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Energy Efficiency, Energy Pricing and Household Poverty: Implications for Nigeria's Energy Transition Strategy

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ABSTRACT

Nigeria faces the dual challenge of widespread poverty and chronic energy constraints, making the design of a sustainable and inclusive energy transition strategy both urgent and complex. While global evidence highlights the role of energy efficiency in reducing household vulnerability and improving welfare, empirical research on its poverty-reducing potential in Nigeria remains limited. This study investigates the impact of energy efficiency, energy prices, and key socio-economic variables on household poverty, drawing on the Energy-Led Growth Hypothesis (ELGH) and Welfare Economics Theory (WET) as its theoretical foundation. Using the Autoregressive Distributed Lag (ARDL) technique, the analysis captures both short- and long-run dynamics. The results show that energy efficiency significantly reduces poverty in both the short and long run, confirming its potential as a cost-effective welfare-enhancing mechanism. Conversely, rising energy prices exert poverty-increasing effects, while education (literacy) is found to be a significant driver of poverty reduction. Urbanization also demonstrates strong short-run poverty-reducing effects, whereas variables such as government expenditure, employment, household consumption, and inflation show weaker or insignificant impacts. The error correction term indicates a stable long-run relationship, with about 31 percent of disequilibrium corrected annually. The study concludes that energy efficiency should be prioritized within Nigeria's energy transition strategy, but tariff reforms must be carefully sequenced with social protection measures, targeted subsidies, and investments in education and infrastructure. These findings highlight the importance of combining energy policy with welfare-enhancing interventions to ensure that Nigeria's transition to sustainable energy is inclusive and equitable.

Keywords: Energy efficiency; Household poverty; Energy transition; Welfare economics; Nigeria.
JEL Classification: Q43, I32, Q48, and D63

INTRODUCTION

Energy poverty has remained a persistent challenge across sub-Saharan Africa, undermining efforts to alleviate income poverty, enhance health outcomes, and promote sustainable development. In Nigeria, which is Africa's most populous country, over 85 million people still lack access to electricity, while millions more experience unreliable and unaffordable energy services (World Bank, 2021). This has entrenched multidimensional poverty and deepened the socio-economic divide between rural and urban households. Historically, Nigeria's energy sector has been dominated by inefficient grid systems, dependence on fossil fuels (particularly diesel and petrol generators), and minimal household-level investments in energy-efficient technologies (International Energy Agency [IEA], 2022). These inefficiencies have contributed to high energy costs, frequent blackouts, and reliance on harmful traditional fuels such as firewood and charcoal, especially among rural and low-income populations.

Globally, energy efficiency has long been recognised as the "first fuel", the cheapest and fastest strategy for managing energy demand, reducing emissions, and enhancing welfare (IEA, 2018). For households, improved energy efficiency translates into lower energy expenditures, better indoor air quality, and enhanced productivity, particularly for women and small enterprises. Despite its transformative potential, energy efficiency has historically been under-prioritised in Nigeria's policy mix due to limited awareness, weak regulation, low investment in efficient appliances and housing infrastructure, and poorly targeted subsidy systems.

Against this backdrop, Nigeria launched its Energy Transition Plan (ETP) in 2022, becoming the first African country to develop a comprehensive, data-driven roadmap to achieve net-zero emissions by 2060 (Federal Government of Nigeria [FGN], 2022). A central pillar of this strategy is the mainstreaming of energy efficiency across residential, industrial, and transport sectors. The rationale is clear: improving energy efficiency not only reduces greenhouse gas emissions but also enhances affordability and energy access, which are the two prerequisites for reducing household poverty. The ETP specifically targets interventions in clean cooking, appliance standards, off-grid solutions, and energy-efficient buildings, aiming to deliver inclusive, low-carbon growth and lift 100 million people out of poverty by 2030 (FGN, 2022).

Despite these ambitious goals, there remains a significant empirical gap in understanding how energy efficiency interventions affect household poverty in practice. Most existing studies have focused on the macroeconomic or environmental outcomes of energy efficiency, with little attention to its distributive impacts in developing countries. This study addresses that gap by examining the relationship between energy efficiency and household poverty in Nigeria, using data and policy insights that would be beneficial to the implementation of the ETP. It seeks to answer a crucial policy question: Can energy efficiency be a tool for poverty reduction, or will the energy transition reinforce existing inequalities?

Poverty in Nigeria has historically remained stubbornly high, with 40.7% of Nigerians projected to live below the international poverty line of US$2.15/day (2017 PPP) by the end of 2024 (Frontier Markets, 2024). Inflation averaging nearly 24.7% in 2023 has further eroded household welfare, driven by rising food and energy prices, subsidy reforms, and currency depreciation (Frontier Markets, 2024). At the same time, over 71% of the population lack access to modern energy services, exacerbating vulnerabilities and limiting welfare outcomes (World Economic Forum, 2023).

Theoretically, this study is anchored on the Energy-Led Growth Hypothesis (ELGH) and the Welfare Economics Theory (WET). ELGH posits that energy is a critical input in the growth process; improvements in efficiency and affordability directly foster economic performance and social welfare (Apergis & Payne, 2012). WET emphasises the role of redistributive policies, public investment, and inclusive access in ensuring that growth translates into poverty reduction (Pigou, 1932; Sen, 1999). Together, these frameworks highlight energy efficiency not just as a driver of growth, but also as a potential pathway for advancing welfare in resource-constrained economies like Nigeria.

This study contributes to the literature in three ways. First, it introduces a normalised measure of energy efficiency as a central explanatory variable in poverty analysis in Nigeria. Second, it integrates socio-economic and macroeconomic determinants (household consumption, energy prices, government expenditure, employment, education, inflation, and urbanization) within a unified theoretical framework grounded in ELGH and WET. Third, it applies the Autoregressive Distributed Lag (ARDL) framework to capture both short- and long-run dynamics, offering insights into the immediate and structural drivers of household poverty.

CONCEPTUAL AND THEORETICAL FRAMEWORK

Conceptual Framework

Household poverty is multidimensional, influenced not only by income but also by access to energy, healthcare, education, employment, and macroeconomic stability. In Nigeria, persistent energy poverty constrains household consumption, limits productivity, and exacerbates inequality (World Bank, 2023; IEA, 2022). This study adopts a framework in which poverty (POV) is affected by a combination of energy-related variables and socio-economic factors. Energy efficiency (ENEF) plays a central role, by reducing the amount of energy required to generate a unit of output, higher efficiency lowers household energy expenditures, improves affordability, and enhances welfare outcomes (IEA, 2018). Conversely, higher energy prices (ENERPr) increase the cost of living, disproportionately affecting poor households. Household consumption growth (HHCEGr) captures changes in household demand and welfare, while government spending growth (GOVEXPGr) reflects public interventions that may mitigate poverty through subsidies, social protection, or investment in energy and infrastructure (Oyadeyi et al., 2024).

Other socio-economic variables include employment (EMP), which directly determines income-generating capacity; education (EDUltr), which enhances human capital and access to better opportunities; inflation (INFL), which erodes real purchasing power; and urbanization (URB), which influences access to infrastructure but can also reinforce inequalities between rural and urban populations. Together, these variables provide a comprehensive lens to assess how energy and macroeconomic conditions shape household poverty in Nigeria.

Theoretical Framework

This study is guided by two complementary theoretical perspectives: the Energy-Led Growth Hypothesis (ELGH) and the Welfare Economics Theory (WET).

Energy-Led Growth Hypothesis (ELGH)

The Energy-Led Growth Hypothesis (ELGH) argues that energy is a fundamental driver of economic growth, where improvements in energy access and efficiency directly enhance production, household welfare, and overall economic performance (Apergis & Payne, 2012). Within this framework, energy efficiency plays a crucial role by reducing costs and freeing resources for alternative consumption needs, thereby improving welfare outcomes. However, higher energy prices may have the opposite effect, as they can reduce welfare and hinder growth, particularly in contexts where households rely heavily on fossil fuels. Household consumption, on the other hand, reflects welfare improvements that are often driven by affordable and efficient energy use, while urbanization, with its relatively better energy infrastructure, can amplify the positive impact of energy efficiency on welfare. Thus, ELGH suggests that an economy characterized by efficient energy use and affordable energy prices is more likely to achieve sustained poverty reduction.

Welfare Economics Theory (WET)

The Welfare Economics Theory (WET) emphasizes fairness, redistribution, and the role of government in ensuring that the benefits of economic growth are equitably shared across all segments of society (Pigou, 1932; Sen, 1999). The theory highlights the limitations of market forces in addressing poverty and advocates state intervention through public spending and inclusive policies. In this regard, government expenditure on energy subsidies, education, and social protection is considered vital for enhancing welfare. Employment is equally important, as it provides income and improves living standards, while education expands human capabilities and supports long-term poverty alleviation. Inflation, however, undermines these welfare gains by eroding real incomes and disproportionately affecting the poor. Poverty, therefore, emerges as the ultimate welfare indicator, shaped by the combined influence of energy factors, macroeconomic dynamics, and social policies.

By combining ELGH and WET, this study recognizes that while energy efficiency can drive growth and welfare, the distribution of benefits depends on complementary policies in education, employment, and social protection. This integrated framework is particularly relevant for Nigeria, where high poverty coexists with chronic energy and macroeconomic challenges.

Empirical Review

The empirical literature on the nexus between energy, poverty, and welfare has expanded in recent decades, though findings remain mixed and context-specific. Several studies highlight the strong link between energy access, affordability, and poverty reduction. For instance, Oyadeyi et al. (2024) and Adenikinju (2008) showed that high energy costs in Nigeria disproportionately burden poor households, limiting welfare gains. Similarly, Karekezi and Kimani (2002) noted that reliance on traditional biomass fuels in sub-Saharan Africa has reinforced energy poverty and hindered household welfare. More recent evidence suggests that inadequate access to modern energy services entrenches multidimensional poverty, particularly in rural areas (World Bank, 2023).

Globally, energy efficiency has been recognized as a cost-effective pathway for both environmental sustainability and welfare improvement (IEA, 2018). Empirical studies have confirmed that efficiency gains lower household expenditures and improve living conditions. For example, Ouedraogo (2013) found that energy efficiency improvements in sub-Saharan Africa were positively associated with human development outcomes. In Nigeria, however, empirical evidence on energy efficiency and household poverty is only beginning to emerge. Ibrahim R. Abubakar (2024) found that income, education, and urban–rural location significantly influence households' ability to switch from biomass to modern energy sources. The study emphasized that targeted subsidies and appliance financing can drive efficiency and reduce energy poverty. This aligns with the Federal Republic of Nigeria's National Energy Efficiency Action Plan (2016), which highlights energy efficiency as a key strategy to reduce energy costs and enhance welfare.

Empirical analyses further reveal the potential of efficiency measures in mitigating household expenditure burdens. O. A. Lawal (2024) showed that energy audits and retrofitting could yield significant cost savings for households, while D. E. Tietie, M. O. Afolabi, and A. O. Ajayi (2021) projected that demand-side energy efficiency policies would substantially reduce household energy expenditures in Nigeria. E. N. Ogbeide-Osaretin (2021) similarly found that energy consumption contributes to poverty reduction but stressed the importance of addressing inequitable access to energy services.

The relationship between energy prices and welfare is complex. Rising fuel and electricity tariffs may encourage efficiency but also impose welfare costs on low-income households. Yunusa et al. (2023) found that increases in petroleum product prices in Nigeria had significant poverty-increasing effects, while Bobasu et al. (2025) reported that energy price shocks in developing economies reduce household consumption and widen welfare inequalities. Recent policy developments provide further evidence: reports by Reuters (2024), Dataphyte (2024), and Energy for Growth Hub (2024) revealed that electricity tariff hikes and subsidy reforms have worsened affordability concerns, forcing many households to revert to costly alternatives like diesel generators. N. T. M. Tran, M. Karanja, and T. S. Adebayo (2025) confirmed this trend in a broader African context, noting that energy cost poverty has intensified in Nigeria in recent years due to pricing reforms and inflationary pressures.

Beyond energy-specific factors, social spending, employment, and education also shape poverty outcomes. Studies emphasize that public expenditure on subsidies, social protection, and infrastructure mitigates the negative effects of energy costs (Ogunyemi & Oladapo, 2025; Oyadeyi et al., 2024; World Bank, 2023). Employment has consistently been shown to reduce household poverty by enhancing income-generation opportunities (Awotide et al., 2015), while education improves human capital, productivity, and resilience to economic shocks (Barro & Lee, 2013).

Macroeconomic stability also plays a role. Persistent inflation erodes real incomes and disproportionately affects the poor (Sulaiman, 2014). Urbanization, while offering better access to infrastructure and services, often leads to new forms of inequality between urban and rural households, particularly in Nigeria, where informal settlements face limited energy and welfare services (UN-Habitat, 2020).

Despite growing scholarship, three main gaps remain. First, most Nigerian studies emphasize energy access or prices, with little focus on energy efficiency as a poverty-reducing mechanism. Second, the distributive effects of energy efficiency within the context of broader socio-economic factors are underexplored. Third, few studies have grounded empirical analysis within an integrated framework combining the Energy-Led Growth Hypothesis (ELGH) and Welfare Economics Theory (WET). This study seeks to address these gaps by providing an econometric analysis of the determinants of household poverty in Nigeria, with a focus on energy efficiency and policy-relevant socio.

METHODOLOGY

Model Specification

The empirical model for this study is anchored on the Energy-Led Growth Hypothesis (ELGH) and the Welfare Economics Theory (WET). The ELGH emphasizes the pivotal role of energy use and efficiency in stimulating economic performance and welfare outcomes (Apergis & Payne, 2012). In this framework, energy efficiency (ENEF) and energy prices (ENERPr) are key drivers of poverty dynamics. Efficient energy use reduces production costs and improves household affordability, while higher energy prices increase the cost of living and exacerbate poverty. The WET, on the other hand, underscores the importance of resource distribution, government intervention, and macroeconomic stability in enhancing welfare (Pigou, 1932; Sen, 1999). Accordingly, variables such as government expenditure (GOVEXPGr), employment (EMP), education

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(EDUltr), inflation (INFL), and urbanization (URB) are included as welfare-enhancing or welfare-reducing factors that mediate the link between economic growth and poverty reduction.

Table 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	$\mathbf{ENEF_t} = \frac{\mathbf{Total\ Primary\ Energy\ Consumption_t}}{\mathbf{GDP_t}}$ Then we normalize it (apply min-max normalization) so that higher values reflect better efficiency: $\mathbf{Normalized\ ENEFt} = \frac{\mathbf{Max(ENEF) - ENEFt}}{\mathbf{Max(ENEF) - Min(ENEF)}}$	(−)	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.
GOVEXPGr	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

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				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:

$$\mathrm{POV_t} = f(\mathrm{ENEF_t}, \mathrm{ENERPr_t}, \mathrm{HHCEGr_t}, \mathrm{GOVEXPGr_t}, \mathrm{EMP_t}, \mathrm{EDUltr_t}, \mathrm{INFL_t}, \mathrm{URB_t})$$

Econometric Form

The log-linear econometric specification is written as:

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

Where:

- $\boldsymbol{\alpha_0}$ = constant term
- $\boldsymbol{\alpha_1}$-$\boldsymbol{\alpha_8}$ = slope coefficients measuring the effect of each explanatory variable on poverty
- $\boldsymbol{\mu_t}$ = error term

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:

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XV October 2025 | Special Issue on Economics

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

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

Presentation and Discussion of Results

Descriptive Statistics

Table 2: Descriptive Statistic Results

	POV	ENEF	ENERPr	GOVEXGr	HHCEGr	INFL	EMP	EDUlrt	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
Jarque-Bera	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.

Unit Root Test

Table 3: Unit Root Test

	Phillips-Perron (PP) at Level		**Phillips-Perron (PP) at 1st Diff**		**Order of integration**
Variables	**T-Stats**	**Critical value.**	**T-Stats**	**Critical value.**	**(d).**
ENEF	-1.133442	-2.941145	-5.796772	-2.943427	**I(1)**
ENERPr	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 (ENERPr), 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.

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

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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.

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
ENERPr	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
EDUlrt	-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(ENERPr)	0.007318	0.002490	2.939091	0.0076
D(GOVEXgr)	0.006672	0.003851	1.732342	0.0972

INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
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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)	-2.198297	0.374061	-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 (ENERPr) 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 negative 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(ENERPr)) 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 (–2.19830, $p < 0.01$), 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.

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

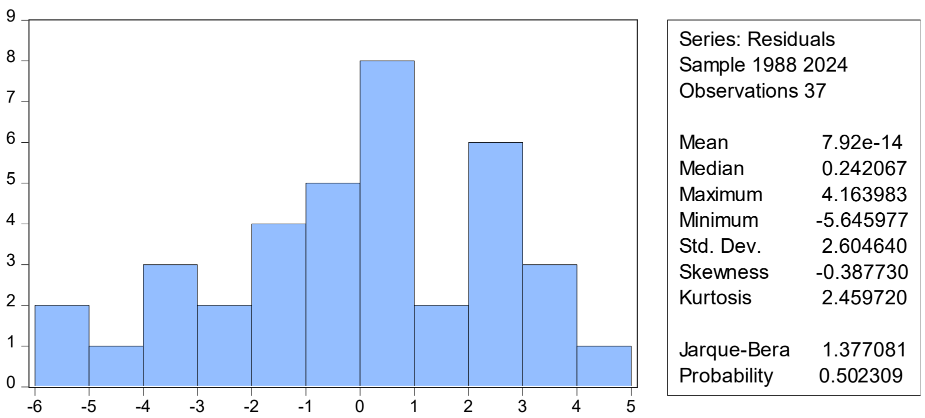

Figure 2: CUSUM Graph

Figure 3: CUSUM Square Graph

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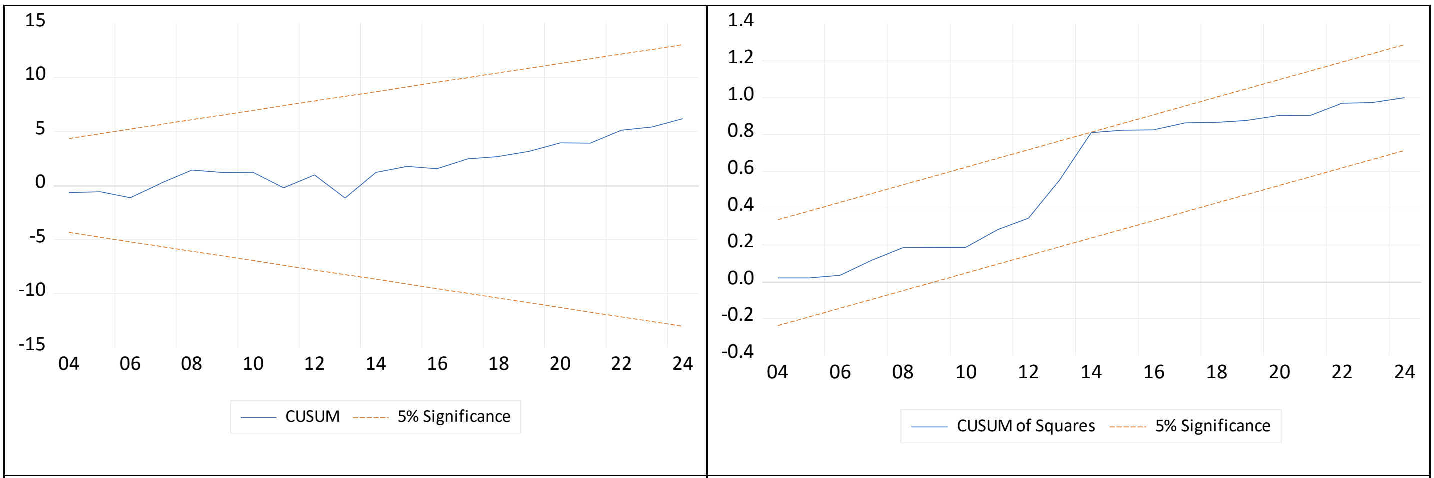

Source: Authors (2025)

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-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.

DISCUSSION OF FINDINGS

The results provide policy-relevant insights into how Nigeria's energy transition can be pro-poor. Consistent with the Energy-Led Growth Hypothesis, energy efficiency significantly reduces household poverty in both the short and long run. This aligns with evidence that efficiency gains lower energy expenditures and free resources for welfare-enhancing uses (IEA, 2018; Ouedraogo, 2013). Conversely, rising energy prices increase poverty, corroborating studies linking fuel and electricity tariff hikes to welfare losses among low-income households (Ogunyemi, & Oladapo, 2025; Yunusa, et al., 2023). These findings highlight that efficiency policies can be inclusive, but tariff reforms must be sequenced with protective measures to avoid regressive impacts.

Education (literacy) also exerts a strong poverty-reducing effect, consistent with welfare economics theory and prior studies linking human capital to resilience and income growth (Barro & Lee, 2013; Awotide et al., 2015). Urbanization reduces poverty in the short run, likely due to better infrastructure and labour opportunities, echoing UN-Habitat (2020) and World Bank (2023) insights. Together, energy efficiency, education, and urban infrastructure emerge as complementary drivers of welfare gains. Other variables government expenditure, employment, household consumption, and inflation were weaker or insignificant. This suggests that the composition and targeting of fiscal policy matter more than aggregate growth (World Bank, 2023), and that job creation without quality and energy access linkages may not yield durable poverty reductions. The short- versus long-run dynamics reflect transitional complexities: efficiency yields strong welfare benefits, while energy price reforms impose immediate costs (Bobasu, et al., 2025). The significant error-correction term confirms a stable long-run relationship, implying that short-run interventions aligned with structural reforms can produce sustained poverty reduction.

Policy implications are clear. First, energy efficiency policies should be central to the transition. Second, tariff reforms must be accompanied by targeted transfers, lifeline tariffs, or subsidies to protect vulnerable households (Sen, 1999). Third, investments in education and skills, coupled with urban and rural energy infrastructure, can spread the welfare gains more equitably. Finally, fiscal policy should prioritize targeted spending on social protection, education, and energy access programs (Ogunyemi, & Oladapo, 2025; Oyadeyi et al., 2024; World Bank, 2023). Overall, the study fills an important gap by demonstrating that energy efficiency directly reduces poverty in Nigeria, but also underscores the need for complementary policies to ensure that the benefits of the energy transition are inclusive and equitable.

CONCLUSION AND POLICY RECOMMENDATIONS

This study investigated the nexus between energy efficiency, energy prices, and household poverty in Nigeria within the framework of the Energy-Led Growth Hypothesis (ELGH) and Welfare Economics Theory (WET). Using the ARDL estimation technique, the results revealed that energy efficiency significantly reduces poverty in both the short and long run, underscoring its potential as a pro-poor driver of welfare within Nigeria's energy transition strategy. Conversely, energy prices were found to exert poverty-increasing effects, highlighting the welfare risks of unbuffered tariff adjustments. Education (literacy) emerged as another significant poverty-reducing factor, reinforcing the central role of human capital development in breaking the cycle of poverty. Urbanization also showed strong short-run poverty-reducing effects, suggesting that access to infrastructure and economic opportunities in urban areas can alleviate welfare deprivation. Other variables such as government expenditure, household consumption, employment, and inflation produced weaker or statistically insignificant effects, suggesting that their impact depends heavily on policy design, targeting, and institutional efficiency.

The findings carry important policy implications for Nigeria's energy transition agenda. First, prioritizing energy efficiency should be a cornerstone of policy, as efficiency measures not only reduce household energy costs but also deliver long-term poverty reduction. This requires investment in efficient appliances, building standards, and renewable-based off-grid systems, particularly in rural and peri-urban areas. Second, given the poverty-increasing effect of energy prices, a gradual and socially sensitive approach to tariff reforms is necessary. Cost-reflective pricing should be accompanied by targeted subsidies, lifeline tariffs, or direct cash transfers to shield vulnerable households from welfare losses during the transition. Third, the significant role of education calls for stronger investments in human capital development, including literacy programs, vocational training, and skills upgrading to improve household resilience and income-generating capacity. Fourth, the positive short-run role of urbanization implies that urban infrastructure expansion such as electrification, housing, and transport, can complement energy efficiency efforts, but this must be balanced with policies to address rural energy poverty to avoid deepening regional inequality.

Finally, the study emphasizes that energy transition policies should be embedded within a broader framework of inclusive welfare economics, where fiscal expenditure is deliberately targeted at reducing vulnerability and expanding opportunities. Public spending should prioritize investments in renewable energy infrastructure, education, and social protection programs that directly reach poor households. By combining efficiency-oriented reforms with redistributive policies, Nigeria can design an energy transition strategy that not only delivers environmental benefits but also advances inclusive development and poverty reduction.

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APPENDIX

Data

Year	GDPPCGR	EDULRT	EMP	TPEC/GDP	GOVEXGR	HHCEGR	INFL	POV	URB	ENENPR	ENEF
1986	-2.52667	56.12032	58.497	671.6111	2.182242	-9.35083	5.717151	18.4	11.60998	0.39	1
1987	0.574529	56.12032	58.489	677.2977	2.135637	-5.5938	11.29032	18.4	11.87072	0.39	0.952843
1988	4.593067	56.12032	58.404	679.5984	2.090982	6.979885	54.51122	18.4	12.14178	0.42	0.933765
1989	-0.70992	56.12032	58.343	685.1884	2.048155	-7.60591	50.46669	18.4	12.41899	0.6	0.887409
1990	8.877	56.12032	58.28	697.6002	2.007048	23.81864	7.3644	18.4	12.70656	0.6	0.784483
1991	-2.18037	55.44675	58.283	712.5468	1.967558	5.90801	13.00697	18.4	12.96306	0.7	0.660536
1992	2.023629	55.44675	58.275	722.2551	1.059521	16.92783	44.58884	24.4	13.14057	0.7	0.580029
1993	-4.50715	55.44675	58.19	715.3422	2.876441	-8.24414	57.16525	24.4	13.25282	5	0.637355
1994	-4.31075	55.44675	58.129	680.0624	2.894572	-9.85231	57.03171	24.4	13.36715	15	0.929917
1995	-2.5956	55.44675	58.066	681.1587	1.427395	4.958746	72.8355	24.4	13.48801	11	0.920825
1996	1.596033	55.44675	58.069	692.3822	-0.05851	19.98309	29.26829	27.9	13.61801	11	0.827754
1997	0.37252	55.44675	58.028	698	2.894012	-3.2421	8.529874	27.9	13.75185	11	0.781168
1998	0.032474	55.44675	57.982	685.3233	1.729373	-0.33343	9.996378	27.9	13.89214	25	0.88629
1999	-1.94111	55.44675	57.926	692.0342	1.699974	-8.53888	6.618373	27.9	14.03376	20	0.830639
2000	2.317775	55.44675	57.905	700.3827	1.671558	1.768542	6.933292	27.9	14.17276	30	0.761409
2001	3.146425	55.44675	57.927	716.1132	1.644076	59.38751	18.87365	27.9	14.30863	30	0.630962
2002	12.27614	55.44675	57.985	719.4873	-12.0786	15.22115	12.87658	27.9	14.44601	26	0.602982
2003	4.495156	54.77318	57.951	740.1777	5.779098	10.76781	14.03178	18.8	14.58746	42	0.431405
2004	6.345041	54.77318	57.966	740.8816	-23.9262	0.226824	14.99803	18.8	14.73501	50	0.425567
2005	3.609661	54.77318	57.956	749.5896	565.5388	12.75268	17.86349	18.8	14.88733	57.5	0.353356
2006	3.238343	70.19835	58.001	735.6947	10.46888	-13.7169	8.225222	18.8	15.02407	65	0.468581
2007	3.741687	70.19835	58.039	741.2802	35.75064	34.58342	5.388008	18.8	15.10529	65	0.422262
2008	3.899943	51.07766	58.067	742.8051	90.75034	-15.9781	11.58108	18.8	15.18834	75	0.409617
2009	5.130162	51.07766	58.095	711.3473	4.426677	22.28252	12.53783	18.8	15.27156	65	0.670484
2010	5.081875	51.07766	58.111	744.8358	-8.07509	1.739826	13.74005	10.3	15.35563	65	0.392777
2011	2.437007	51.07766	58.133	766.3292	17.84247	-3.05619	10.82614	10.3	15.43947	65	0.214541
2012	1.403509	51.07766	55.691	785.2607	4.573578	0.00566	12.22424	9.9	15.52917	141	0.05755
2013	3.832366	51.07766	53.225	766.9222	-1.98196	21.06499	8.495518	9.9	15.62846	97	0.209623
2014	3.552162	51.07766	53.671	750.9709	-10.2574	0.613701	8.047411	9.9	15.7425	97	0.341901
2015	0.076962	51.07766	54.094	764.1229	-7.01454	1.453278	9.009435	9.4	15.87368	87	0.232837
2016	-4.05271	51.07766	54.506	767.2427	-11.8973	-5.72998	15.69681	9.4	16.01398	145	0.206966
2017	-1.70987	51.07766	54.951	770.3624	-15.116	-0.95243	16.50227	9.4	16.15486	145	0.181095
2018	-0.59039	62.01601	55.383	773.4821	-7.98878	5.220878	12.09511	9	16.30465	145	0.155225
2019	-0.26346	62.01601	55.805	776.6019	33.1644	-0.99314	11.39642	9	16.47127	145	0.129354
2020	-4.16206	62.01601	54.812	779.7216	8.78314	-0.98381	13.24602	9.1	16.65154	147.5	0.103483
2021	1.182828	62.01601	54.886	782.8413	61.57662	25.62268	16.95285	9.1	16.85185	161	0.077613
2022	0.823296	62.01601	55.476	785.9611	-34.0309	-7.68239	18.84719	9.2	17.07071	195	0.051742
2023	1.585152	62.01601	54.685	789.0808	15.85602	2.533398	15.09017	12.7	17.11039	540	0.025871
2024	1.597317	62.01601	54.549	792.2006	3.154494	2.470803	15.37642	18.6	17.24412	1030	3.98E-07