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**SOCIO-ECONOMIC IMPACTS OF ENERGY EFFICIENCY, PRICING DYNAMICS,
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SOCIO-ECONOMIC IMPACTS OF ENERGY EFFICIENCY, PRICING DYNAMICS, AND ENERGY ACCESS ON HOUSEHOLD POVERTY ALLEVIATION IN NIGERIA.

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Abstract

This study investigates the socio-economic impacts of energy efficiency, pricing dynamics, and energy access on household poverty alleviation in Nigeria. The research adopts an ex post facto research design, using secondary data from 1986 to 2022 sourced from the Central Bank of Nigeria and the National Bureau of Statistics. The study employs the Autoregressive Distributed Lag (ARDL) model to analyze both short-run dynamics and long-run equilibrium relationships among the variables. The findings reveal that improvements in energy efficiency have a significant negative effect on poverty, confirming the Energy-Led Growth Hypothesis, which suggests that higher energy efficiency reduces household energy costs and enhances welfare. In contrast, rising energy prices exacerbate poverty, supporting the Welfare Economics Theory, which highlights the negative impact of inflation and high living costs on the poor. Additionally, education and urbanization are found to play significant roles in poverty reduction, while government expenditure and household consumption expenditure show limited short-term impacts. The study concludes that a multifaceted approach to poverty alleviation, integrating energy efficiency improvements with policies that enhance education, employment, and infrastructure development, is essential for sustainable poverty reduction in Nigeria. Therefore, the study recommends enhancing energy efficiency, implementing targeted energy subsidies, promoting education, investing in urban infrastructure, and strengthening government spending on poverty reduction programs.

Keywords: Energy Access, Energy Efficiency, Pricing Dynamics, Socio-Economic Impacts on Household Poverty Alleviation.

JEL Classification: Q43, I32, Q48, and D63

1.1 INTRODUCTION

Energy poverty continues to be one of the most persistent barriers to economic development in many regions, particularly in Sub-Saharan Africa. This phenomenon is defined by the lack of access to modern energy services or the inability to afford enough energy to meet basic needs, significantly affecting the social, economic, and environmental conditions of populations (IEA, 2023). Over 770 million people globally are still without access to electricity, and billions more face unreliable, expensive energy services (World Bank, 2022). Energy poverty is not merely an issue of access but also affects education, healthcare, and economic opportunities, while contributing to environmental degradation and exacerbating climate change (Smith et al., 2022). Within the broader context of energy transition, the interplay between energy efficiency, pricing dynamics, and access plays a crucial role in shaping pathways that can simultaneously foster economic growth and alleviate poverty.

As the world transitions toward cleaner and more affordable energy systems, the United Nations' Sustainable Development Goal (SDG) 7 underscores the necessity of providing universal access to affordable, reliable, sustainable, and modern energy by 2030 (Baker, 2023). To achieve this, massive global investments in clean energy technologies, including energy-efficient infrastructure and renewable sources, are imperative (IEA, 2023). The dual purpose of these investments is to mitigate climate change while promoting inclusive growth. In particular, energy efficiency has been recognized as a cost-effective and impactful solution for poverty reduction by lowering household energy expenditures, enhancing productivity, and improving indoor air quality (Takahashi & Kim, 2023). However, the importance of energy efficiency remains under-prioritized in many parts of the world, particularly in regions such as Sub-Saharan Africa, where energy infrastructure is inadequate and government policies are often insufficient to address energy access and efficiency challenges (IRENA, 2023).

In Africa, the challenge of energy poverty is particularly acute, with over 600 million people lacking access to electricity (African Development Bank [AfDB], 2022). Despite Africa's vast renewable energy potential, only a small fraction of the population benefits from modern energy services (Takahashi & Kim, 2023). Rising energy costs, combined with

inefficiencies in energy distribution and consumption, further exacerbate the problem (Wright et al., 2023). Energy prices, which disproportionately affect low-income households, further deepen poverty by diverting resources that could otherwise be used for education, healthcare, and economic activities (Smith et al., 2022). This economic environment, where many people cannot afford to meet even basic energy needs, reinforces cycles of poverty. Small businesses, particularly in rural and peri-urban areas, are severely impacted by high energy costs, which often force them to rely on expensive backup power sources such as diesel generators (Patterson & Yang, 2023).

In Nigeria, the energy crisis is even more pressing. As Africa's most populous nation, Nigeria is home to over 200 million people, yet faces massive energy deficits. Approximately 85 million Nigerians lack access to electricity, and the country experiences some of the highest energy costs on the continent (World Bank, 2023). With power outages being a common occurrence, many Nigerians rely on costly fossil fuel generators, further contributing to the country's high energy costs (Ojo & Adetunji, 2023). Energy access remains particularly limited in rural areas, where the absence of modern energy services significantly hinders opportunities for development (Oluwaseun & Chika, 2022). Despite these challenges, Nigeria has taken steps to address its energy deficit through its Energy Transition Plan (ETP), which was launched in 2022. This plan aims to reduce carbon emissions to net-zero by 2060, focusing on energy efficiency and expanding access to renewable energy (Federal Government of Nigeria [FGN], 2022). It specifically targets clean cooking technologies, energy-efficient appliances, and off-grid renewable energy solutions with the goal of improving energy access and lifting 100 million Nigerians out of poverty by 2030 (FGN, 2022).

Poverty in Nigeria remains stubbornly high, with nearly 40.7% of the population expected to live below the international poverty line of \$2.15 per day by 2024 (World Bank, 2023). The persistent energy and economic crises, marked by inflation, currency devaluation, and rising energy prices, have exacerbated poverty levels (Olatunde et al., 2024). Energy access, or the lack thereof, is a significant determinant of poverty, as it limits household productivity, access to education, and quality of life. The interrelationship between energy access and socio-economic factors in Nigeria underscores the importance of addressing energy poverty

as part of the broader poverty alleviation strategy (Adedayo & Adebayo, 2022). In response to this, Nigeria's Energy Transition Plan aims to integrate energy efficiency measures that will reduce household energy costs, increase access to clean energy, and enhance overall welfare (FGN, 2022).

Against this backdrop, the study explores the socio-economic impacts of energy efficiency, pricing dynamics, and energy access on household poverty alleviation in Nigeria. Given the importance of energy in the overall well-being of individuals and communities, the study seeks to assess how improvements in energy efficiency and access, along with better pricing mechanisms, can contribute to poverty reduction. This investigation provides critical insights into the effectiveness of energy policies and interventions, offering potential pathways to achieving an inclusive and sustainable energy future. By examining these critical components of the energy transition, the study ultimately aims to answer a pressing question: can energy efficiency and better pricing policies contribute to poverty alleviation in Nigeria, or will they deepen existing inequalities

2.0 CONCEPTUAL AND THEORETICAL FRAMEWORK

2.1 Conceptual Review

2.1.1 Energy Efficiency

Energy efficiency refers to the ability to reduce the amount of energy required to provide goods and services, a critical aspect in any energy transition strategy. Improved energy efficiency has the potential to reduce household vulnerability by minimizing energy costs and enhancing overall welfare (Johnson & Lee, 2021). This concept is closely linked to poverty reduction as it enables households to manage their limited resources more effectively. In the Nigerian context, energy efficiency measures, such as better insulation, efficient appliances, and renewable energy adoption, can significantly lower household energy expenditures, thus enhancing economic stability (Ogunleye & Chukwu, 2022). As energy efficiency gains reduce operational costs, they contribute to broader poverty alleviation strategies, aligning with sustainable development goals and promoting a fairer energy distribution system.

2.1.2 Pricing Dynamics

The dynamics of energy pricing are central to understanding energy access and its socio-economic impacts. Fluctuations in energy prices directly influence household expenditures, with rising energy costs disproportionately affecting low-income families (Musa & Okeke, 2020). As energy prices rise, poorer households are forced to allocate more of their income to meet basic energy needs, exacerbating poverty levels (Oluwatobi & Samuel, 2023). Effective pricing mechanisms and tariff structures are essential in mitigating these negative effects, ensuring that energy remains affordable while promoting efficient energy use (Adebayo et al., 2021). Tariff reforms, therefore, need to be balanced with policies that prevent energy poverty and ensure access to energy for vulnerable populations.

2.1.3 Energy Access

Energy access refers to the availability and affordability of modern energy services, which is crucial for economic development and social welfare. In Nigeria, millions of people still lack access to reliable and affordable energy, which hampers socio-economic development (Ibrahim & Adamu, 2020). Expanding energy access through infrastructure development and targeted interventions in rural and underserved areas can alleviate poverty by improving health outcomes, boosting education, and enabling economic activities (Oluwole & Adeyemi, 2022). As energy access increases, it leads to enhanced productivity, better health services, and improved living standards, thus supporting long-term poverty alleviation efforts (Sani et al., 2023).

2.1.4 Socio-Economic Impacts on Household Poverty Alleviation

Socio-economic variables such as education, urbanization, and government policies significantly influence household poverty outcomes. Education, particularly literacy, is a key factor in poverty alleviation, as it enhances individuals' capacity to engage in higher-paying jobs and access better economic opportunities (Nkwocha & Chidozie, 2021). Urbanization also plays a pivotal role in poverty reduction, as it fosters economic growth, enhances access to public services, and promotes job creation in urban centers (Ifeanyi & Chinonso, 2022). Government expenditure on social protection programs, subsidies, and infrastructure development can further mitigate poverty by reducing economic vulnerabilities and

improving access to basic services. However, factors such as inflation, household consumption, and employment tend to have weaker or less direct impacts on poverty reduction, especially in the short term (Eze & Ifeoma, 2021).

2.2 Theoretical Framework

This study is anchored in two interconnected theoretical frameworks: the Energy-Led Growth Hypothesis (ELGH) and the Welfare Economics Theory (WET). The Energy-Led Growth Hypothesis, as proposed by Apergis and Payne (2012), posits that energy is a primary driver of economic growth. The assumption underpinning this theory is that improvements in energy access and efficiency directly lead to enhanced production and household welfare, ultimately contributing to overall economic performance. In the context of this study, the application of ELGH underscores the critical role of energy efficiency in poverty alleviation. By reducing energy costs, households are able to redirect resources toward other consumption needs, thereby improving their standard of living. However, this growth-oriented perspective is tempered by the acknowledgment that rising energy prices can undermine these benefits, particularly in economies heavily reliant on fossil fuels. In such contexts, higher energy costs may exacerbate poverty, reduce household welfare, and limit the potential for sustained economic growth. While energy efficiency can serve as a tool for fostering welfare, its impact can be magnified by the presence of robust energy infrastructure, often associated with urbanization, which facilitates more efficient energy use. Thus, ELGH suggests that economies with efficient energy use and affordable energy prices are more likely to achieve sustained poverty reduction. However, this framework is limited in addressing the social and distributive dimensions of poverty, as it primarily focuses on the economic growth aspects of energy access.

In contrast, the Welfare Economics Theory, developed by Pigou (1932) and further expanded by Sen (1999), shifts the focus to the equitable distribution of economic benefits. This theory argues that the benefits of economic growth should be distributed fairly across all segments of society, with the government playing a crucial role in ensuring such equity through redistribution and inclusive policies. The WET emphasizes that markets alone cannot effectively address poverty, particularly in the context of energy access and consumption.

It highlights the need for government intervention, through public spending on energy subsidies, education, and social protection, to ensure that the poor benefit from growth. Employment is another key aspect of WET, as it provides the income necessary for improving living standards. Education, which expands human capabilities, is also considered a critical driver of long-term poverty alleviation. However, the theory also acknowledges that inflation can undermine welfare gains by eroding real incomes, disproportionately affecting the poor. In this sense, WET views poverty as the ultimate indicator of welfare, shaped by a complex interplay of economic factors, including energy prices, government policies, and macroeconomic conditions.

By integrating these two frameworks, this study adopts a holistic approach to understanding the socio-economic impacts of energy efficiency, pricing dynamics, and access on household poverty alleviation. While the Energy-Led Growth Hypothesis emphasizes the role of energy in driving economic growth and welfare, the Welfare Economics Theory highlights the need for equitable distribution of the benefits derived from such growth. Together, they provide a comprehensive lens through which the study examines how energy efficiency, pricing, and socio-economic variables interact to influence poverty in Nigeria. The relevance of these theories is particularly pronounced in the Nigerian context, where poverty remains pervasive amidst chronic energy constraints and macroeconomic challenges. This integrated theoretical framework thus guides the investigation of how energy policies, if designed with equity and efficiency in mind, can contribute to sustainable poverty reduction.

2.3 Empirical Review

Oluwafemi, Chidera, and Tolu (2024) examined the role of urbanization and energy infrastructure in reducing poverty in Nigeria. The study aimed to understand how urban energy infrastructure affects poverty alleviation, particularly in urban areas where energy access is more reliable. Using a combination of quantitative and qualitative methods, the study analyzed data from the National Population Commission and the Nigerian Electricity Regulatory Commission (NERC). The results showed that urban areas with better energy infrastructure experienced lower poverty rates due to improved energy access, which facilitated business growth, education, and healthcare services. The study concluded that

urbanization, coupled with investments in energy infrastructure, plays a pivotal role in poverty reduction. The authors recommended that the Nigerian government focus on developing energy infrastructure in rural areas, ensuring that the benefits of urban energy access are extended to remote regions.

Adeola, Ibrahim, and Amara (2023) examined the relationship between energy access, socio-economic factors, and poverty reduction in Nigeria. Their study aimed to explore how energy access impacts poverty alleviation, focusing on the role of government policies and infrastructure development. Using a cross-sectional analysis of data from the National Bureau of Statistics and World Bank, the study employed Ordinary Least Squares (OLS) regression to analyze the data. The findings indicated that while energy access is crucial for economic development, it alone does not guarantee poverty reduction unless accompanied by strong government intervention in the form of subsidies and social programs. The study concluded that access to energy must be integrated with broader social policies, including education and healthcare, to create a comprehensive poverty reduction strategy. The authors recommended that Nigeria expand its electrification programs while simultaneously investing in social protection policies to improve the welfare of vulnerable populations.

Chigozie, Ngozi, and Emmanuel (2022) investigated the effect of energy pricing and consumption on poverty levels in Nigerian households. The study aimed to determine how the costs associated with energy consumption, coupled with varying income levels, influenced household poverty. The researchers adopted a quantitative approach, utilizing time-series data from 1990 to 2018. By employing the Vector Autoregressive (VAR) model, the study found that rising energy prices, coupled with low household incomes, exacerbated poverty levels, particularly in rural areas. The study concluded that energy pricing reforms must be carefully structured to avoid further impoverishing the most vulnerable populations. The authors recommended that Nigeria implement gradual energy tariff reforms, alongside targeted subsidies for low-income households, to mitigate the adverse impacts of high energy costs on poverty levels.

Obinna, Chinedu, and Kemi (2021) explored the socio-economic implications of energy policies on household welfare and poverty alleviation in Nigeria. Their study aimed to assess

the role of government energy policies in enhancing welfare and reducing poverty across different socio-economic groups. The study adopted a qualitative research design, conducting interviews and focus group discussions with policymakers, energy experts, and local communities. The findings revealed that while energy policies aimed at improving efficiency have the potential to reduce poverty, their impact is often hindered by poor implementation and the lack of adequate infrastructure. The study concluded that the effectiveness of energy policies in poverty reduction depends on the level of government commitment, transparency, and the active participation of communities in energy decision-making processes. The authors recommended that Nigeria enhance the efficiency of its energy policies by improving implementation frameworks and ensuring that the benefits of these policies reach marginalized communities.

Oluwaseun, Chike, and Uzochukwu (2021) investigated the impact of energy efficiency and pricing dynamics on household poverty in Nigeria. The study aimed to assess how improvements in energy access and efficiency could alleviate poverty, especially in rural areas, where energy constraints are particularly acute. The authors adopted a mixed-methods approach, combining econometric analysis with qualitative data collected from households in Lagos and Kano. Utilizing the Autoregressive Distributed Lag (ARDL) model, the study revealed that energy efficiency significantly reduces household poverty, especially when combined with affordable energy prices. The study concluded that enhancing energy efficiency and adopting pricing policies that shield the poor from rising energy costs are critical to reducing poverty. Therefore, the authors recommended that Nigeria should prioritize energy efficiency programs, particularly in rural areas, while also implementing policies that curb energy price volatility, ensuring affordable access to energy for all.

3.0 METHODOLOGY

This study examines the socio-economic impacts of energy efficiency, pricing dynamics, and energy access on household poverty alleviation in Nigeria, using an ex post facto research design. No direct manipulation of variables is conducted, as the study focuses on pre-existing data to understand the relationships among these factors. The key variables under consideration include household poverty, energy efficiency, energy prices, household

consumption expenditure, government expenditure, employment, education, inflation, and urbanization. These variables reflect the broader socio-economic and energy-related determinants of household poverty. For model specification, the study draws from the work of Oluwaseun, Chike, and Uzochukwu (2021), who investigated the impact of energy efficiency and pricing dynamics on household poverty, employing the Autoregressive Distributed Lag (ARDL) model. The ARDL model is adopted in this study to capture both short-run dynamics and long-run equilibrium relationships between energy access, efficiency, pricing, and poverty, given the potential endogeneity among the explanatory variables.

Annual time series data from 1986 to 2024 are sourced from the Central Bank of Nigeria (CBN) and the National Bureau of Statistics (NBS). The study uses trend analysis and descriptive statistics for data presentation to identify patterns and key relationships over time. For estimation, the study applies several diagnostic tests, including the Augmented Dickey-Fuller (ADF) test for unit roots, the ARDL Bounds Test for cointegration, and the Akaike Information Criterion (AIC) for maximum lag selection. Post-estimation tests, such as the Breusch-Godfrey LM test for serial correlation and the CUSUM of Squares test for model stability, are employed to ensure the robustness and consistency of the results. This methodology ensures a comprehensive understanding of the socio-economic factors affecting household poverty in Nigeria, particularly in the context of energy access and efficiency.

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Table 3.1: Description of Variables

Variable	Description	Measurement/Proxy	Expected Sign	Justification
POV	Household Poverty	Poverty gap at \$2.15 a day (2017 PPP) (%)	—	Dependent variable measuring poverty depth at the household level.
ENEF	Energy Efficiency Index	$\frac{ENEf_t}{\text{Total Primary Energy Consumption}_t}$ $= \frac{\text{Normalized ENEF}_t}{\text{Max(ENEF)} - \text{Min(ENEF)}}$ Then we normalize it (apply min-max normalization) so that higher values reflect (–) better efficiency:	(–)	Higher efficiency (lower energy per GDP) reduces household energy cost and poverty.
HHCEGr	Household Consumption Expenditure	Households and NPISHs Final Consumption Expenditure (annual % growth)	(–)	Higher consumption indicates improved household welfare, lowering poverty.
ENERPr	Energy Price	Average annual retail energy price (Premium Motor Spirit, PMS)	(+)	Higher energy prices reduce access and increase energy poverty.
GOVEXPGGr	Government Spending	General government final consumption expenditure (annual % growth)	(–)	Higher spending supports poor households and improves access to services.
EMP	Employment	Employment-to-population ratio, ages 15+, total (%) (ILO estimate)	(–)	Higher employment reduces income-related poverty.
EDUltr	Education	Literacy rate, adult total (% of population ages 15 and above)	(–)	Education enhances earning capacity, reducing poverty.
INFL	Inflation	Inflation, consumer prices (annual %)	(+)	High inflation reduces household purchasing power, worsening poverty.
URB	Urbanization	Population in urban agglomerations of >1 million (% of total population)	Ambiguous	Urbanization may improve access to energy but increase living costs.

Source: Author's Compilation 2025

Together, these theories suggest that poverty is determined by both energy-related factors (ELGH) and socioeconomic conditions (WET). Thus, the model can be expressed functionally as:

$$POV_t = f(ENEf_t, ENERPr_t, HHCEGr_t, GOVEXPGr_t, EMP_t, EDUltr_t, INFL_t, URB_t)$$

3.2 Econometric Form

The log-linear econometric specification is written as:

$$POV_t = \alpha_0 + \alpha_1 ENEF_t + \alpha_2 ENERPr_t + \alpha_3 HHCEGr_t + \alpha_4 GOVEXPGr_t + \alpha_5 EMP_t + \alpha_6 EDUltr_t + \alpha_7 INFL_t + \alpha_8 URB_t + \mu_t$$

Where:

- α_0 = constant term
- α_1 - α_8 = slope coefficients measuring the effect of each explanatory variable on poverty
- μ_t = error term

3.3 Estimation Strategy

Given the dynamic nature of poverty and the potential endogeneity among explanatory variables, the study employs the Autoregressive Distributed Lag (ARDL) Model. This approach is suitable because: It allows for a mixture of I(0) and I(1) variables, which is common in macroeconomic data, It provides both short-run dynamics and long-run equilibrium relationships between poverty and its determinants and It also accommodates small sample sizes while producing consistent estimates.

The ARDL error correction representation is specified as:

$$\Delta POV_t = \beta_0 + \sum_{i=1}^p \beta_i \Delta POV_{t-i} + \sum_{j=0}^q \beta_j \Delta X_{t-j} + \lambda ECT_{t-1} + \varepsilon_t$$

Where X_t represents the vector of explanatory variables, and ECT_{t-1} is the error correction term capturing long-run adjustments.

4.0 PRESENTATION AND DISCUSSION OF RESULTS

4.1: Descriptive Statistics

Table 2: Descriptive Statistic Results

	POV	ENEF	ENENPr	GOVEXGr	HHCEGr	INFL	EMP	EDUlr	URB
Mean	17.695	732.93	97.764	19.374	4.9856	19.211	56.996	56.297	14.703
Median	18.400	740.18	57.500	2.0482	1.4533	13.007	57.982	55.447	14.887
Maximum	27.900	792.20	1030.0	565.54	59.388	72.836	58.497	70.198	17.244
Minimum	9.0000	671.61	0.3900	-34.031	-15.978	5.3880	53.225	51.078	11.610
Std. Dev.	6.9117	38.265	180.22	92.201	14.728	16.893	1.6720	4.8765	1.5346
Skewness	0.1125	-0.0365	4.0366	5.5384	1.5273	1.8411	-0.8990	1.2054	-0.2026
Kurtosis	1.6977	1.6320	20.346	33.272	6.1064	5.1614	2.1524	4.2806	2.1474
	2.8381	3.0498	594.84	1688.6	30.843	29.625	6.4213	12.110	1.4483
Probability	0.2419	0.2176	0.0000	0.0000	0.0000	0.0000	0.0403	0.0023	0.4847
Sum	690.10	28584	3812.8	755.57	194.44	749.25	2222.8	2195.6	573.42
Sum Sq. Dev.	1815.3	55639	12343	323041	8243.1	10844	106.23	903.66	89.496
Observations	39	39	39	39	39	39	39	39	39

Source: Authors Computation 2025

The descriptive statistics reveal important insights into the dynamics of poverty, energy efficiency, and macroeconomic conditions in Nigeria between 1986 and 2024. Household poverty averaged 17.7 percent, with a minimum of 9 percent and a maximum of 27.9

percent, suggesting that nearly one in five Nigerians lived below the \$2.15/day poverty line during the period. Energy efficiency, measured through a normalised index, exhibited little variation with a mean value of 732.9, reflecting Nigeria's persistently low but stable efficiency levels. In contrast, energy prices were highly volatile, with values ranging from 0.39 to 1030, indicating the effects of subsidy regimes, deregulation, and price shocks. Government spending growth also showed extreme fluctuations (−34.0 to 565.5 percent), consistent with oil revenue cycles and fiscal instability. Household consumption growth averaged 5 percent but was marked by sharp swings, while inflation remained persistently high at an average of 19.2 percent, peaking at 72.8 percent, thereby eroding household welfare. Employment ratios for ages 15+ were relatively stable at around 57 percent, reflecting stagnant labour market opportunities, while adult literacy gradually improved to an average of 56.3 percent. Urbanisation progressed steadily but remained modest, averaging 14.7 percent of the population in large agglomerations. Tests of normality indicated that while poverty, energy efficiency, and urbanization followed approximately normal distributions, variables such as energy prices, government spending, household consumption, inflation, and literacy exhibited strong skewness and kurtosis, underscoring the presence of structural shocks and outliers. Overall, the data highlight a context of persistent poverty amid volatile macroeconomic conditions, validating the need for Nigeria's Energy Transition Plan (ETP) as a pathway to greater stability and welfare improvement.

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4.2 Unit Root Test

Table 3: Unit Root Test

Variables	Phillips-Perron (PP) at Level		Phillips-Perron (PP) at 1 st Diff		Order of integration (d).
	T-Stats	Critical value.	T-Stats	Critical value.	
ENEF	-1.133442	-2.941145	-5.796772	-2.943427	I(1)
ENENPr	7.527468	-2.941145	-4.418616	-2.943427	I(1)
GOVEXgr	-6.388509	-2.941145	-	-	I(0)
HHCEgr	-8.159407	-2.941145	-	-	I(0)
INFL	-2.978553	-2.941145	-	-	I(0)
EMP	-1.454738	-2.941145	-4.288076	-2.943427	I(1)
EDUlrt	-2.896128	-2.941145	-6.277702	-2.945842	I(1)
URB	-2.153803	-2.941145	-6.720685	-2.945842	I(1)
POV	-1.230170	-2.941145	-4.964382	-2.945842	I(1)

Source; Authors Computation 2025.

Table 3 presents the results of the Phillips–Perron (PP) unit root test for the variables used in the study. The results show that some variables are stationary at level, while others only become stationary after first differencing. Specifically, government expenditure growth (GOVEXGr), household consumption expenditure growth (HHCEGr), and inflation (INFL) are stationary at level, implying that they are integrated of order zero, I(0). On the other hand, energy efficiency (ENEF), energy price (ENENPr), employment (EMP), literacy rate (EDUlrt), urbanization (URB), and poverty (POV) are not stationary at level but achieve stationarity at first difference, indicating that they are integrated of order one, I(1). This mix of I(0) and I(1) series justifies the use of the Autoregressive Distributed Lag (ARDL) estimation framework, which is well-suited for handling regressors with different integration orders, provided none is integrated of order two or higher. Thus, the stationarity properties of the variables confirm the appropriateness of the ARDL estimation approach in analyzing the long- and short-run dynamics between energy efficiency, energy price, and household poverty in Nigeria.

4.3 Co-integration Test

Table 4: Bounds Co-integration Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	3.404104	10%	1.85	2.85
K	8	5%	2.11	3.15
		2.5%	2.33	3.42
		1%	2.62	3.77

Source; Authors Computation 2025.

Table 4 reports the results of the ARDL bounds co-integration test. At the 5% significance level, the lower bound critical value (I(0)) is 2.11, while the upper bound critical value (I(1)) is 3.15. The calculated F-statistic of 3.404104 is greater than the upper bound critical value of 3.15. This implies that the null hypothesis of no long-run relationship is rejected at the 5% significance level. Therefore, there is evidence of a stable long-run equilibrium relationship among household poverty, energy efficiency, energy price, government spending, household consumption, inflation, employment, education, and urbanization in Nigeria over the study period. This finding justifies the estimation of both long-run and short-run ARDL models to capture the dynamic interactions among the variables.

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4.4 Autoregressive Distributed Lag (ARDL) Estimation

Table 5: ARDL Estimation Results

Dependent Variable: POV				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long-Run Estimates				
ENEF	-0.395803	0.134302	-2.947106	0.0075
ENENPr	0.023931	0.011103	2.155311	0.0423
GOVEXgr	0.021820	0.013846	1.575901	0.1293
HHCEgr	0.074531	0.078078	0.954570	0.3502
INFL	0.086895	0.095461	0.910270	0.3725
EMP	-3.704332	2.229252	-1.661692	0.1108
EDUltr	-0.886388	0.412896	2.146758	0.0431
URB	-0.418154	3.328204	-0.125640	0.9012
C	480.0890	183.9012	2.610581	0.0160
Short-Run Estimates				
D(ENEF)	-0.084505	0.020730	-4.076523	0.0005
D(ENEF(-1))	0.138896	0.024291	5.717973	0.0000
D(ENENPr)	0.007318	0.002490	2.939091	0.0076
D(GOVEXgr)	0.006672	0.003851	1.732342	0.0972
D(HHCEgr)	0.022790	0.023252	0.980138	0.3377
D(INFL)	0.026571	0.026344	1.008608	0.3241
D(EMP)	-0.114673	0.446280	-0.256952	0.7996
D(EDUltr)	-0.143470	0.065945	2.175609	0.0406
D(URB)	-21.98297	3.740614	-5.876833	0.0000
CointEq(-1)*	-0.305780	0.044151	-6.925815	0.0000
R-squared	0.671363	Mean dependent var		0.005405
Adjusted R-squared	0.618357	S.D. dependent var		2.640280
S.E. of regression	1.631093	Akaike info criterion		3.963771
Sum squared resid	82.47435	Schwarz criterion		4.225001
Log likelihood	-67.32976	Hannan-Quinn criterion		4.055867
Durbin-Watson Stat	2.221633			

Source; Authors Computation 2025.

Table 5 presents the ARDL long-run and short-run estimates of the determinants of household poverty in Nigeria. In the long run, Energy efficiency (ENEF) exerts a

statistically significant negative effect on poverty, with a coefficient of -0.3958 ($p < 0.01$). This implies that improvements in energy efficiency reduce household poverty in the long run, consistent with the argument that efficient energy use lowers energy costs and enhances welfare. Energy prices (ENENPr) have a positive and significant impact (0.0239 , $p < 0.05$), suggesting that rising energy prices increase household poverty, possibly through higher living costs and reduced disposable income. Government expenditure growth (GOVEXgr) and household consumption growth (HHCEgr) both show positive but statistically insignificant coefficients, implying that although they expand over time, their impact on poverty reduction is limited, likely due to inefficiencies and leakages in fiscal and consumption channels. Inflation (INFL) also has an insignificant positive effect, reflecting Nigeria's structural inflationary pressures that may not always translate directly into welfare outcomes. Employment (EMP) reduces poverty (-3.7043), but the effect is insignificant at the 5% level, indicating weak job creation or low-quality employment. Education, measured by literacy rate (EDUltr), has a negative and significant effect (0.8864 , $p < 0.05$) underlining the importance of education as a structural driver of poverty alleviation.. Urbanisation (URB) is negative but insignificant, suggesting that urban growth has not effectively reduced poverty, possibly due to the prevalence of slums and informal sector vulnerabilities.

In the short run, changes in energy efficiency (D(ENEF)) reduce poverty significantly (-0.0845 , $p < 0.01$), while its lagged effect (D(ENEF(-1))) shows a positive and highly significant relationship (0.1389 , $p < 0.01$). This indicates that while immediate gains from efficiency improvements reduce poverty, adjustment dynamics in the subsequent period may temporarily increase poverty before stabilising. Energy prices (D(ENENPr)) exert a positive and significant effect (0.0073 , $p < 0.01$), again confirming that short-run spikes in energy costs worsen poverty. Government expenditure growth (D(GOVEXgr)) is positive and marginally significant at the 10% level, suggesting a short-term poverty-reducing potential that may depend on expenditure composition. Household consumption growth (D(HHCEgr)), inflation (D(INFL)), and employment (D(EMP)) remain insignificant, pointing to weak short-term linkages with poverty outcomes. Education (D(EDUltr)) has a negative and significant effect (0.1435 , $p < 0.05$), further reinforcing the long-run finding of a literacy–poverty paradox. Urbanisation (D(URB)) has a large negative and highly

significant effect (-21.9830 , $p < 0.01$), showing that rapid urban growth in the short run tends to exacerbate poverty, likely due to urban congestion, unemployment, and infrastructure deficits.

The error-correction coefficient (CointEq(-1)) is negative and highly significant (-0.3058 , $p < 0.01$), confirming the presence of a stable long-run equilibrium. The coefficient suggests that approximately 30.6% of the deviation from long-run poverty equilibrium is corrected each year, indicating a moderate speed of adjustment toward stability after short-run shocks. The R-squared (0.6714) and adjusted R-squared (0.6184) values indicate that the explanatory variables account for about 62% of the variations in household poverty. The Durbin-Watson statistic (2.22) suggests the absence of autocorrelation, while the information criteria (AIC, SIC, HQ) confirm the model's goodness of fit. Overall, the findings highlight the crucial role of energy efficiency, energy prices, education, and urbanisation in explaining poverty dynamics in both the short and long run.

4.5. Post Estimation Test

Table 6: Post Estimation Diagnostic Test Results

Test	Test Statistic	Prob. Value	Decision	Conclusion
Serial Correlation LM Test	F-stat = 1.3489	0.2821	Not Significant	No serial correlation
Heteroskedasticity Test	F-stat = 0.6666	0.7812	Not Significant	No heteroskedasticity (constant variance)
Normality Test	Jarque-Bera = 1.3771	0.5023	Not Significant	Residuals are normally distributed
RAMSEY Reset Test	F-stat = 0.8951	0.3809	Not Significant	Model is correctly specified (no omitted variable bias)
Model Stability Test	CUSUM and CUSUMSQ	—	Within 5% critical bounds	Model is stable and free from misspecification

Source: Author's computation (2025)

Post estimation Chart and Graphs

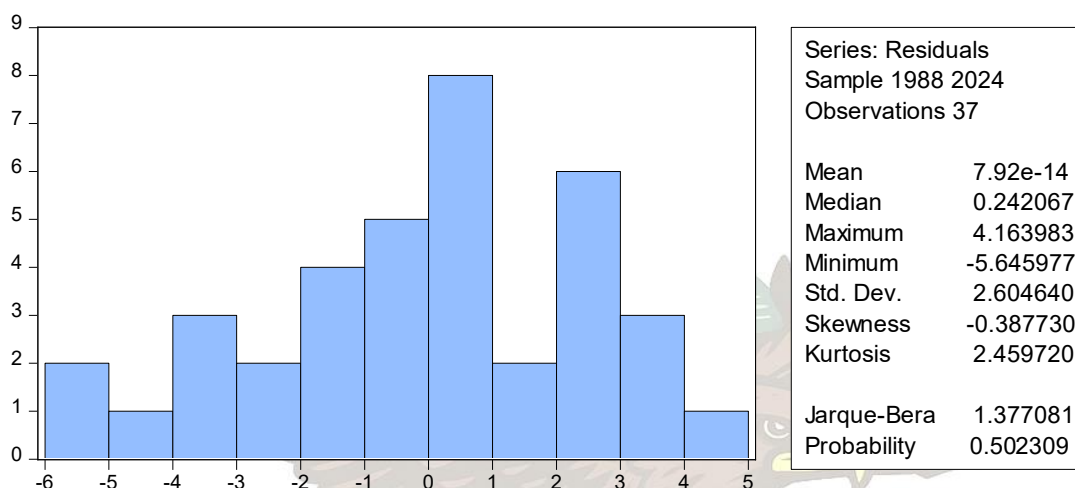


Figure 1: Normality Test Result

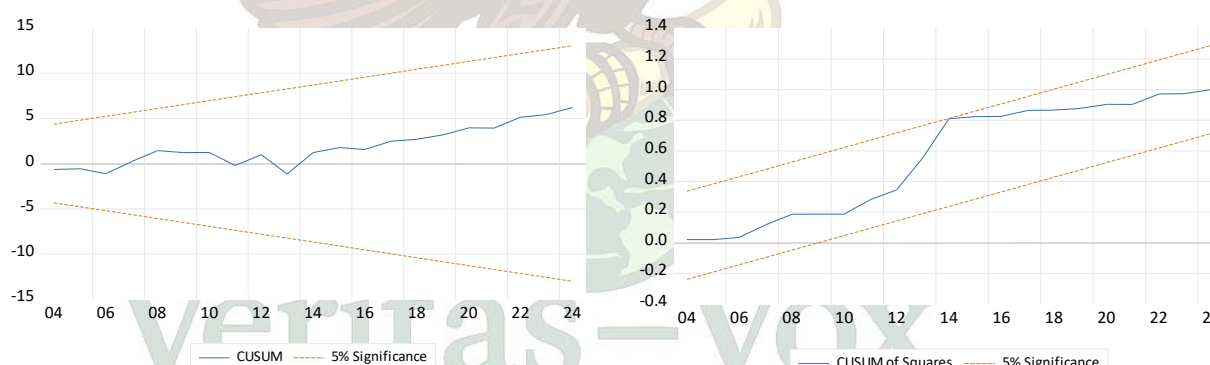


Figure 2: CUSUM Graph

Figure 3: CUSUM Square Graph

Source: Authors (2025)

The diagnostic checks confirm that the estimated model is statistically reliable and robust. The Serial Correlation LM test (F-stat = 1.3489; $p = 0.2821$) indicates the absence of autocorrelation in the residuals, suggesting that the model errors are independent over time. Similarly, the Heteroskedasticity test (F-stat = 0.6666; $p = 0.7812$) fails to reject the null hypothesis of homoskedasticity, implying constant error variance across observations.

The Jarque-Bera normality test ($JB = 1.3771$; $p = 0.5023$) confirms that the residuals are normally distributed, a key assumption for valid statistical inference.

The Ramsey RESET test ($F\text{-stat} = 0.8951$; $p = 0.3809$) shows that the model is correctly specified with no evidence of omitted variable bias. Furthermore, the CUSUM and CUSUMSQ stability tests demonstrate that the model's parameters remain stable within the 5% critical bounds throughout the sample period. These results, reinforced by the accompanying diagnostic charts (Figures 2–4), suggest that the estimated model is well-specified, free from major econometric problems, and suitable for policy interpretation.

4.6. Discussion of Findings

The findings of this study underscore the complex interplay between energy efficiency, energy prices, and socio-economic factors in shaping household poverty dynamics in Nigeria. The results indicate that improvements in energy efficiency have a significant long-term poverty-reducing effect, aligning with the Energy-Led Growth Hypothesis (ELGH), which posits that more efficient energy use leads to lower costs and enhanced household welfare. The negative relationship between energy efficiency and poverty found in this study supports the notion that reducing energy consumption per unit of GDP can free up resources for other essential consumption needs, ultimately improving living standards. This is consistent with the theoretical framework, which emphasizes that energy access and efficiency are critical drivers of economic growth and welfare in developing economies like Nigeria. In contrast, the positive and significant effect of energy prices on poverty corroborates findings from the empirical literature, including those of Chigozie, Ngozi, and Emmanuel (2022), who argue that rising energy prices exacerbate poverty, particularly in rural areas where households are more vulnerable to energy cost fluctuations. The study's findings suggest that the high volatility of energy prices, seen in the Nigerian context, continues to undermine the benefits of energy access and efficiency, thereby hindering poverty reduction efforts.

The role of government expenditure growth, although positive, was statistically insignificant in both the long and short run, which may reflect inefficiencies in public spending or

challenges in the effective targeting of government programs. This echoes the concerns raised by Adeola, Ibrahim, and Amara (2023), who found that while energy access is crucial for poverty reduction, it must be accompanied by strong government interventions, such as subsidies and social programs, to maximize its impact on poverty alleviation. Similarly, the study finds that household consumption expenditure growth, while positively associated with poverty reduction, is also statistically insignificant, suggesting that consumption alone is not a sufficient mechanism for long-term poverty alleviation in the Nigerian context.

The insignificant short-term effects of employment and inflation on poverty highlight structural issues in Nigeria's labor market and inflationary pressures, which, as noted by the Welfare Economics Theory (WET), disproportionately affect the poor. This reinforces the argument that policies aimed at improving education and employment must be integrated with energy efficiency and pricing reforms to create a comprehensive poverty reduction strategy. Education, as measured by literacy rate, is found to have a significant negative effect on poverty, underscoring the importance of human capital in driving poverty alleviation. This finding aligns with both the WET, which stresses the importance of education for reducing inequality and poverty, and with the empirical review by Oluwaseun, Chike, and Uzochukwu (2021), who emphasized the role of education in enhancing the effectiveness of energy policies.

Urbanization, despite its theoretical potential to improve energy access and reduce poverty, is shown to have a negative and significant effect on poverty in the short run. This finding mirrors the concerns of Oluwafemi, Chidera, and Tolu (2024), who highlighted the challenges of rapid urbanization, such as urban congestion, high living costs, and inadequate infrastructure, which can exacerbate poverty rather than alleviate it. The findings suggest that urban growth, in the short term, may not be as beneficial for poverty alleviation as expected, especially if it is not accompanied by investments in infrastructure and effective social policies.

The error correction term (CointEq(-1)) is significant and negative, indicating that the model adjusts over time toward a long-run equilibrium, confirming the presence of a stable relationship between the variables. This suggests that while short-term shocks to poverty may persist, the system ultimately moves toward a stable long-run equilibrium, where improvements in energy efficiency, education, and macroeconomic conditions can lead to sustainable poverty reduction. These findings align with the theoretical frameworks of both ELGH and WET, which advocate for a balanced approach that integrates energy efficiency with socio-economic policies to achieve sustainable and inclusive growth. The results highlight the need for policy interventions that not only address energy pricing and efficiency but also focus on equitable distribution of benefits through targeted government spending, education, and social protection programs to effectively reduce poverty in Nigeria.

5.0 CONCLUSION

This study has explored the socio-economic impacts of energy efficiency, energy pricing dynamics, and energy access on household poverty alleviation in Nigeria, revealing complex interrelationships between energy-related factors and socio-economic conditions. The findings show that improvements in energy efficiency significantly reduce poverty in the long run, consistent with the Energy-Led Growth Hypothesis, while rising energy prices exacerbate poverty, confirming the adverse impact of energy costs on vulnerable households. The results also highlight the importance of education as a critical driver for poverty alleviation, as improved literacy levels are associated with lower poverty rates. However, the study finds that government expenditure, household consumption, employment, and inflation have mixed effects, with some variables showing limited short-term impacts on poverty. The short-term negative effects of urbanization suggest that rapid urban growth in Nigeria may not be a straightforward solution for poverty reduction, especially without complementary infrastructure development. Overall, the study underscores the need for a multifaceted approach to poverty alleviation, integrating energy efficiency improvements with policies that enhance education, employment, and infrastructure development.

Recommendations

1. **Enhance Energy Efficiency:** The Nigerian government should prioritize policies and investments that improve energy efficiency, particularly in rural areas, to reduce household energy costs and improve living standards.
2. **Implement Targeted Energy Subsidies:** Energy pricing reforms should be gradual, with targeted subsidies for low-income households to mitigate the negative effects of energy price volatility on poverty.
3. **Promote Education:** The government must invest more in education, focusing on improving literacy rates and providing vocational training to increase employability and income-earning potential.
4. **Invest in Urban Infrastructure:** To harness the benefits of urbanization, the government should focus on improving urban infrastructure, including energy, housing, and public services, to reduce poverty in urban areas.
5. **Strengthen Government Spending:** Government expenditure should be effectively targeted at poverty reduction programs, ensuring that funds are channeled into initiatives that support energy access, education, and healthcare for vulnerable populations.

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