford modern energy services. Such interventions are particularly important for households that remain vulnerable despite the availability of energy infrastructure.

Joint Significance of Household Socioeconomic Characteristics

The Probit model is jointly significant, as indicated by the likelihood-ratio test with a Prob > χ^2 value of 0.0000. This result indicates that the explanatory variables collectively provide statistically significant information for explaining variation in the probability of household energy poverty.

The finding reinforces the multidimensional nature of energy poverty. No single household characteristic is sufficient to explain energy deprivation. Instead, educational attainment, household size, economic capacity, and residential location operate within a broader socioeconomic context. Although household head gender is not statistically significant individually, its inclusion in the model does not alter the overall significance of the explanatory variables.

The model has a Pseudo R^2 of 0.1296. This indicates that the explanatory variables included in the model capture part of the variation in the probability of household energy poverty, while a substantial proportion remains associated with factors outside the current specification. These may include housing quality, asset ownership, access to energy infrastructure, geographic conditions, energy prices, and government policies.

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Therefore, the results should not be interpreted as indicating that the included variables fully explain household energy poverty. Rather, they provide empirical evidence that socioeconomic and spatial characteristics are important correlates of energy deprivation in West Sumatra.

Policy Implications

The findings provide several implications for energy poverty reduction policies in West Sumatra. First, the MEPI results indicate that energy poverty remains relevant despite relatively broad access to modern energy services. Policies should therefore move beyond electricity access and also address the availability and affordability of clean cooking fuels.

Second, the negative association between education and energy poverty suggests that improvements in human capital may contribute to reducing long-term energy vulnerability. Expanding access to formal education, vocational education, and skills development may improve employment opportunities and household economic capacity, which in turn can strengthen access to modern energy.

Third, larger households have a higher probability of experiencing energy poverty. Energy assistance and social protection programs may therefore benefit from considering household size when identifying vulnerable households. Targeting mechanisms that account for household composition can help ensure that energy assistance reaches households facing greater energy requirements.

Fourth, the relatively large marginal effect associated with urban residence indicates that rural energy poverty deserves particular attention. Expanding electricity networks, strengthening clean cooking fuel distribution, improving rural energy infrastructure, and developing locally suitable renewable energy systems can help reduce spatial disparities in energy access.

Finally, the negative association between household expenditure and energy poverty highlights the importance of addressing the economic dimension of energy deprivation. Energy poverty policies should therefore be integrated with broader poverty reduction and livelihood programs. Improving household income and employment opportunities can increase the capacity of households to afford adequate and cleaner energy services.

Overall, the findings indicate that energy poverty in West Sumatra is a multidimensional issue shaped by household socioeconomic conditions and residential location. An integrated policy approach combining human capital development,

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economic empowerment, rural infrastructure development, and access to affordable modern energy is therefore more appropriate than relying on a single policy intervention.

CONCLUSION

This study concludes that household energy poverty remains a relevant socioeconomic issue in West Sumatra Province. Based on the Multidimensional Energy Poverty Index (MEPI), 23.25% of households were classified as energy poor in 2020, with an MEPI value of 0.1221 and an average deprivation intensity of 52.53%. Although the overall level of energy poverty was relatively low, the findings indicate that a substantial proportion of households continued to experience deprivation in access to adequate and modern energy services, particularly clean cooking energy.

The Probit regression results show that household socioeconomic and spatial characteristics are significantly associated with the probability of experiencing energy poverty. Education of the household head, residential location, and household expenditure have negative and statistically significant associations with energy poverty, indicating lower probabilities among households with higher educational attainment, those living in urban areas, and those with greater expenditure capacity. In contrast, household size has a positive and significant association, indicating that larger households face a higher probability of energy poverty. Meanwhile, the gender of the household head is not statistically significant, suggesting that gender alone does not sufficiently explain differences in household energy poverty after controlling for other socioeconomic characteristics.

The marginal effects further demonstrate the relative importance of these factors. Residential location has the largest marginal effect among the significant variables, highlighting the importance of the urban-rural disparity in energy access. Education is also strongly associated with a lower probability of energy poverty, while an increase in household size is associated with a higher probability. These findings demonstrate that energy poverty is not solely a matter of energy availability but is also closely related to households' socioeconomic capacity and geographic context.

The overall model is statistically significant, although the Pseudo R^2 indicates that other factors outside the model also contribute to explaining household energy poverty. Therefore, future research should consider additional dimensions, such as housing conditions, asset ownership, energy infrastructure, energy prices, geographic characteristics, and access to government energy programs.

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From a policy perspective, reducing energy poverty in West Sumatra requires an integrated approach. Improving rural energy infrastructure and access to clean cooking fuels should be accompanied by efforts to strengthen education, household economic capacity, and targeted support for larger and economically vulnerable households. Such a multidimensional approach is expected to improve equitable access to modern, affordable, safe, and clean energy services.

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