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Analysis of Energy Poverty in Indonesia Based on Multidimensional Energy Poverty Index (MEPI) Approach

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Abstract

Energy poverty is a complex development problem because it not only relates to income limitations but also reflects households' inability to access and utilize modern energy services properly. This study aims to analyze the level of household energy poverty in Indonesia using the Multidimensional Energy Poverty Index (MEPI) approach and to examine the influence of the Human Development Index (HDI) and economic inequality on energy poverty, with region as a control variable. This study uses secondary data from the 2023 National Socio-Economic Survey (SUSENAS), which covers 339,847 households. MEPI is calculated based on five main dimensions: access to cooking fuel, lighting, ownership of household appliances, educational and entertainment facilities, and communication tools. The subsequent analysis was conducted using multiple linear regression with the Ordinary Least Squares (OLS) method. The results show that energy poverty in Indonesia remains concentrated in the eastern region, especially in the dimensions of cooking fuel, indoor pollution, and ownership of education and communication equipment. Empirically, HDI has a significant negative effect on energy poverty, while economic inequality has a positive effect that increases energy poverty. These findings confirm that improving human development quality and reducing economic inequality are key factors in sustainably addressing energy poverty in Indonesia.

Keywords: Energy Poverty; Multidimensional Energy Poverty Index (MEPI); Human Development Index; Economic Inequality; Indonesia

INTRODUCTION

Overcoming energy poverty is one of the main areas that Indonesia's development focuses on to achieve the Goals Sustainable Development Goals (SDGs) Number 7. According to the Ministry of Energy and Mineral Resources (EMR), 2022), Indonesia has achieved extraordinary achievements by increasing the electrification ratio to 99.45 percent in 2021. However, the problem of energy poverty in Indonesia still exists and requires significant attention. The prevalence of households classified as energy poor, which is 11 percent, is proven based on data from the Indonesian National Socio-Economic Survey (SUSENAS) conducted in 2019. According to , a large number of families in Indonesia, estimated to number more than 23 million, do not have access to electricity. In addition, about 14 million people continue to rely on wood fuel for cooking, a practice that adversely affects their health.

Indonesia as a developing country faces the problem of energy poverty. In Indonesia, energy poverty is still a real and complex challenge (Samudro et al., 2024; Hakim Mutaqqim, 2014). Although the national electrification ratio continues to increase, the reality is that there are still many households, especially in disadvantaged, infected, and isolated areas, who have not enjoyed proper access to modern energy. revealed that many households in rural areas are experiencing deprivation in terms of the duration of power outages and the limitations of household appliances, despite being technically connected to the power grid (Sharma et al., 2019; Nussbaumer et al., 2012). The following is a picture of Indonesian households' access to electricity for the 2006-2023 period:(Pérez-Fargallo et al, 2023)

That household access to electricity in Indonesia shows a trend that continues to increase from 2006 to 2019, then in 2020 it experienced a significant decrease to 97% due to Covid-19 further worsening energy poverty in household electricity access, then in 2021 it increased again by 99.2%, in 2022 it increased by 100% and in 2023 it fell again at 99.4%, this is due to a condition in which households are unable to adequately meet their basic energy needs due to a combination of insufficient income and increased energy costs. The following is a picture of household access to electricity in various provinces in Indonesia for the 2006-2023 period: (Irpan Pebri Setiadi Hasibuan dan Djoni Hartono, 2024)

Household access to electric lighting in various provinces in Indonesia shows an increasing trend from 2021 to 2023. Provinces on the island of Java, such as West Java, Central Java, and East Java, as well as provinces in Sulawesi and Kalimantan, generally have almost perfect access to electricity, with percentages approaching or reaching 100%. However, there are significant differences in some regions, especially in parts of Eastern Indonesia, such as Papua and East Nusa Tenggara. In Papua, for example, electricity access to lighting is still very low until 2023. These regions still face challenges in electricity distribution, mainly due to limited infrastructure and the high cost of installing electricity in remote areas.(Rizal, R.N., et al, 2024)

The Government of Indonesia has implemented various policies to realize the fulfillment of modern energy access for all levels of households, one of which is by implementing a kerosene to Liquefied Petroleum Gas (LPG) conversion program. Based on Presidential Regulation Number 104 of 2007 concerning the supply, distribution, and pricing of 3 kg LPG cylinders, this program increases the use of LPG as the main cooking fuel from only 10.57% in 2007 to 87.12% in 2022. However, the latest data shows that there are still Indonesian households that use firewood as cooking fuel by 9.19% in 2022.

Indonesians, especially those in the most remote, isolated and underdeveloped areas, still rely on traditional materials such as firewood for cooking. Firewood is not only cheap and easy to get, but it has also been around for a long time and is considered easier to use for cooking than other fuels (Kurniawan, 2018). Smoke from burning with firewood that is not equipped with an adequate ventilation system will have an impact on health and the environment. Economic progress requires a more efficient use of moderate energy, excessive consumption of fossil fuels will have a bad impact on the environment. The following is the percentage data on the population in various provinces in Indonesia in the use of Cooking Fuel in 2023 as follows:(Gunarto et al, 2024)

Explaining the use of cooking fuel shows that there are several provinces in Indonesia that still have access to clean and decent cooking fuel such as East Nusa Tenggara, Maluku, North Maluku, West Papua and Papua which indicates that almost all households in the province still use unclean cooking fuel such as firewood or charcoal, this shows that the regions in the eastern region Indonesia in general still faces major challenges in terms of access to clean energy for cooking purposes. Then several regions such as DKI, Riau Islands, Riau Aceh have started to use modern energy access such as LPG, Biogas, Natural Gas and Electricity.

Energy poverty generally describes a situation where individuals or households are unable to adequately access and utilize modern energy services, whether for cooking, lighting, communication, or other daily activities. In contrast to general poverty which is usually measured through monetary approaches such as minimum expenditure or poverty line, energy

poverty is more complex because it cannot be fully explained by the income aspect alone. Similarly, households are considered energy-poor if they do not have an electricity connection or still cook with solid fuels such as wood and charcoal. This approach oversimplifies the problem, as it ignores other aspects such as the quality of the power grid, the time of daily power on, and the availability and ownership of supporting household appliances.(Widyastuti, A.T et al, 2023)

Although the issue of energy poverty is getting more and more attention in the discourse of sustainable development, research that specifically measures energy poverty in Indonesia with the Multidimensional Energy Poverty Index (MEPI) is still relatively limited. Most previous research still uses conventional or one-dimensional approaches, for example only measuring access to electricity or clean fuels that are not able to capture the complexity of energy deprivation experienced by households as a whole.(Esquivel García, C.L et al, 2024)

To overcome these limitations, the researchers developed a multidimensional approach, one of which is Multidimensional Energy Poverty Index (MEPI). Its ability to combine various indicators that complement each other, so as to provide a complete picture of access and utilization of energy in daily life is an advantage of Multidimensional Energy Poverty Index (MEPI). According to and also, (Santillán, O.S et al, 2020) (Rizal, R.N., et al, 2024)Multidimensional Energy Poverty Index (MEPI) not only focuses on technical aspects such as access to electricity, but also takes into account how households utilize energy to support health, education, entertainment, and communication. This makes it particularly relevant to be applied in developing countries that have inequality in infrastructure and quality of energy services.

Households' access to clean, affordable and efficient energy has an interaction with Sustainable Development Goals (SDGs) others in different contexts show the relationship between Energy Consumption, Gross Domestic Product (GDP) per capita, and the Human Development Index. Due to the inability to achieve the level of social and materially necessary household energy services, some households experience a daily energy consumption problem known as "energy poverty". Energy Poverty can affect health, education, and productivity in turn affect human well-being. Energy poverty directly targets low-income families who are less successful in overcoming the causes of energy poverty. There are several socio-economic factors that affect energy poverty in Indonesia, including the Human Development Index and Economic Inequality.

The Human Development Index is assumed to be related to energy poverty The Human Development Index in this study is suggested on its strategic role as an indicator (Oscar S. Santillán et al, 2020)Aggregate which represents the quality of human life. The Human Development Index covers three main dimensions of human development, namely health, education, and decent living standards. These dimensions are closely intertwined with access to adequate energy. Energy is needed not only to meet basic needs such as lighting and cooking, but also to support health services, education, and household productivity activities. Therefore, energy limitations are often a direct obstacle to improving the quality of life. The following is the development of the Human Development Index in various provinces in Indonesia in 2021-2023 (Santillán, O.S et al, 2020).

It shows that there has been an increase in the Human Development Index from 2021-2023, namely in 2021 the Human Development Index in Indonesia is 73.16%, increased in

2022 to 73.77%, and in 2023 it increases to 74.39% so that this reflects progress in development, namely education, health, and a decent standard of living. The increase in the Human Development Index in Indonesia occurred due to improvements in access and quality of education services, increasing life expectancy as an indicator of health, especially in previously underdeveloped areas. Technological advances and expanded access to information also strengthen the role of the community in accessing educational opportunities and other public services.

Although the Human Development Index is increasing, challenges such as energy poverty are still serious obstacles to the achievement of equitable human development. In the education sector, limited electricity can hinder the learning process at home, especially for students in remote areas. In the health dimension, the use of solid fuels such as wood or charcoal for cooking causes air pollution in households which has a negative impact on health, especially mothers and children. Meanwhile, in terms of living standards, limited access to energy limits productivity, income, and access to information and technology.

Santillan's research (2020) found that there is a strong correlation between the Multidimensional Energy Poverty Index and the Human Development Index. In the study, countries with higher Human Development Index values tended to have lower levels of energy poverty, suggesting that better human development is related to more decent energy access. The use of the Human Development Index as a variable X can help explain how socio-economic development plays a role in reducing energy poverty rates.

Research conducted by Santillan (2020) shows a close relationship between the level of human development and energy poverty, it is important to use an approach that is able to capture the dynamics of these relationships in depth, one of the approaches is a multilevel micro-macro approach used to analyze the relationship between variables at the household (micro) level and regional aggregate characteristics such as the Human Development Index (macro). According to Liu (2023), this approach is effective at avoiding cross-level inference errors and is able to capture contextual influences on individual perpetrators or conditions. In this context, household energy poverty (MEPI) can be influenced by the condition of the Human Development Index at the regional level.

In addition to the Human Development Index, economic inequality is also one of the macroeconomic socioeconomic factors that affect energy poverty, as it often reflects differences in access to resources, including electricity. In the existing literature, many academics have tried to explore the current state of energy poverty at the macro level and provide appropriate policy recommendations to reduce energy poverty. The impact of carbon emissions, digital divides, geography, and other factors on energy poverty has been widely discussed. However, few studies have explored the relationship between income inequality and energy poverty from a household perspective, and there is almost no literature that analyzes the impact of economic inequality on energy poverty.

Income is the most important element that affects household energy use and determines the affordability of household energy consumption. The income gap symbolizes the gap in energy consumption between households, and as the inequality in income distribution continues to deteriorate, fewer and fewer people are tapping into more wealth, leading to disparities in household energy consumption and the emergence of more energy-deficient households (Zhao, J., Jiang, Q. Z., Dong, X. C., and Dong, K. Y, 2021).

Economic inequality Usually measured by the Williamson Index. Increasing awareness of energy security, environmental sustainability, poverty, and inequality has drawn attention to the relationship between energy poverty (Chaudhuri, K., and Huaccha, G, 2023). Over the past decade, a series of studies have shown that energy access is critical to development policies and programs to reduce poverty and inequality. Another measure of inequality that is often used is the percentage of spending in the bottom 40 percent of the population or known as the World Bank size (Zheng, J. J., Dang, Y. J., and Assad, U, 2023).

Based on this measure, the level of inequality is divided into three categories, According to Portnov (2010), from various indices/coefficients, the williamson index is one of the reliable indices to measure income inequality in regions with different populations. In general, the Williamson Index is used in economics to assess per capita income inequality between regions.

Economic inequality is a state in which there are significant differences in the distribution of wealth, income, or access to resources among individuals, groups, or regions within a Society. This inequality is usually seen in the differences between the rich and the poor, or between the developed and the disadvantaged. According to Shinentiara (2023), low-income households tend to have limited access to adequate electrical energy or use electrical energy at a lower basic rate but with a certain usage limit. In contrast, the higher economic group has wider access, including more use of electronic devices, but is less affected by rising electricity bills because of their higher purchasing power.

Energy price movements have important implications for economic development, one of which is poverty. This is because energy consumption is directly related to community activities and welfare through heating and cooling, lighting, cooking, and equipment operation. Unlike most other consumer goods, energy consumption is often considered a basic need whose satisfaction is necessary for an acceptable quality of life. Because access to fuel and electricity is highly dependent on the price level and given that price dependence is on policy choices (e.g. choices about taxation or energy mix), the relationship between energy prices and poverty is important. Problems also occur, both from an academic and public policy perspective. Paula Bezerra's findings (2022) underscore income inequality associated with energy poverty conditions, and conclude that households that are not energy poor tend to have at least twice as high incomes as households that are considered energy poor.(Yaqin, 2023).

In addition to socioeconomic factors such as the Human Development Index and economic inequality, regional factors also play an important role in explaining the variation in energy poverty between regions in Indonesia. Indonesia's vast geographical and archipelago conditions cause differences in the availability of energy infrastructure between the Western, Central, and Eastern regions. The Western region, which includes the islands of Java and Sumatra, generally has better levels of electrification and energy infrastructure compared to the Central and Eastern regions, such as Kalimantan, Sulawesi, Maluku, and Papua facing limitations in energy supply, distribution infrastructure, as well as relatively high energy costs.

This difference shows that energy poverty is influenced not only by socioeconomic factors, but also by the distribution of infrastructure and energy policies that tend to be centered in the Western region. Therefore, entering (World Bank, 2022)Region variable As a control variable it is important to ensure that the influence of socioeconomic variables on energy poverty is not distorted by spatial differences.

This gap suggests that there is still significant scientific contribution room for research that examines energy poverty more comprehensively. By combining the Multidimensional Energy Poverty Index (MEPI) approach and Macroeconomic Socio-Economic Factors in various provinces in Indonesia, this study is expected to provide a clear, accurate, and applicable picture for the formulation of equitable and sustainable energy policies. Based on the data and phenomena described above, the researcher is interested in conducting research and raising research topics related to "Energy Poverty Analysis in Indonesia Based on the Multidimensional Energy Poverty Index (MEPI) Approach".

This study aims to analyze the condition of energy poverty in Indonesia using the Multidimensional Energy Poverty Index (MEPI) approach in order to capture a more comprehensive picture of energy deprivation beyond mere access to electricity. The study is expected to provide benefits both academically and practically by enriching the literature on multidimensional energy poverty measurement, as well as offering evidence-based insights for policymakers in identifying vulnerable regions and dimensions of energy deprivation. The findings can support the formulation of more targeted and inclusive energy policies, contribute to the achievement of sustainable energy development goals, and serve as a reference for future research on energy poverty and social welfare in developing countries.

RESEARCH METHOD

This study used a quantitative approach that aims to comprehensively analyze the influence of Gross Regional Domestic Product, Human Development Index, Economic Inequality and Per Capita Expenditure. In addition, this quantitative research also aims to research social economic problems by testing existing theories using variables that can be measured with numbers and analyzing them with statistical procedures so that they can determine generalization predictions according to existing theories. (Creswell, J. W, 2020)

This research uses secondary data from the National Socio-Economic Survey (SUSENAS) sourced from the institution that provides related data, namely the Central Statistics Agency (BPS RI, 2023) which provides information related to the socio-economic condition of households in Indonesia, including relevant variables to measure energy poverty in a multidimensional manner. SUSENAS is one of the oldest national representative surveys covering all regions of Indonesia. This survey began in 1963-1964, and since 1993 this survey has included nationally representative surveys (Rand, 2020).

SUSENAS consists of two types of instruments, namely the core questionnaire and the module questionnaire. In this study, a core questionnaire was used that collected household and individual data such as Lighting Sources, Cooking Fuel, Household Appliances and tools used for communication. In addition, the SUSENAS core questionnaire also contains information on housing conditions and social protection. In this study, cross section data was used. Cross-Section data is a type of data consisting of variables collected on a number of individuals or categories at a certain point in time, the type of cross-section data is the Human Development Index, and Economic Inequality.

The data used in this study was documentary data in the form of data collection carried out with categories and classifications of written data related to research problems that can be sourced from institutions or institutions, in this case at the Central Statistics Agency (BPS).

Analysis of Energy Poverty in Indonesia Based on Multidimensional Energy Poverty Index (MEPI) Approach

In this study, energy poverty indicators were assessed using the Multidimensional Energy Poverty Index (MEPI). Where each indicator is given a certain weight that reflects its level of importance. This weight not only reflects the level of importance, but also provides a basis for the preparation of policy recommendations based on empirical findings. Results Multidimensional Energy Poverty Index (MEPI) produces a score that is in the range between 0 to 1 with a deprivation limit of 0.333 The Alkire Foster method creates a requirement that households that cross the deprivation limit are considered to be exposed to multidimensional poverty, This measurement is in line with the concept of multidimensional poverty by UNDP, which indicates the level of sustainability of energy access at the provincial level. However, given the dichotomous nature of energy poverty variables, namely being classified as "energy poor" or "not energy poor", in this study, the energy poverty variable is needed as a binary dummy variable, not as a continuous variable.(Cut Nurul Aida et al, 2020)

This approach is in line with previous research such as those conducted by Nussbaumer et al., (2012) and Koomson and Danquah (2021), which categorized households as energy poor if their MEPI score is greater than or equal to 0.333. Households in this category are coded as "1". In contrast, households with scores below that threshold value were categorized as "not energy poor" and coded as "0."

The Multidimensional Energy Poverty Index (MEPI) was developed to measure energy poverty not only in terms of the number of households experiencing lack of access to energy (incidence), but also the severity of the condition (intensity). Technically, the Multidimensional Energy Poverty Index (MEPI) is obtained through the following steps:

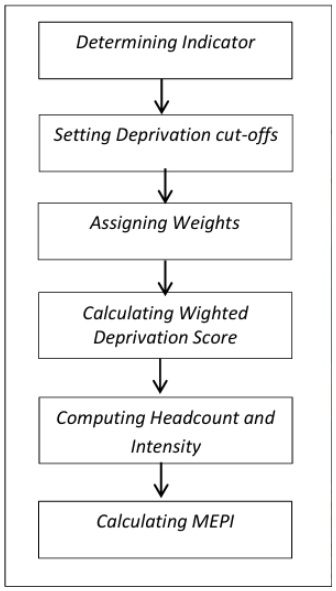

Figure 1. Calculation Stage of Multidimensional Energy Poverty Index (MEPI)

RESULTS AND DISCUSSION

This study analyzes the effect of the Human Development Index and Economic Inequality on energy poverty based on the Multidimensional energy Poverty Index approach in 34 provinces in Indonesia. This study uses the Ordinary Least Squares (OLS) method with a cross-section approach, and is equipped with a classical assumption test to ensure the validity of the regression model.

Classic Assumption Test

Multicolonarity Test

These results show that there is no indication of multicollinearity among the independent variables in the model. Thus, each independent variable can play an independent role in explaining the dependent variable, so that the regression model used can be said to be feasible and stable for use in further analysis.

Heterokedasticity Test

Based on the results of the Breusch–Pagan/Cook–Weisberg test to detect the presence of heteroscedasticity, a chi-square (χ^2) statistical value of 5.45 with a probability value **(**Prob > χ^2**)** of 0.0195 was obtained**.** At a significance level of 5 percent ($\alpha = 0.05$), the probability value is smaller than α ($0.0195 < 0.05$), so it can be concluded that in the regression model there are symptoms of heteroscedasticity, i.e. the inequality of residual variance between observations. Therefore, to overcome the potential for bias due to the violation of these assumptions, regression is carried out with a robust standard error approach, so that the estimation results remain valid and can be interpreted statistically.

Based on the results of the regression model estimation using *the robust standard error* method, information was obtained that the overall model was significant with a Prob > F value of 0.0000, which means that independent variables, namely the Human Development Index, Economic Inequality, and Region simultaneously had a significant effect on energy poverty. The R-squared value of 0.6067 indicates that about 60.67% of the variation in energy poverty can be explained by all three independent variables in the model, while the remaining 39.33% is explained by other factors outside the study model.

Statistical Test

Partial Test (t-test)

Table 1. Partial Test (t-test)

Variable	T	P > | t |
Human Development Index	-3.50	0.001
Economic Inequality	3.22	0.003
Region	-1.90	0.067

Source : Data Processed 2025

Based on the results of the partial test (t-test), the Human Development Index calculated t value was -3.50 with a p-value of $0.001 < 0.05$**,** showing that the Human Development Index has a significant effect on energy poverty (Multidimensional Energy Poverty index). A negative coefficient indicates that an increase in the Human Development Index will reduce the level of energy poverty. In other words, the higher the quality of human development, the lower the level of vulnerability to energy poverty. In other words, improving the quality of human development that includes aspects of education, health, and living standards has a strong potential to reduce energy deprivation.

Based on the results of the partial test (t-test), the t-value of Economic Inequality was obtained at 3.22 with a p-value of $0.003 < 0.05$, showing that economic inequality has a positive and significant effect on energy poverty. This positive coefficient shows that the more unequal the distribution of income or development between regions, the more likely it is that some households will not be able to access adequate and affordable energy. This means that the higher the inequality between regions, the higher the level of energy poverty that occurs. This

indicates that the uneven distribution of development can worsen energy access for low-income groups.

Based on the results of the partial test (t-test), the t-value of the Region calculation was -1.90 with a p-value of 0.067, which means that the Region variable is not significant at the 95% confidence level ($\alpha = 0.05$), but significant at the 90% confidence level ($\alpha = 0.10$). The direction of the negative coefficient shows that households in Western regions tend to have lower levels of energy poverty than non-Western regions.

Simultaneous Test (F Test)

The F-test was used to find out whether the independently variable together had a significant influence on the dependent variables in the regression model. In the context of this study, the F-test examines whether the Human Development Index, economic inequality and region simultaneously affect energy poverty as measured using the Multidimensional Energy Poverty Index. Based on the regression results, an F value of 0.0000 was obtained. Since the p-value is much smaller than the significance level of 0.05, it can be concluded that the regression model is statistically significant. This means that the variables of the Human Development Index, economic inequality and the region as a whole have a real influence on the Multidimensional Energy Poverty Index.

Coefficient of Determination (R2)

The determination coefficient or R-squared (R^2) in this model is 0.6067 which means that about 60.67% of the variation in the Multidimensional Energy Poverty Index can be explained by the variables of the Human Development, Economic Inequality and Regional Index as independent variables in the model. Meanwhile, the remaining 39.33% was explained by other variables outside the model that were not included in the analysis. This R^2 value is classified as quite high, which means that the regression model has a good ability to explain the phenomenon of energy poverty in the study area. Therefore, the R^2 value of 0.6067 is representative to illustrate the influence of the Human Development, Economic and Regional Inequality index on the Multidimensional Energy Poverty Index.

1. Multiple Linear Regression Analysis

Multiple linear regression aims to see whether or not there is a correlation between the two regression variables used.

Table 2. Test Results *of the Ordinary Least Squares Method*

VARIABLES	SCOREMEPI033
IPM	-0.0255***
	(0.00730)
IndexWilliamson	0.118***
	(0.0367)
RegionB	-0.0594*
	(0.0312)
Constant	1.987***
	(0.552)
Observations	34
R-squared	0.607

Robust standard errors in parentheses

p<0.01, p<0.05, p<0.1
Source : Processed Data (2025)

A simple linear regression analysis conducted using the Ordinary Least Squares (OLS) method shows that the Human Development, Economic and Regional Inequality Index has a significant effect on the level of energy poverty measured through the Multidimensional Energy Poverty Index. Regression Formula using the Ordinary Least Squares (OLS) method:

$$\mathbf{MEPIi = 1.987 - 0.0255\ IPM_i + 0.118\ IWi - 0.0594\ W_i + \varepsilon i}$$

The estimation results showed that the Human Development Index Coefficient coefficient was -0.0255 with a significance level *** ($p < 0.01$) indicating that the Human Development Index had a negative and significant effect on energy poverty. This means that every 1 unit increase in the Human Development Index will reduce the energy poverty score by 0.0255 points, assuming other variables remain the same. These results confirm that improving the quality of human development through improving education, health, and living standards can significantly reduce the level of energy poverty in a region. This negative coefficient direction indicates that the higher the level of human development of an area, the lower the level of energy poverty it experiences.

The results of the estimation showed that the Economic Inequality Coefficient coefficient was 0.118 with a sign of *** ($p < 0.01$) indicating a positive and significant influence on energy poverty. This means that an increase in economic inequality by 1 unit will increase energy poverty by 0.118 points. This means that the larger the gap between regions, the higher the energy poverty rate. The positive direction of the coefficient in the Economic Inequality variable (Williamson Index) indicates that the higher the level of economic inequality, the higher the level of energy poverty.

The estimation results showed a regional coefficient of -0.0594 with a sign of * ($p < 0.10$) indicating that the regional variable had a negative and significant effect at the level of 10% on energy poverty. This means that households in the Western region have a lower energy poverty score of 0.0594 than households in the Non-Western region. These results illustrate a spatial gap, where the Western region is relatively better in terms of energy infrastructure, distribution, and accessibility than other regions in Indonesia. The direction of the negative coefficient in the Region variable shows that households in the Western region have a lower level of energy poverty than the non-Western region. This indicates that the better the geographical condition and energy infrastructure of a region, the less likely it is to experience energy poverty.

Energy Poverty Based on the Multidimensional Energy Poverty Index Approach in Indonesia

Based on the results of the Multidimensional Energy Poverty Index (MEPI) measurement, it is known that the level of energy poverty in Indonesia still shows significant disparities between provinces. Using a deprivation threshold of 0.33, it can be seen that a number of provinces are still experiencing energy poverty in various dimensions simultaneously, ranging from access to clean fuel and lighting, to ownership of essential

household appliances, such as refrigerators, communication devices, and entertainment and education support devices. The province with the highest Multidimensional Energy Poverty Index value was recorded in Papua, followed by East Nusa Tenggara, West Papua, Maluku and North Maluku.

The high Multidimensional Energy Poverty Index scores in these regions reflect that most households still face difficulties in meeting their basic energy needs adequately. On the other hand, provinces such as DKI Jakarta, East Kalimantan, Bangka Belitung Islands, Riau, South Sumatra, Bengkulu and Aceh show relatively low Multidimensional Energy Poverty Index scores, which indicates that the majority of their people already have access to modern energy and adequate household facilities. These findings confirm that energy poverty in Indonesia is not solely caused by limited physical infrastructure, but is also closely related to the level of human development, people's purchasing power, and socio-economic disparities between regions.

Pendekatan Multidimensional Energy Poverty Index provide a more comprehensive and contextual understanding of the phenomenon of energy poverty. Through this approach, energy poverty is not only viewed from the aspect of limited access to modern energy sources, but also includes the dimensions of quality, affordability, and sustainability of energy use by households. Multidimensional Energy Poverty Index able to represent the conditions of energy poverty more comprehensively, in accordance with the socio-economic and geographical complexity of a region.

Therefore, this approach can be used as a Strategic conceptual foundation in the formulation of energy development policies that are more inclusive, fair, and oriented towards improving people's welfare. These findings are in line with research that energy poverty in Indonesia is multidimensional and can be measured with MEPI. In addition, human development and access to technology are key variables in reducing energy deprivation, and the multidimensional approach used in this study follows the framework of proposing that energy deprivation should be viewed from various aspects of basic energy services.(Widyastuti, A.T et al, 2023)(Santillán, O.S et al, 2020)

The Influence of the Human Development Index on Energy Poverty in Indonesia

The Human Development Index has a significant influence on the level of energy poverty in Indonesia, which is measured using the Multidimensional Energy Poverty Index. The Human Development Index regression coefficient of -0.255458 indicates that every one unit increase in HDI will decrease the value of the Multidimensional Energy Poverty Index by 0.255458 points, assuming the other variables remain constant. This means that the higher the level of human development in an area, the lower the level of energy poverty it experiences.

This result was reinforced by a p-value of 0.001 which was well below the significance level of 0.05. This indicates that the influence of the Human Development Index on the Multidimensional Energy Poverty Index is statistically significant, or in other words, the negative relationship between the two variables does not occur by chance. Overall, these findings underscore that improving people's quality of life, as reflected through Human Development Index indicators such as education, health, and income, contributes greatly to reducing the rate of energy poverty in Indonesia. Therefore, energy poverty reduction strategies

cannot be separated from efforts to improve comprehensive and sustainable human development.

(Widyastuti, A.T et al, 2023)These findings are in line with studies in World Development Sustainability, who also found that their regression model of energy poverty yielded the highest R^2 value of 0.3728, when including a number of control variables such as financial inclusion and household characteristics. Amartya's capability theory states that access to education, health, and decent living standards reflected in the Human Development Index is closely related to the ability of households to access modern energy. Provinces with higher Human Development Indexes tend to have better infrastructure and more economically and socially prepared communities to make optimal use of energy services. Thus, it can be concluded that the Human Development Index has a negative and significant relationship with the level of energy poverty, which means that improving the quality of human development can be one of the effective strategies in reducing energy poverty in Indonesia in a sustainable manner.

The Effect of Economic Inequality on Energy Poverty in Indonesia

Economic inequality has a significant influence on the level of energy poverty in Indonesia, which is measured using the Multidimensional Energy Poverty Index. The regression coefficient of Economic Inequality of 0.1183682 shows that every one-unit increase in Economic Inequality will decrease the value of the Multidimensional Energy Poverty Index by 0.1183682 points, assuming the other variables remain constant. This means that the larger the gap between regions, the higher the energy poverty rate. The positive direction of the coefficient in the Economic Inequality variable (Williamson Index) indicates that the higher the level of economic inequality, the higher the level of energy poverty.

This result is reinforced by a p-value of 0.003 which is well below the significance level of 0.05. This indicates that the influence of Economic Inequality on the Multidimensional Energy Poverty Index is statistically significant, or in other words, the positive relationship between the two variables does not occur by chance. Overall, these findings confirm that economic inequality between regions has a significant role in influencing the level of energy poverty in Indonesia. Increased economic inequality, reflected through the Williamson Index, shows that unequal income distribution and development lead to disparities in access to modern energy sources between regions.

Areas with higher levels of inequality tend to have less developed energy infrastructure and lower people's purchasing power, so their vulnerability to energy poverty is increasing. Therefore, efforts to reduce energy poverty need to be accompanied by policies that emphasize the equitable distribution of economic development, increasing access to energy infrastructure in disadvantaged areas, and strengthening the economic capacity of communities in areas with high inequality.

(Paula Bezerra et al, 2022)These findings are in line with those that also found that significant increases in access to modern energy fuels and, in the level of some primary fuels, equipment ownership, Brazil still shows a significant prevalence of energy poverty. The problem of affordability has not been solved, and it remains a major problem today: 11% of households still live in conditions of energy poverty, and in rural areas this number rises to 16%. Taking into account the social and geographical heterogeneity of Brazil, we characterize

energy poverty in different regions and socioeconomic groups. The results show that remote areas in the northern region are the most deprived of energy services. underscore income inequality associated with conditions of energy poverty, and concludes that households that are not energy poor tend to have at least twice as high incomes as households that are considered energy poor. (Paula Bezerra et al, 2022)(Paula Bezerra et al, 2022)

The Influence of Regions on Energy Poverty in Indonesia

The Regional Variable in this study serves as a control variable that represents the difference in geographical and development conditions between regions in Indonesia, which are categorized into Western and Non-Western regions. The results of the regression estimation showed that the Region variable had a regression coefficient of -0.0594221 with a significance value of 0.067, which means that the influence of the region on the energy poverty level was statistically significant at a significance level of 10% percent. A negative coefficient value indicates that households in the Western region tend to have lower levels of energy poverty compared to households in the Non-Western region, assuming the other variables in the model remain constant.

The direction of this negative coefficient indicates a spatial inequality in the distribution of energy access in Indonesia. The Western region, which generally has more advanced energy infrastructure, a wider electricity grid, and a higher rate of urbanization, has a better ability to meet household energy needs. On the other hand, areas outside the Western region such as most of Central and Eastern Indonesia still face limited infrastructure, geographical distance from energy distribution centers, and relatively low people's purchasing power. This condition causes higher levels of energy deprivation in households in the region.

These findings are consistent with the research of Paweł Ulman and Małgorzata Ćwiek (2020) which showed that the risk of housing poverty in Poland is higher in rural areas than in urban areas, due to limited infrastructure and weaker economic conditions. In a similar context, the results of this study show that regional inequality in energy infrastructure development in Indonesia is also a factor that deepens the gap in energy poverty between regions. These findings are also supported by Wenxing Jia and Shengnan Wu (2022) finding that energy poverty in China shows a spatial pattern of "high in the west and central, low in the east", suggesting that geographical location and differences in development between provinces play an important role in energy poverty variation.

CONCLUSION

This study concludes that the Human Development Index (HDI) exerts a negative and significant effect on energy poverty in Indonesia, as measured by the Multidimensional Energy Poverty Index (MEPI), with a regression coefficient of −0.0255458 ($p = 0.001$), indicating that enhancements in education, health, and income reduce MEPI values. Conversely, economic inequality has a positive and significant impact (coefficient = 0.1183682, $p = 0.003$), worsening energy poverty, while the regional control variable shows a negative effect (coefficient = −0.0594221, $p = 0.067$). The model's R-squared of 0.6067 explains 60.67% of provincial variations in energy poverty, underscoring the influence of socioeconomic and spatial factors beyond mere infrastructure. For future research, longitudinal analyses incorporating policy

interventions, such as targeted subsidies or renewable energy programs, could explore causal dynamics and effectiveness in mitigating these disparities across Indonesia's regions.

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Analysis of Energy Poverty in Indonesia Based on Multidimensional Energy Poverty Index (MEPI) Approach