Research Paper

Multidimensional Energy Poverty Deprivation among Households in Yogyakarta, Indonesia

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Received : Sept 27, 2025	Revised : Sept 28, 2025	Accepted : Sept 28, 2025	Online : October 14, 2025

Abstract

Energy poverty is increasingly viewed as a multidimensional challenge that extends beyond access to electricity connections to encompass clean cooking, appliance ownership, and digital access. Although Indonesia has achieved near-universal electrification, little is known about how energy poverty evolves at the provincial level, particularly in Yogyakarta, where rural–urban inequalities persist. This study applies the Multidimensional Energy Poverty Index (MEPI), based on the Alkire–Foster method, to *Survei Sosial Ekonomi Nasional* (SUSENAS) data for the years 2021–2023, covering approximately 4,000 households per year. Five equally weighted indicators — namely, cooking fuel, electricity access, appliances, entertainment/education devices, and communication facilities — were used, with a cutoff of 0.30 to identify energy-poor households. The results show that the incidence of energy poverty declined from 19.8% in 2021 to 14.4% in 2023, while the intensity of deprivation remained stable at approximately 44%. Gunung Kidul consistently exhibited the highest deprivation, while Bantul and Yogyakarta City recorded the lowest. Cooking fuel and communication were the most significant contributors, with communication deprivation rising to affect more than half of households by 2023. The findings highlight that energy poverty in Yogyakarta is no longer primarily about access to electricity, but rather about the ability to use energy effectively, underscoring the need for policies that promote clean cooking, affordable appliances, and digital inclusion to achieve Sustainable Development Goal 7.

Keywords: *energy poverty, MEPI, Yogyakarta, SUSENAS, multidimensional deprivation*

INTRODUCTION

Access to modern, reliable, and affordable energy is recognized as a cornerstone of sustainable development. It is enshrined in Sustainable Development Goal 7 (SDG 7), which seeks to "ensure access to affordable, reliable, sustainable, and modern energy for all (Minas et al., 2024). Energy enables lighting, heating, cooking, communication, and participation in social and economic life, making it fundamental for health, education, and productivity (Katoch et al., 2024). However, energy poverty persists globally, particularly in developing countries, where millions of households lack not only electricity but also the means to utilize it for essential services. In Indonesia, national electrification rates have surpassed 99 percent, yet challenges of affordability, quality, and access to energy services continue to shape household welfare, particularly in rural areas (Rusmawati et al., 2023).

Conventional measures of energy poverty, such as electrification rates or per capita energy consumption, often fail to capture these multidimensional realities. As argued by Nussbaumer et al. (2012), energy poverty is better understood as deprivation in essential energy services, not merely a lack of physical supply. The Multidimensional Energy Poverty Index (MEPI), based on the Alkire–Foster methodology, addresses this gap by identifying households as energy poor when they experience simultaneous shortfalls in multiple energy-related dimensions. This approach has been widely applied across diverse contexts, from South Asia to Sub-Saharan Africa, and is increasingly

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used to monitor progress toward SDG 7 (Alkire & Foster, 2011; Omar & Hasanujzaman, 2021).

Yogyakarta provides a compelling case study for analyzing energy poverty using a multidimensional framework. The province has achieved near-universal electrification, yet household access to modern cooking fuels, energy-efficient appliances, and digital connectivity remains uneven, with marked disparities between urban and rural districts. Previous studies in Indonesia have noted that rural households, particularly in less developed regions, continue to rely on biomass fuels and face limited access to appliances, which restricts their ability to translate electricity connections into tangible welfare gains (Cahyani et al., 2022; Widyastuti et al., 2023). Despite these challenges, systematic evidence on the multidimensional character of energy poverty at the provincial level remains scarce.

This study contributes to the literature by applying the MEPI to household-level data from the *Survei Sosial Ekonomi Nasional* (SUSENAS) for 2021, 2022, and 2023 to measure the incidence, intensity, and drivers of energy poverty in Yogyakarta. Specifically, it seeks to (i) estimate the level and trend of multidimensional energy poverty across districts, (ii) identify which dimensions contribute most to overall deprivation, and (iii) analyze whether reductions in intensity accompany improvements in incidence. By focusing on a province that is both highly urbanized and still characterized by persistent rural deprivation, the study sheds light on the evolving nature of energy poverty in middle-income contexts. The findings are expected to inform policies that move beyond electrification toward integrated strategies that enhance access to modern cooking fuels, essential appliances, and digital inclusion, thereby advancing Indonesia's progress toward SDG 7.

LITERATURE REVIEW

Multidimensional energy poverty (MEP) refers to the lack of access to modern energy services that are essential for health, education, and socio-economic well-being. It extends beyond financial constraints to encompass the availability, accessibility, and quality of energy services, including electricity, clean cooking, and communication. In Indonesia, deprivation in modern cooking services remains a significant issue, with households experiencing deprivation in more than half of the weighted indicators (Rizal et al., 2024). Similar patterns are observed in sub-Saharan Africa, where reliance on biofuels and limited access to electricity for lighting affects over 90 percent of households (Dake & Christian, 2023).

The Multidimensional Energy Poverty Index (MEPI), adapted from the Alkire–Foster method, has become a widely used tool to assess MEP. By considering multiple deprivations, it measures both incidence and intensity of poverty. Applications in South Africa and Pakistan show significant rural–urban gaps, with rural households consistently more deprived (Olawumi Israel-Akinbo et al., 2018; Qurat-ul-Ann & Mirza, 2021b). Other studies highlight the role of socio-economic factors: in Bangladesh, literacy and urban residence lower the risk of energy poverty (Hasanujzaman & Omar, 2022), while in Pakistan, higher EDM,mucation, and income reduce deprivation severity (Qurat-ul-Ann & Mirza, 2021a).

Regional variation remains a central focus of MEP research. In Indonesia, household head characteristics and geography influence deprivation levels (Rizal et al., 2024), whereas in South Africa, affordability and accessibility gaps are more pronounced in rural areas (Ye & Koch, 2023). In West Africa, inefficient cooking and lighting systems continue to constrain development (Compaore et al., 2024). These findings emphasize that reducing MEP requires context-specific strategies, including clean cooking programs, improved affordability of modern fuels and appliances, and digital inclusion, to align with the objectives of Sustainable Development Goal 7.

RESEARCH METHOD

Data

This study employs household-level data from the Survei Sosial Ekonomi Nasional (SUSENAS) conducted in 2021, 2022, and 2023. SUSENAS is a nationally representative socio-economic survey conducted annually by Statistics Indonesia (BPS), which covers information on demographic characteristics, consumption, housing, education, health, and household assets. For this analysis, we restrict the sample to households residing in Yogyakarta Province, which comprises both urban and rural areas across five districts and one municipality. In 2021, the SUSENAS sample for the Yogyakarta region consisted of 4,044 households; in 2022, the sample included 3,966 households; and in 2023, the sample comprised 4,022 households.

The SUSENAS sampling design follows a two-stage stratified cluster method, with census blocks as primary sampling units and households as secondary units. Each wave is independently drawn, yielding repeated cross-sections rather than panel data. Sampling weights are applied in all estimations to ensure representativeness at the provincial level. The variables required for constructing the Multidimensional Energy Poverty Index (MEPI) are drawn from three sections of the SUSENAS questionnaire: (i) housing and energy use (cooking fuel, electricity access), (ii) household appliance (refrigerator, air conditioner, water heater, television, computer/laptop), and (iii) communication and information facilities (fixed-line telephone, mobile phone, internet access).

Estimation Strategy: Multidimensional Energy Poverty Index

Dimensions, indicators, and deprivation rules

We adopt the Alkire–Foster (AF) multidimensional poverty methodology (Alkire & Foster, 2011), adapted to energy poverty following (Nussbaumer et al., 2012). Households are evaluated across five key energy service dimensions using five binary indicators. A household is considered deprived in an indicator if it fails to meet the minimum condition described in Table 1.

The choice of dimensions and indicators follows the logic that energy poverty is not solely a matter of having an electricity connection but rather the capability to access and use modern energy services that are essential for basic well-being, productivity, and social participation. Each indicator reflects a critical channel through which insufficient energy access constrains household welfare.

1. **Cooking fuel (modern vs. traditional)**. Reliance on traditional biomass fuels (wood, charcoal, dung) exposes households to household air pollution, with well-documented adverse health effects, particularly on respiratory and cardiovascular outcomes (Liu et al., 2020; Qurrota & Umaroh, 2022; Rizal et al., 2024). Moreover, cooking with inefficient fuels increases time burdens, especially for women, thus reducing opportunities for education and income generation (Jagoe et al., 2020). Clean fuels, therefore, constitute a core dimension of energy poverty (Nussbaumer et al., 2012).
2. **Electricity access**. Electricity is widely recognized as a prerequisite for lighting, refrigeration, communication, and modern services. Without electricity, households remain excluded from opportunities in education, health, and economic productivity (Chakravorty & Pelli, 2022; Katoch et al., 2024). For this reason, electricity access is a primary dimension in most multidimensional indices of energy poverty.
3. **Household appliances (refrigerator, AC, water heater)**. Appliance ownership is not merely a matter of wealth but of the ability to convert electricity into valuable services such as food preservation, thermal comfort, and hot water for hygiene. The lack of these appliances reflects an *effective deprivation* of energy services, even among electrified households (Day et al., 2016).
4. **Entertainment/education appliances (TV or computer/laptop)**. Access to media and digital devices enables education, information, and participation in social and political life. Their absence signifies exclusion from basic informational and learning opportunities, which

are increasingly energy-dependent (Day et al., 2016; Nussbaumer et al., 2012).

5. **Communication and internet (telephone, mobile phone, internet)**. Communication technologies are now fundamental to social and economic integration. Their availability depends on both electricity and affordability. Lack of access implies deprivation from essential services such as emergency communication, employment networks, and financial inclusion (Kituyi et al., 2025).

Together, these five indicators capture the core services that energy enables: cooking, lighting, thermal comfort and preservation, education and information, and communication. As argued in the literature, energy poverty is best understood as a set of *capability deprivations* rather than an input shortfall (Nussbaumer et al., 2012; Sen, 1999). By structuring the MEPI around these domains, we align with established approaches while adapting to data availability in the Indonesian context.

Table 1. Dimensions, indicators, deprivation rules, and weights

Dimension	Indicator	Deprived if...	Weight
Cooking fuel	Modern cooking fuel	Uses any fuel besides electricity, LPG, kerosene, natural gas, or biogas	0.29
Lighting	Electricity access	No access to electricity	0.29
Means of appliances	Household appliance ownership	No refrigerator and no AC and no water heater	0.14
Entertainment/education	Ownership of edu/ent appliances	No TV and no computer/laptop	0.14
Communication	Telecommunication / internet	No landline, and no mobile phone, and no internet access	0.13

Identification and cutoff

Let $g_{ij} \in \{0,1\}$denote household i's deprivation status in indicator j (1 = deprived), and let $w_j > 0$ be the indicator weight with $\sum_j w_j = 1$. The weighted deprivation score for household i is

$$c_i = \sum_j w_j g_{ij} \quad (1)$$

Using the Alkire–Foster dual-cutoff rule, a household is identified as energy poor if its weighted deprivation score meets or exceeds the multidimensional cutoff k:

$$\text{energy poor if } c_i \leq k \quad (2)$$

Following the MEPI literature, we set $k = 0.30$ in the baseline; prior applications commonly use $k = 0.30$ and report that rankings are robust for $k \in [0.20,0.40]$.

Let $q$be the number of energy-poor households in a population of size n. The **incidence** (headcount ratio) is

$$H = \frac{q}{n} \quad (3)$$

Let $s_i = c_i$ be the weighted score of energy-poor household i. The intensity (average deprivation among the energy poor) is

$$A = \frac{1}{q}\sum_{i=1}^{q} s_i \quad (4)$$

The MEPI is the product:

$$\text{MEPI} = H \times A \quad (5)$$

These expressions are standard in MEPI/AF implementations and widely used in empirical studies. When $k = 0.30$ means a household is classified energy-poor when it experiences deprivations amounting to at least 30% of the total weighted indicator space; H captures how many households are energy-poor, A captures how deprived those households are on average, and MEPI combines both into a single summary measure. Robustness of country/ranking results to nearby k values is documented in the original MEPI sensitivity analyses.

FINDINGS AND DISCUSSION

Table 2 presents the incidence (H), intensity (A), and the Multidimensional Energy Poverty Index (MEPI) for Yogyakarta Province between 2021 and 2023. The results show apparent spatial disparities in energy poverty across Yogyakarta. In 2021, Gunung Kidul had the highest incidence (H = 0.334) and MEPI (0.150), while Bantul and Yogyakarta City recorded the lowest (H = 0.091 and 0.148; MEPI = 0.040 and 0.063). Kulon Progo and Sleman fell in between. Although incidence varied widely, the intensity of deprivation was relatively stable at around 0.44 across districts. From 2021 to 2023, the provincial incidence declined from 19.8% to 14.4%, reducing MEPI from 0.087 to 0.064, while intensity remained nearly unchanged. Spatial inequalities persisted, with Gunung Kidul and Kulon Progo consistently showing the highest levels of deprivation, while Bantul and Yogyakarta City consistently showed the lowest. These findings highlight the structural disadvantages of rural districts compared to more urbanized areas, which benefit from greater infrastructure and diversified energy use.

The results indicate that while the incidence (H) of multidimensional energy poverty varies substantially across districts and over time, the intensity (A) remains strikingly stable, clustering between 0.426 and 0.459. In the MEPI framework, intensity represents the average share of weighted deprivations suffered by energy-poor households. In other words, once a household is classified as energy poor, it is typically deprived of about 44–46 percent of the energy indicators. This implies that the problem is not limited to a single shortfall (such as lack of electricity) but reflects multiple overlapping deprivations—for example, a household may rely on traditional cooking fuels, lack basic appliances, and have no access to digital communication simultaneously. The relative stability of A across districts and years suggests that the *depth of deprivation* among the energy-poor has not improved, even as the number of households falling below the poverty cutoff decreases (Cahyani et al., 2022; Widyastuti et al., 2023; Yin et al., 2023).

The MEPI, defined as the product of incidence and intensity, captures both the extent and severity of energy poverty. A higher MEPI indicates not only that more households are energy poor, but also that those households face a greater breadth of deprivations. For instance, in 2021, Gunung Kidul recorded a MEPI of 0.150, reflecting both its high incidence (H = 0.334) and the substantial intensity of deprivation (A = 0.449). By contrast, Bantul's MEPI was only 0.040 in the same year, owing to its much lower incidence (H = 0.091), despite a similar intensity of deprivation. At the provincial level, MEPI declined from 0.087 in 2021 to 0.064 in 2023, primarily due to reductions in incidence, while intensity remained nearly unchanged. This suggests that progress has been made in lifting households out of energy poverty; however, those still below the threshold remain trapped in conditions of persistent, multidimensional deprivation (Alkire et al., 2018; United Nations Development Programme & Oxford Poverty and Human Development Initiative, 2019).

Table 1. Incidence, intensity, and MEPI of multidimensional energy poverty in Yogyakarta, 2021–2023

Component	Kulon Progo	Bantul	Gunung Kidul	Sleman	Yogyakarta City	DIY (Province)
2021						
Headcount ratio (H)	0.240	0.091	0.334	0.181	0.148	0.198
Intensity (A)	0.446	0.440	0.449	0.431	0.426	0.439
MEPI (H×A)	0.107	0.040	0.150	0.078	0.063	0.087
2022						
Headcount ratio (H)	0.199	0.068	0.273	0.108	0.111	0.151
Intensity (A)	0.457	0.441	0.451	0.454	0.423	0.444
MEPI (H×A)	0.091	0.030	0.123	0.049	0.047	0.067
2023						
Headcount ratio (H)	0.207	0.073	0.239	0.125	0.079	0.144
Intensity (A)	0.459	0.438	0.452	0.432	0.418	0.444
MEPI (H×A)	0.095	0.032	0.108	0.054	0.033	0.064

Furthermore, Figure 1 reports the share of households in Yogyakarta that are deprived in each of the five MEPI indicators between 2021 and 2023. The figures reveal substantial variation across indicators, reflecting the diverse ways in which households experience energy poverty. Deprivation in cooking fuel declined from 18.8 percent in 2021 to 15.1 percent in 2023, suggesting gradual progress toward the adoption of clean fuel. However, persistent reliance on biomass highlights the importance of affordability and behavioral factors (Ahmed & Ntuli, 2024). By contrast, electricity access deprivation was nearly absent across all years, reflecting near-universal electrification in the province, though prior research cautions that connection alone does not guarantee adequate or reliable service.

More critical are deprivations in access to appliances and communication. Appliance deprivation affected almost 40 percent of households in 2021 and, despite improvement, still covered one-third of households by 2023. Even more striking, communication deprivation affected nearly half of households in 2021 and rose to 50.7 percent in 2023, making it the dominant source of energy poverty. In contrast, deprivation in entertainment/education devices was relatively low and declining. These findings underscore that while electrification targets have largely been met, multidimensional energy poverty in Yogyakarta is increasingly defined by households' limited ability to translate energy access into valuable services and digital participation.

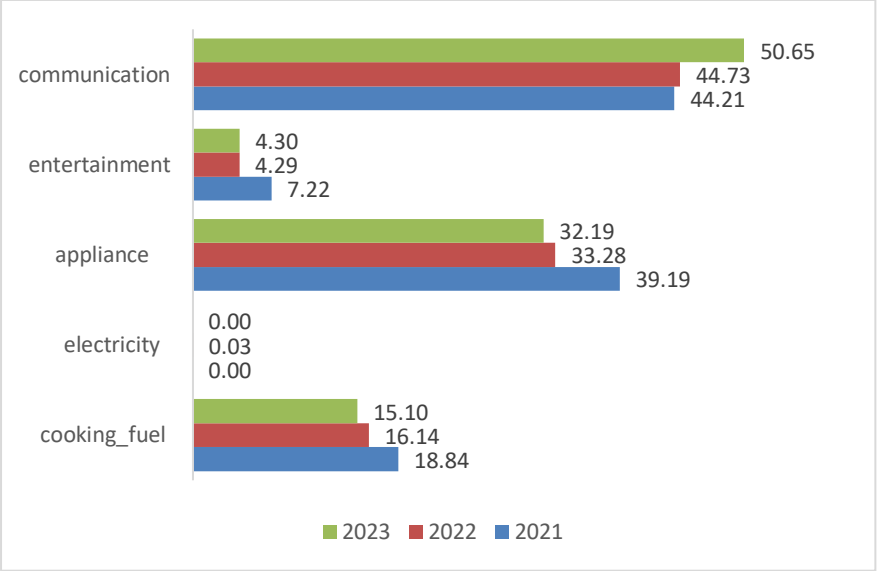

Figure 1. Percentage of households deprived by indicator, Yogyakarta 2021–2023 (%)

The majority of households experienced one form of deprivation, with the proportion increasing from 43.5% in 2021 to 49.3% in 2023. This indicates that while severe multidimensional deprivation is rare, a large share of households continues to face at least one persistent shortfall. Households experiencing two deprivations declined modestly from 22.6 percent in 2021 to 19.4 percent in both 2022 and 2023, suggesting progress in reducing more complex deprivation profiles.

At the extremes, the share of households experiencing three or more deprivations fell slightly over time, from 6.7 percent in 2021 to 4.6 percent in 2023. Very few households faced four simultaneous deprivations, and this proportion became nearly negligible by 2023 (0.05 percent). Conversely, the proportion of households with no deprivation at all remained relatively stable, ranging from 27.1 percent in 2021 to 26.6 percent in 2023, with a slight increase in 2022 (29.9 percent).

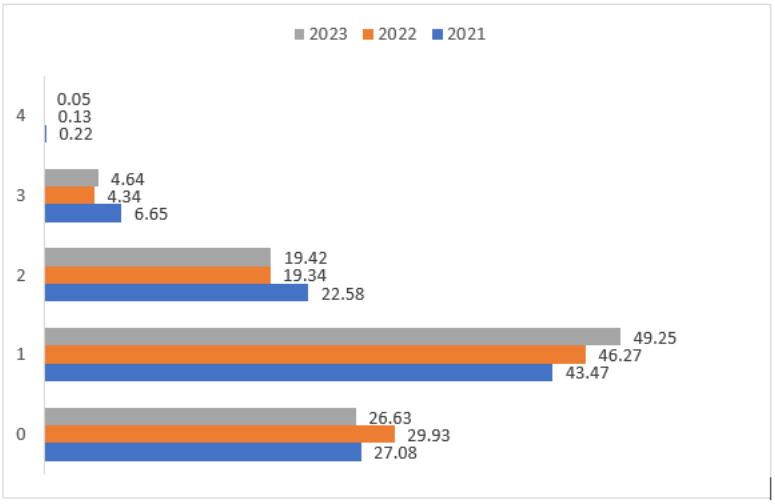

Figure 2. The share of households facing different numbers of energy service deprivations

The results of this study highlight important dynamics of multidimensional energy poverty in Yogyakarta Province. A first key finding is the persistence of rural–urban disparities (Nuryadin et al., 2023). Gunung Kidul and Kulon Progo recorded the highest MEPI values. At the same time,

Bantul and Yogyakarta City had the lowest, reflecting structural disadvantages in rural areas where households remain dependent on traditional fuels, lack basic appliances, and have limited digital access. Although the incidence of energy poverty declined between 2021 and 2023, the intensity remained stable at around 44–46 percent, indicating that those who are energy poor continue to face multiple overlapping deprivations. This suggests that infrastructure expansion alone, such as electrification, is insufficient to reduce the breadth of energy poverty (Alnour et al., 2024).

The results also show that energy poverty in Yogyakarta has shifted from a problem of basic access to one of energy services and digital inclusion. Electricity deprivation is almost nonexistent, yet appliance deprivation affects roughly one-third of households, and communication deprivation increased to more than half by 2023, making it the single most significant contributor to provincial energy poverty. Clean cooking fuel deprivation also remains a central issue, especially in rural districts, where it accounts for over half of total deprivation. Together, these results highlight that energy poverty in Yogyakarta is increasingly defined by the affordability and effective use of energy services rather than mere connections, underscoring the need for integrated policies that promote clean cooking adoption, appliance access, and digital inclusion to achieve Sustainable Development Goal 7 (Guevara et al., 2023; Katoch et al., 2024).

CONCLUSIONS

This study utilized the Multidimensional Energy Poverty Index (MEPI) to analyze household survey data from SUSENAS 2021–2023, assessing the incidence, intensity, and structure of energy poverty in Yogyakarta Province. Three main conclusions emerge. First, while the incidence of energy poverty declined over the study period, the intensity remained constant, indicating that households experiencing energy poverty continue to face multiple overlapping deprivations. Second, energy poverty in Yogyakarta has shifted from a problem of electricity access, which is nearly universal, to challenges of clean cooking adoption, appliance ownership, and digital inclusion. Third, persistent rural–urban disparities remain, with Gunung Kidul and Kulon Progo exhibiting much higher deprivation levels than Bantul and Yogyakarta City.

The study contributes to the literature by demonstrating how a multidimensional framework can capture evolving forms of energy poverty in an urbanizing, middle-income context. It highlights that policy efforts must move “beyond connections” to focus on enabling households to use energy effectively, including clean cooking programs, affordable access to essential appliances, and inclusive digital infrastructure.

In conclusion, multidimensional energy poverty in Yogyakarta is declining in breadth but remains persistent in depth. Addressing these challenges requires integrated strategies that combine infrastructure with affordability, access to technology, and behavioral change, thereby contributing to the achievement of Sustainable Development Goal 7, which aims for affordable, reliable, sustainable, and modern energy for all.

LIMITATIONS & FURTHER RESEARCH

This study has several limitations. First, the analysis relies on repeated cross-sectional data from SUSENAS, which restricts the ability to track the same households over time. Second, the MEPI indicators are constrained by data availability, so certain important aspects such as energy expenditure, reliability of supply, or seasonal variation could not be captured. Third, the findings are specific to Yogyakarta and may not fully represent other Indonesian provinces. Future research should consider panel data approaches, incorporate additional dimensions, and compare results across regions to strengthen the generalizability of insights.

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