Energy Consumption and Unemployment in Nigeria: An Autoregressive Distributed Lag (ARDL) Investigation

Adaora Edna Uzokwe, Alwell Nteegah, Boniface Oriji

Emerald Energy Institute, University of Port Harcourt.

Abstract— The high level of unemployment in spite of the vast energy resource in Nigeria make it imperative to examine how energy consumption has affected unemployment in Nigeria over the period 1990 - 2023. The study proxied energy consumption by automotive gas oil consumption, premium motor spirit consumption, solar energy consumption, hydropower energy, natural gas-to-power consumption. while unemployment in Nigeria was measured by unemployment rate. The data were sourced from the World Bank, National Bureau of Statistics Nigerian National Petroleum Company Ltd annual reports amongst others. The models specified were estimated using the Autoregressive Distributive Lag estimation technique after conducting the required pre-estimation tests. The results showed that: Automotive gas oil consumption and premium motor spirit consumption reduced unemployment rate, solar energy consumption retarded unemployment rate in the short-run and long-run, hydropower energy consumption had negative effect on unemployment while natural gas-to-power consumption also has a negative and significant effect on unemployment rate in the short-run but has a positive and significant effect on unemployment rate in the long-run. Sequel to the findings, the study recommends; increase investment in renewable energy source, domestic refining of crude oil and building of gas infrastructure in order to stabilise price and enhance reduce unemployment in Nigeria.

Keywords— Automotive gas oil consumption, premium motor spirit consumption, solar power consumption, natural gas consumption and unemployment rate.

I. INTRODUCTION

In recent times, many nations aspire for accelerated economic growth and development through implementation of some targeted plan that requires higher energy consumption to boost industrial activities. As such, energy plays a crucial role in the economic growth and development of all nations (Kaygusuz, 2009). Umeh, Ochuba, and Ugwo (2019) state that energy is an essential economic resource that greatly affects people's health, education, employment, industrial advancement, and prosperity as a whole. To fully enjoy economic growth and development, there must be an adequate supply of energy and efficient application of that energy. Africa and other emerging nations have social and economic challenges that energy cannot solve on its own. However, the inability to get inexpensive and dependable energy services is acknowledged as a substantial obstacle to any nation's progress. Consequently, without appropriate energy consumption, affordability of contemporary energy services, and a enough energy capacity, economic growth and development may be hindered (Nkoro, et al 2019).

Energy consumption plays a foundational role in driving industrialization and agricultural productivity, two critical pillars of economic development. In both developed and emerging nations, energy is the lifeblood of production. Manufacturing processes rely heavily on electricity and fuel to power machinery, operate plants, and facilitate logistics. In Nigeria, industries i.e. cement, textiles, and food processing depend on a stable energy supply to maintain productivity and ensure competitiveness in both domestic and international markets. Without sufficient energy, industries operate below capacity, leading to reduced output, job losses, and revenue decline. In agriculture, energy is vital for irrigation systems, mechanized farming equipment, fertilizer production, and post-harvest storage. As energy consumption increases and becomes more accessible and affordable, farmers are able to expand their activities, rise yields, and reduce food losses. This enhances food security, raises rural incomes, and promotes job creation and reduces poverty cross the economy. As an result, rising energy consumption directly supports higher output, economic diversification, and resilience, which are all crucial for long term employment generation (Ikpe & Oyedeji, 2023). In furtherance, energy consumption substantially contributes to employment generation and entrepreneurship development. A growing energy sector, particularly in electricity generation, distribution, and renewable energy, creates both direct and indirect job opportunities. Directly, it employs engineers, technicians, and utility workers in building and maintaining energy infrastructure. Indirectly, it supports millions of Micro, small, and medium enterprises (MSMEs) by enabling them to operate more efficiently and expand their production (Okeoma, Nwachukwu, Ezeonye & Osatemple, 2023). More importantly, the International Renewable Energy Agency (IRENA, 2023) reported that the renewable energy industry employed 13.7 million people worldwide in 2022, with solar energy alone accounting for 4.9 million jobs. In Nigeria, the off-grid solar market has created over 50,000 jobs in installation, maintenance, and sales. Additionally, reliable electricity reduces operational costs for small and medium enterprises (SMEs), which employ over 80 percent of Nigeria's workforce (Manufacturers Association of Nigeria, 2023).

Nigeria, despite being Africa's largest oil producer, faces severe energy crises that have stifled economic growth, exacerbated increased unemployment. Between 1990 and 2023, the nation's energy sector has been dominated by inefficient

consumption patterns, comprising heavy reliance on automated gas oil (AGO/diesel), premium motor spirit (PMS/petrol), and underutilization of renewable energy sources like hydro, solar, and natural gas-to-power. Despite having abundant energy resources, Nigeria struggles with erratic power supply, forcing households and businesses to depend on expensive and polluting alternatives like diesel and petrol generators. This energy deficit has substantially hindered industrial productivities, increased operational costs, and discouraged foreign investment, contributing to rising unemployment. The economic consequences of Nigeria's energy crisis are evident in rising rate of unemployment. The National Bureau of Statistics (NBS, 2023) reports that unemployment stands at 33.3 percent, with youth unemployment exceeding 42 percent. The manufacturing sector, which should drive employment, contributes only 9 percent to GDP due to high energy costs (MAN, 2023). SMEs, which account for 80 percent of Nigeria's employment, spend 30-40 percent of their revenue on alternative energy sources, reducing profitability and expansion capacity. The lack of reliable electricity has also discouraged foreign direct investment (FDI), which declined from $8.8 billion in 2011 to $3.3 billion in 2022 (World Bank, 2023). It is against the identified problem that this study seeks to evaluate the extent to which energy consumption has affected unemployment in Nigeria. The specific objectives of the study are to: examine the effect of automotive gas oil consumption on unemployment rate in Nigeria, determine the effect of premium motor spirit consumption on unemployment rate in Nigeria, investigate the effect of solar energy consumption on unemployment rate in Nigeria, ascertain the effect of hydropower energy on unemployment rate in Nigeria, and evaluate the effect of natural gas-to-power consumption on unemployment rate in Nigeria.

II. LITERATURE REVIEW

Theoretical Framework

This study is anchored on Energy Transition Theory. Energy Transition Theory was primarily conceptualised and developed by Vaclav Smil, a Canadian scientist and policy analyst. This theory was further advanced by scholars in energy studies during the late 20th century and early 21st century. Although Smil did not formally propose a singular "Energy Transition Theory," he is recognised for establishing the empirical and conceptual groundwork for analysing energy transitions throughout historical periods. This is particularly evident in his works from the 1980s to the 2000s, comprising Energy in World History (1994) and Energy Transitions. History, Requirements, Prospects (2010). To understand how energy consumption relates to a flourishing economy, one must go no further than the energy transition hypothesis. Under the energy transition theory, researchers i.e. Hosier and Dowd (1987) and Leach (1992) found a nexus between the energy type applied and financial benefit. Many people believe that energy is the key to today's booming economy, especially in nations that have seen rapid expansion in the last several years. In congruent with this notion, a nation's GDP per capita has a substantial outcome on its energy use pattern. The argument, which is as per consumer theory, proposes that people would

choose new energy sources more as their discretionary income rises. The comfort and simplicity of application of these sources, compared to older or less efficient options, are the reasons behind this choice. There exists a clear relationship between GDP and energy usage, in congruent with this idea. Developed nations use more high-quality energy than developing nations. The Energy Transition hypothesis posits that a nation lacking access to modern energy sources will face increased challenges in reducing poverty and achieving sustainable development. Ensuring access to energy is a critical element in efforts to eradicate poverty, as the lack of energy restricts economic activity and production (Kaygusuz, 2011; Sovacool, 2012). Pachauri and Spreng, 2004.

Energy Transition Theory elucidates the result of energy consumption on economic development by emphasising the transition from traditional, carbon-intensive energy sources to contemporary, cleaner alternatives, which can facilitate sustainable economic expansion. Societies that implement more efficient and renewable energy technologies, comprising solar, wind, hydropower, and natural gas, improve energy access, decrease environmental degradation, and reduce energy costs. These advancements subsequently boost industrial productivity, draw investment, and generate green jobs. The enhancement of energy infrastructure facilitates essential sectors i.e. manufacturing, agriculture, health, and education, consequently promoting overall economic development. The theory suggests that energy transitions involve more than just technical changes; they are transformative processes that alter social, economic, and institutional frameworks. This enables the development of more inclusive and resilient economic systems, particularly in emerging nations i.e. Nigeria.

Empirical Review

This research reviewed related empirical studies by several authors regarding energy consumption and economic development in Nigeria and other countries of the world in this section as follow:

From 1990 to 2022, Onyekachi et al. (2025) evaluated the result of energy usage on macroeconomic expansion in Nigeria. As per neo-classical growth theory, this work applied the VECM and the Granger causality test as its analytical underpinning. The results indicated a dynamic nexus between Nigeria's energy usage and economic development in the extended term.

Olubiyi et al. (2025) evaluated the nexus between energy consumption, unemployment, and urbanisation in South Africa and Nigeria utilising a three-factor vector autoregressive (VAR) research. Impulse response functions, variance decomposition, and Granger causality are all part of our research. The result point to a one-way nexus between unemployment and energy use, likewise a two-way influence between energy consumption and urbanisation in Nigeria.

Mombekova et al. (2024) analysed the link between macroeconomic expansion and energy consumption data from seven rising nations. These nations: China, India, SA, TI, Mexico, and Thailand. The study applied Swamy's Random Co-efficient Model and Seemingly Unrelated Regression (SUR) models to observe the factors' connection, we find that

macroeconomic expansion has a beneficial effect on energy use. Consistent with our evaluation utilising the General Methods of Moments approach, all energy consumption measurements have a favourable effect on economic development.

Using the energy growth nexus as a framework, Mihai et al. (2024) appraised the nexus between carbon emissions, energy consumption, and economic development. In an effort to do this, we relied on linear regression as our main analytical method and applied Eurostat and OECD data covering the 27 member states of the EU from 2010 to 2022. The results point to a strong nexus between CO_2 emissions as per production and those as per demand, likewise between CO_2 emissions as per production and total energy use

Mawunyo, Philip and Andrea (2022) examined the nexus between unemployment and energy efficiency. The study applied the stochastic frontier approach and the generalized method of moments to an unbalanced panel dataset for 51 African countries, spanning 1991–2017. The results confirmed the theoretical prediction that, directly, energy efficiency reduces unemployment. However, further empirics showed that economies with better human capital experience greater reduction in unemployment than those with less-developed human capital.

Utilising a non-linear panel ARDL model, Wajid, Solomon, Ibrahim, and Bezon (2022) appraised the imbalanced nexus between energy usage and economic development. The research comprised 85 nations in its total sample, with sub-samples for the following groups: the Next Eleven, the Big Four in Western Europe, the Asia-Pacific area, the Group of Seven, SAARC, ECO, and the Arab League. The study period extended from 1977 to 2014

Adamu and Maijama'a (2021) investigated the connection among electricity energy consumption, unemployment, inflation and transport in Nigeria from 1990 to 2019. Theoretical Philips curve was rejected by both Fully Modified Ordinary Least Square (FMOLS) and Ordinary Least Square (OLS) regression as the relationship is positive. Impulse response function further affirmed the positive response of unemployment to inflation. Transport energy consumption has significant negative impact on unemployment; the same is obtained by its interaction term also.

Chama, Yahya and Hindou (2021) carried out a study on the role of renewable energy sector in reducing unemployment. The causality between renewable energy consumption and unemployment will be tested using the VAR model, the Johansen co-integration test, and the Granger causality test, for the period 1990-2017. The results suggested that there is causality running from renewable energy consumption to unemployment. In fact, renewable energy sector can contribute to reduce the employment rate in Morocco.

Muktar and Abdullahi (2021) examined the impact of electricity supply on unemployment in Nigeria. To this end, annual time series data were collected for a period of 36 years from 1986-2020; and were analysed using the Ordinary Least Squares (OLS) technique. Findings from the study revealed a strong positive linear correlation between unemployment reduction and electricity supply, while it established a negative correlation between unemployment reduction and government policy.

Hlalefang, Nwabisa, Clement, Izunna and Siyasanga (2020) examined the relationship between renewable energy consumption and unemployment in South Africa over the period 1990-2014. The autoregressive distributed lag model was employed to test the long-run and short-run impacts of renewable energy consumption on unemployment. The results revealed that renewable energy consumption has a negative and significant effect on unemployment in the long-run. However, in the short-run, the variables have an insignificant relationship.

Veli, Emel, Sinem and Gökçe (2020) examined the relationship between unemployment rates and renewable energy consumption: Evidence from Fourier ADL Cointegration Test. The study found answered the question that whether new energy technologies create new employment areas or not and help to solve unemployment problem. The results showed that there is a cointegration relationship between the variables for Australia, Austria, Chile, France, Germany, Japan, Mexico, Portugal, Spain and United States.

III. Methodology

Annual time series data were used and sourced/extracted from World Development Indicators (WDI) of World Bank, National Bureau of Statistics (NBS), Nigerian National Petroleum Company (NNPC) annual statistical bulletins, and Energy Commission of Nigeria (ECN) reports. Moreover, the data covered a period of thirty-four (34) years ranging from 1990 to 2023.

Model Specification

Theoretically, the analytical framework of this study was anchored on Cobb-Douglas Production Function because of its relevance to this study. Furthermore, this empirical model was built on the work of Ogungbenle (2021) in his analysis of the effect of consumption of energy on economic growth in Nigeria. However, the model was subjected to slight modifications in order to incorporate and accommodate all the variables adopted with respect to the objectives of the study.

The functional forms of the modified models are specified as follows:

$$UPR = f(AGO, PMS, SEC, HPC, NGC) \tag{1}$$

More explicitly, the above models are transformed into econometric forms with the inclusion of constant variables, parameters and error terms as follows:

$$UPR_t = \delta_0 + \delta_1 AGO_t + \delta_2 PMS_t + \delta_3 SEC_t + \delta_4 HPC_t + \delta_5 NGC_t + \mu_t \tag{2}$$

The above model (2) is transformed into log linear forms as follows:

$$InUPR_t = \delta_0 + \delta_1 InAGO_t + \delta_2 InPMS_t + \delta_3 InSEC_t + \delta_4 InHPC_t + \delta_5 InNGC_t + \mu_t \tag{3}$$

The Autoregressive Distributed Lag (ARDL) model specification of the above model is given as;

$$\Delta \ln(UPR_t)$$
$$= \delta_0 + \delta_{1i}\Delta\ln(UPR_{t-1}) + \delta_{2i}\Delta\ln(AGO_{t-1})$$
$$+ \delta_{3i}\Delta\ln(PMS_{t-1}) + \delta_{4i}\Delta\ln(SEC_{t-1}) + \delta_{5i}\Delta\ln(HPC_{t-1})$$
$$+ \beta_{6i}\Delta\ln(NGC_{t-1}) + \sum_{t=1}^{p}\alpha_{1i}\Delta 1n(UPR_{t-1})$$
$$+ \sum_{t=1}^{q}\alpha_{2i}\Delta 1n(AGO_{t-1}) + \sum_{t=1}^{p}\alpha_{3i}\Delta 1n(PMS_{t-1})$$
$$+ \sum_{t=1}^{q}\alpha_{4i}\Delta 1n(SEC_{t-1}) \sum_{t=1}^{q}\alpha_{5i}\Delta 1n(HPC_{t-1})$$
$$+ \sum_{t=1}^{P}\alpha_{6i}\Delta 1n(NGC_{t-1}) + \lambda ECT_{t-1} + \varepsilon_{1i} \qquad (4)$$

A Priori Expectation: $\delta_1 < 0$, $\delta_2 < 0$, $\delta_3 < 0$, $\delta_4 < 0$, $\delta_5 < 0$.

Where: UPR = Unemployment rate, AGO = Automotive gas oil consumption, PMS = Premium motor spirit consumption, SEC = Solar energy consumption, HPC= Hydropower energy, NGC = Natural gas-to-power consumption, δ_0 = Regression intercept, δ_1 - δ_5 = Long-run Parameters, α_1- α_6= Short-run parameters, In = Natural log, Δ = Difference operator and indicates the optimum lag, t = Time subscript, λ = Speed of adjustment which is expected to be less than zero, μ_t = Error term

Data Analysis Techniques

The analytical procedure for this study began by providing the summary statistics for each series that were included in our functional model. This was followed by unit root test and cointegration test as stated earlier, so as to ensure that the estimated model is not spurious in nature and if a co-integrating regression can be estimated. In estimating the model, the study resorted to use autoregressive distributed lag (ARDL) technique proposed by Pesaran, Shin and Smith (2001) since the variables in our models have mixture of I(0) and I(1) series.

IV. RESULTS AND DISCUSSION

TABLE 1: Descriptive Statistics

	UPR	AGO	PMS	SEC	HPC	NGC
Mean	4.830588	4910.206	9636.853	81.19265	6338.824	194080.7
Median	3.770000	3763.500	9176.500	2.250000	5995.000	141580.3
Maximum	10.10000	13920.00	18044.00	816.0000	8349.000	455258.3
Minimum	1.900000	1137.000	4640.000	0.020000	4387.000	45025.50
Std. Dev.	2.287394	3636.787	3814.660	191.3077	1066.157	131464.9
Skewness	1.197746	0.884877	0.454568	2.683237	0.452437	0.596928
Kurtosis	2.904863	2.769386	2.225742	9.346562	2.290589	1.892766
Jarque-Bera	8.142203	4.512382	2.020175	97.86033	1.872922	3.755950
Probability	0.017059	0.104749	0.364187	0.000000	0.392013	0.152899
Sum	164.2400	166947.0	327653.0	2760.550	215520.0	6598744.
Sum Sq. Dev.	172.6616	4.36E+08	4.80E+08	1207754.	37510773	5.70E+11
Observations	**34**	**34**	**34**	**34**	**34**	**34**

Source: *Author's Computation (2025).*

The descriptive statistics in Table 1 provide crucial preliminary clarity into the behaviour of all the variables (unemployment rate, automotive gas oil consumption, premium motor spirit consumption, solar energy consumption, hydropower energy, natural gas-to-power consumption) in our dataset. Table 4.1 shows that unemployment rate (UPR) has a mean of 4.83% and this suggests relatively low recorded

unemployment on average. The maximum unemployment rate (UPR) is 10.10 while the minimum is 1.90%. The standard deviation of 2.29 implies low deviation or dispersion of unemployment rate (UPR) from its mean. Also, automotive gas oil consumption (AGO) has a mean of 4,910.21 million litres which indicates its vital role in Nigeria's energy mix. The maximum value is 13,920.00 and minimum is 1,137.00. The standard deviation of 3,636.79 confirm high has low deviation or dispersion from the mean. Furthermore, premium motor spirit consumption (PMS) has a mean of 9,636.85 million litres. This reflects high and widespread usage, especially in transportation and households. The maximum premium motor spirit consumption (PMS) is 18,044.00 and the minimum premium motor spirit consumption (PMS) is 4,640.00 million litres. The standard deviation of 3,814.66 indicates high deviation or dispersion from the mean. In addition, solar energy consumption (SEC) has a mean of 81.19 GWh. This indicate relatively low average use and reflects Nigeria's late entry into solar energy development. The maximum consumption is 816.00 GWh and the minimum is 0.02 GWh. The standard deviation is high at 191.31, emphasizing large deviation or dispersion from the mean. Moreover, hydropower energy consumption (HPC) has a mean of 6,338.82 GWh. This reflects its consistent and long-standing contribution to Nigeria's energy sector. The maximum recorded hydropower energy consumption (HPC) is 8,349.00 GWh and the minimum is 4,387.00 GWh. The standard deviation of 1,066.16 reflects moderate deviation or dispersion from the mean. Lastly, natural gas-to-power consumption (NGC) has a very high mean of 194,080.70 MMSCF, reflecting its increasing importance in power generation. The maximum natural gas-to-power consumption (NGC) of 455,258.30 MMSCF and the minimum of 45,025.50 MMSCF shows massive expansion in natural gas-to-power usage. The standard deviation is also very high at 131,464.90, indicating large deviation or dispersion from the mean.

Unit Root Test

For the purpose of this study, Augmented Dickey-Fuller (ADF) was used to carry out the unit root test and the results are presented in Table 2:

TABLE 2: Augmented Dickey-Fuller (ADF) Test Results

Variables	ADF	Mackinnon Critical Value @ 5%	P-value (Prob.*)	Decision	Order of Integration
ADF At Levels					
LOG(UPR)	-1.357749	-2.954021	0.5906	Non-stationary	
LOG(AGO)	0.175460	-2.960411	0.9664	Non-stationary	
LOG(PMS)	-1.130560	-2.963972	0.6903	Non-stationary	
LOG(SEC)	-0.052034	-2.967767	0.9458	Non-stationary	
LOG(HPC)	-3.011429	-2.954021	0.0387	Stationary	
LOG(NGC)	-1.129166	-2.957110	0.6919	Non-stationary	
ADF At First Difference					
LOG(UPR)	-4.754589	-2.957110	0.0006	Stationary	I(1)
LOG(AGO)	-6.063057	-2.960411	0.0000	Stationary	I(1)
LOG(PMS)	-8.776263	-2.960411	0.0000	Stationary	I(1)
LOG(SEC)	-5.980101	-2.957110	0.0000	Stationary	I(1)
LOG(HPC)	-	-	-	-	I(0)
LOG(NGC)	-7.775854	-2.957110	0.0000	Stationary	I(1)

Source: *Author's Computation (2025).*

The Augmented Dickey-Fuller (ADF) unit root test result presented in Table 2 showed that at their levels, the ADF test statistics for five of the variables which unemployment rate (UPR), automotive gas oil consumption (AGO), premium motor spirit consumption (PMS), solar energy consumption (SEC) and natural gas-to-power consumption (NGC), are all less in absolute value than their respective 5% MacKinnon critical values, with p-values well above the 0.05 threshold, indicating that these series are non-stationary at level. After first differencing, all these previously non-stationary variables became stationary and are all integrated of order one, I(1), suggesting that shocks to these variables have long-term effects. These findings are important for model specification in time series analysis. However, an exception is found in hydropower energy consumption (HPC) as it has an ADF statistic which is greater in absolute term than its 5% critical value as well as a p-value which is below 0.05. This result implies that hydropower energy consumption (HPC) is stationary at level, or integrated of order zero, I(0). Since the dataset contains a mix of I(0) and I(1) variables, traditional regression techniques like Ordinary Least Squares (OLS) are inappropriate. Instead, methods such as the Autoregressive Distributed Lag (ARDL) model or cointegration approaches are more suitable, as they can handle both I(0) and I(1) series. Ignoring these integration properties could lead to misleading or spurious results in estimating the impact of energy consumption on economic development indicators in Nigeria.

Correlation Analysis

The results of correlation analysis of are presented in Table 3:

TABLE 3: Correlation Matrix of UPR Model

	LOG (UPR)	LOG (AGO)	LOG (PMS)	LOG (SEC)	LOG (HPC)	LOG (NGC)
LOG(UPR)	1					
LOG(AGO)	0.1015953	1				
LOG(PMS)	0.2714186	0.29141	1			
LOG(SEC)	0.3567926	0.47097	0.265493	1		
LOG(HPC)	0.4916429	0.470941	0.46373	0.511715	1	
LOG(NGC)	0.3235651	0.488784	0.5861	0.681269	0.445077	1

Source: *Author's Computation (2025).*

Table 3 is a correlation matrix showing the pairwise Pearson correlation coefficients among the independent variables in a regression model where the dependent variable is the unemployment rate (UPR). When examining the inter-correlations among the independent variables themselves which is crucial for detecting multicollinearity, the highest correlation is between natural gas-to-power consumption and solar energy consumption (0.6813), followed by natural gas-to-power consumption and premium motor spirit consumption (0.5861), and hydropower energy consumption and solar energy consumption (0.5117). These values are moderate but do not reach the conventional multicollinearity concern threshold of 0.80 or higher. Most of the remaining correlations are below 0.50, which further reduces the risk of multicollinearity. Therefore, there is sufficient statistical evidence to conclude that there is no evidence of multicollinearity among the explanatory variables in this model. The variables can be reliably included in the regression without fear of distortion in

the coefficient estimates or inflated standard errors due to inter-variable linear dependence.

Bounds Cointegration Test

The results of bounds cointegration test are presented in Table 4:

TABLE 4: ARDL Bound Cointegration Test Result of UPR Model

Test Statistic	Value		
F-statistic	7.652710		K
Significance	Lower Bound [I(0)]	Upper Bound [I(1)]	
10%	2.080	3.000	5
5%	2.390	3.380	
1%	3.060	4.150	

Source: *Author's Computation (2025).*

The table presents the ARDL Bounds Test result for the unemployment rate (UPR) model, specifically to test for the presence of a long-run relationship between unemployment and the independent variables (automotive gas oil consumption, premium motor spirit consumption, solar energy consumption, hydropower energy consumption, and natural gas-to-power consumption). The F-statistic value is 7.652710, which is then compared against the Pesaran critical values (also called lower and upper bounds) at three significance levels: 10%, 5%, and 1%. At the 5% significance level, the lower bound is 2.390 and the upper bound is 3.380. Since the computed F-statistic of 7.652710 is greater than the upper bound at all conventional levels of significance, we reject the null hypothesis of no long-run relationship. This result implies that there exists a statistically significant long-run cointegrating relationship between unemployment rate (UPR) and the energy-related explanatory variables (automotive gas oil consumption, premium motor spirit consumption, solar energy consumption, hydropower energy consumption, or natural gas-to-power consumption (depending on the exact model specification) in the model.

Short-Run ARDL Estimation

The results of short-run ARDL estimation of the model are presented in Table 5:

TABLE 5: Results of Short-run ARDL Estimation of UPR Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
Dependent Variable = LOG(UPR)				
COINTEQ*	-0.688862	0.080916	-8.513264	0.0000
DLOG(AGO)	-0.647443	0.164715	-3.930684	0.0007
DLOG(AGO(-1))	0.433848	0.175555	2.471298	0.0213
DLOG(PMS)	-0.225641	0.039475	-5.716102	0.0000
DLOG(SEC)	-0.456023	0.116062	-3.929142	0.0007
DLOG(SEC(-1))	0.262777	0.102177	2.571775	0.0171
DLOG(HPC)	-0.052163	0.083128	-0.627505	0.5351
DLOG(NGC)	-3.805781	1.149528	-3.310735	0.0031
DLOG(NGC(-1))	0.319399	0.896751	0.356173	0.7250
DLOG(NGC(-2))	-3.505519	1.204213	-2.911046	0.0079

Adjusted R-squared = 0.761721
F-statistic = 14.70037
Prob(F-statistic) = 0.000000
Durbin-Watson stat 2.134969

Source: *Author's Computation (2025).*

The ARDL short-run error correction model presented above estimates how different forms of energy consumption

affect the unemployment rate (UPR) in Nigeria in the short-run. The error correction term (COINTEQ) has a coefficient of -0.688862 with a p-value of 0.0000, which is statistically significant at the 5% level. This indicates that approximately 69% of the disequilibrium from the previous year's unemployment rate is corrected in the current period, implying a relatively fast speed of adjustment towards the long-run equilibrium. The negative and significant coefficient confirms the validity of the ARDL model and the presence of a long-run relationship. Looking at current automotive gas oil consumption (AGO), it has a negative coefficient of -0.647443 and a p-value of 0.0007. This indicates that automotive gas oil consumption (AGO) has a significant negative effect on unemployment rate in the short-run. Also, current premium motor spirit consumption (PMS) has a coefficient of -0.225641 with a p-value of 0.0000. This indicates that premium motor spirit consumption (PMS) has a significant negative effect on unemployment rate in the short-run. Furthermore, solar energy consumption (SEC) exhibits a different pattern. The current change in solar energy consumption (DSEC) has a negative and significant coefficient of -0.456023 and p = 0.0007. This indicates that solar energy consumption (SEC) has a significant negative effect on unemployment rate in the short-run. More importantly, hydropower energy consumption (HPC) has a coefficient of -0.052163 and a p-value of 0.5351. This indicates that hydropower energy consumption (HPC) appears to have an insignificant negative impact on unemployment rate in the short-run. Additionally, natural gas-to-power consumption (NGC) presents a more complex dynamic. The current effect natural gas-to-power consumption (DNGC) has a large negative coefficient of -3.805781 and a significant p-value of 0.0031. This indicates that natural gas-to-power consumption (NGC) has a significant negative effect on unemployment rate in the short-run. Lastly, the Adjusted R-squared value of 0.761721 implies that approximately 76.2% of the variations in the unemployment rate are explained by the independent variables (automotive gas oil consumption, premium motor spirit consumption, solar energy consumption, hydropower energy consumption, and natural gas-to-power consumption) in the model, indicating a strong explanatory power. The F-statistic of 14.70037 with a p-value of 0.000000 confirms that the overall model is statistically significant. Moreover, the Durbin-Watson statistic of 2.13 is close to 2, suggesting that there is no problem of autocorrelation in the residuals, which supports the model's reliability.

In summary, the short-run ARDL results demonstrate that changes in automotive gas oil consumption, premium motor spirit consumption, solar energy consumption, hydropower energy consumption, and natural gas-to-power consumption significantly influence unemployment in Nigeria. These findings have critical policy implications, suggesting that energy policy reforms should prioritize job-creating energy sectors like automotive gas oil, premium motor spirit and natural gas-to-power, while carefully managing the transition to renewables like solar to avoid unintended short-term labor market disruptions.

Long-Run ARDL Estimation

The results of long-run ARDL estimation:

TABLE 6: Results of Long-run ARDL Estimation

Dependent Variable: LOG(UPR)			
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(AGO)	-0.426082	0.459178	-0.927924	0.3623
LOG(PMS)	-2.334786	0.781569	-2.987307	0.0062
LOG(SEC)	-0.243288	0.118063	-2.060662	0.0499
LOG(HPC)	0.489483	0.325280	1.504806	0.1449
LOG(NGC)	3.033855	0.796526	3.808860	0.0008
C	5.014953	5.386643	0.930998	0.3608

Source: *Author's Computation (2025).*

The ARDL long-run model presented above evaluates the impact of different types of energy consumption on unemployment rate (UPR) in Nigeria. Starting with automotive gas oil consumption (AGO), the coefficient is -0.426082 with a p-value of 0.3623. This negative coefficient implies that increased automotive gas oil consumption could reduce unemployment in the long-run, possibly by supporting transportation, agriculture, and industrial activities. Also, the impact of premium motor spirit consumption (PMS) is both economically and statistically significant. The coefficient is -2.334786 and the p-value is 0.0062, which is significant at the 5% level. This result implies that in the long-run, a one percent increase in premium motor spirit consumption leads to a 2.33% reduction in unemployment. Similarly, solar energy consumption (SEC) shows a coefficient of -0.243288 and a p-value of 0.0499, making it significant at the 5% level. This result suggests that an increase in solar energy consumption leads to a decrease in unemployment in the long-run. In the case of hydropower energy consumption (HPC), the coefficient is 0.489483 while the p-value is 0.1449, which is above the 5% significance threshold. This indicates a positive and statistically insignificant relationship between hydropower usage and unemployment. The positive sign and the insignificance of the coefficient could be interpreted as counterintuitive, implying that increased hydropower use might not necessarily translate to reduced unemployment. Finally, natural gas-to-power consumption (NGC) has a positive and statistically significant relationship with unemployment, with a coefficient of 3.033855 and a p-value of 0.0008. This means that a one percent increase in natural gas-to-power consumption leads to a 3.03% increase in unemployment in the long-run.

Post-Estimation Tests Model Two (UPR Model)

The results of post-estimation tests of model two (UPR model) are presented in Table 7:

TABLE 7: Post-Estimation Tests Results of UPR Model

Test	F-Statistic	Probability	Null Hypothesis	Decision
Normality Test	3.439217	0.179136	H_0: Normally distributed	Retain H_0
Serial Correlation LM Test	1.505377	0.2536	H_0: No serial correlation	Retain H_0
Heteroskedasticity Test	0.763815	0.6849	H_0: Homoscedasticity	Retain H_0
Ramsey RESET test	0.600650	0.4496	H_0: Correctly specified	Retain H_0

Source: *Author's Computation (2025).*

The diagnostic test results presented provide essential insights into the reliability, validity, and robustness of the

ARDL model used in analyzing the relationship between energy consumption and unemployment rate in Nigeria. In summary, the diagnostic tests jointly suggest that the ARDL model is well-behaved and statistically sound. The residuals are normally distributed, there is no evidence of serial correlation or heteroskedasticity, and the model is correctly specified. These results validate the robustness of the estimated coefficients and the overall reliability of the regression outputs. Consequently, policymakers and researchers can place greater confidence in the empirical findings derived from this model, knowing that the assumptions underlying classical regression analysis have not been violated.
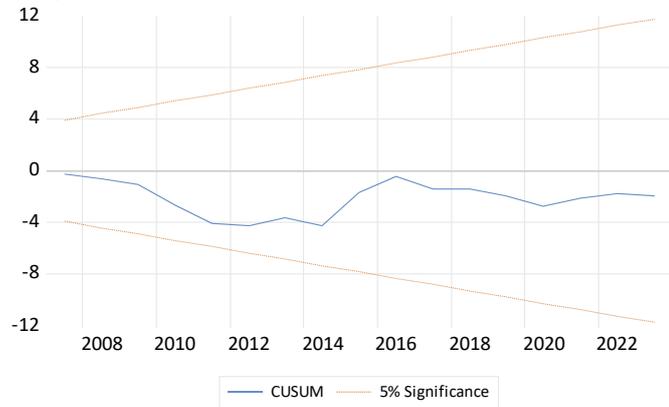

Figure 1: Stability CUSUM Test

The CUSUM (Cumulative Sum) stability test plots a blue line representing the cumulative sum of recursive residuals against time and includes two dotted red lines that represent the 5% significance boundaries (critical limits). In this case, the blue CUSUM trend line lies entirely within the two dotted red lines throughout the sample period. This indicates that the model is structurally stable, meaning that the estimated parameters (coefficients) of the model do not exhibit significant changes over time.

V. DISCUSSION OF FINDINGS

In the unemployment model, automotive gas oil consumption showed a negative and statistically significant effect on unemployment in the short run but has a negative and non-significant effect on unemployment rate in the long-run. This implies that while automotive gas oil consumption may have some employment benefits, such effects are stable or substantial enough to be deemed consistent in the short-run. This finding is supported by the empirical results of Okedere, Fakinle and Sonibare (2018) who argued that automotive gas oil directly contributes to both unemployment and poverty reduction in Nigeria. Also, the finding of the study showed that premium motor spirit consumption has a negative and significant effect on unemployment rate in the short-run and long-run. In other words, premium motor spirit consumption was found to reduce unemployment in the short and long-run, showing strong statistical significance in both poverty and unemployment models. This finding aligns with Wang, Wang and Li (2022) who concluded that affordable and widespread premium motor spirit consumption spurs informal sector growth and economic activities, thereby alleviating poverty and

joblessness. The findings of the study revealed that solar energy consumption has a negative and significant effect on unemployment rate in the short-run and long-run. Specifically, the short-run result in the unemployment model revealed that solar energy has a significant negative impact on poverty and unemployment in the short-run. This finding conforms to the finding of Okeoma, Nwachukwu, Ezeonye and Osatemple (2023) who found that renewable energy such as solar energy adoption improves household energy access and translates into formal job creation due to the capital-intensive and low-labor nature of solar installations. Moreover, the findings of this study showed that hydropower energy consumption has a negative and non-significant effect on unemployment rate in the short-run and long-run. Specifically, hydropower energy had statistically insignificant negative effects on unemployment in the short-run model, indicating that hydropower energy consumption marginally reduces unemployment rate in Nigeria in the short-term while it also marginally reduces unemployment rate in Nigeria in the long-term. This finding conforms to the finding of Ekeocha, Penzin and Ogbuabor (2020) who ascertained that despite hydropower's potential to drive large-scale industrial growth and job creation, its contribution in Nigeria remains muted due to technical and institutional challenges. Lastly, the finding of this study indicated that natural gas-to-power consumption has a negative and significant effect on unemployment rate in the short-run but has a positive and significant effect on unemployment rate in the long-run. This result aligns with the findings of Ishioro (2020) who reported that natural gas expansion contributes to macroeconomic growth, reduces energy poverty, and supports employment in emerging economies.

VI. CONCLUDING REMARKS

The analysis of the effect of energy consumption on economic development in Nigeria between 1990 and 2023 reveals a complex but insightful relationship between various energy sources and unemployment. The results of the study showed that automotive gas oil consumption, premium motor spirit consumption, solar energy consumption, hydropower energy and natural gas-to-power consumption have joint significant effect on unemployment rate in Nigeria in both short-run and long-run. Based on the findings, the study therefore concluded that energy consumption plays a vital role in reducing unemployment in Nigeria. Based on the results and findings of this study, the following recommendations are proffered: The government through the energy sector should gradually reduce dependence on automotive gas oil by promoting cleaner alternatives, while simultaneously improving efficiency in sectors that still rely heavily on diesel, such as transportation and small-scale manufacturing, through incentives for energy-efficient technologies. Policymakers should ensure the availability and affordability of premium motor spirit through improved refining capacity and elimination of supply bottlenecks. However, reforms should balance this with a gradual transition to more sustainable fuels to avoid long-term environmental and fiscal costs. The energy should scale-up investment in solar infrastructure and create employment-linked solar energy programs, especially in rural

and underserved areas. Programs such as solar-based vocational training and community electrification can enhance its job creation potential.

REFERENCES

[1]. Adamu, S., & Maijama'a, D. (2021). Investigation of the nexus among electric energy consumption, unemployment, inflation, transport in Nigeria. *Journal of Economics, Management & Social Science, 7*(1), 61-79.

[2]. Chama, E. M., Yahya, S. & Hindou, B. (2021). The role of renewable energy sector in reducing unemployment: The Moroccan case. *E3S Web of Conferences 234*, 01-10.

[3]. Ekeocha, P. C., Penzin, D. J., & Ogbuabor, J. E. (2020). Energy consumption and economic growth in Nigeria: A test of alternative specifications. *International Journal of Energy Economics and Policy, 10*(3), 369-379.

[4]. Hlalefang, K., Nwabisa, K., Clement, M., Izunna, A., & Siyasanga, D. (2020). renewable energy consumption and unemployment in South Africa. *International Journal of Energy Economics and Policy, 10*(2), 170-178.

[5]. Hosier, R. & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis. *Resources and Energy*, 9: 347–361.

[6]. Ikpe, V., & Oyedeji, E. (2023). Energy consumption & economic growth in Nigeria (1971 - 2021): A multifaceted analysis using descriptive statistics, charts, logistic regression, and neural networks. *Asian Journal of Probability and Statistics, 25*(4), 56-76.

[7]. Ishioro, B. O. (2020). Energy consumption and economic growth in Nigeria: An Augmented Neoclassical Growth Model perspective. *Journal of Environmental Management and Tourism, 10*(7), 1637-1657.

[8]. Kaygusuz, K. (2009). Energy services and energy poverty for sustainable rural development. *Renewable and Sustainable Energy Reviews*, *15:* 936–947.

[9]. Kaygusuz, K. (2011). Energy and environment issues relating to greenhouse gas emissions for sustainable development in Turkey. *Renewable and Sustainable Energy Reviews*, 253-270.

[10]. Leach, G. (1992). The energy transition. *Energy Policy*, *20*(2), 116-123.

[11]. Manufacturers Association of Nigeria (MAN). (2023). *Sectoral impact of energy costs on manufacturing*.

[12]. Mawunyo, A., Philip, K. A., & Andrea, V. (2022). Towards sustainability: Does energy efficiency reduce unemployment in African societies? *Sustainable Cities and Society 79*: 103-113.

[13]. Mihai, F., Alecu, A., & Ionescu, G. H. (2024). A study regarding the relationship between carbon emissions, energy consumption, and economic development in the context of the energy growth nexus. *Sustainability, 16*(2), 789.

[14]. Mombekova, S., Aliyev, K., & Satrovic, E. (2024). The relationship between energy consumption, population and economic growth in developing countries. *Energy Strategy Reviews, 51*, 101320.

[15]. Muktar, I. & Abdullahi, Z. (2021). Impact of electricity supply on unemployment in Nigeria (1986-2020). *International Journal of Intellectual Discourse (IJID), 4*(4), 115-126.

[16]. Nkoro, E., Ikue-Johnb, N. & Joshua, G. I. (2019). Energy consumption and economic growth in Nigeria: A revisit of the energy-growth debate. *Review of Social Sciences*, 1(2), 1-9.

[17]. Ogungbenle, S. (2021). Energy consumption and manufacturing economic growth in Nigeria. Journal of Economics and Allied Research, 6(4), 1-12.

[18]. Okedere, O. B., Fakinle, B. S., & Sonibare, J. A. (2018). Consumption of Premium Motor Spirit and Automotive Gas Oil in Nigeria: Implication for a Greenhouse Gas Emission. *Ife Journal of Science and Technology*, *1*(2), 276-295.

[19]. Okeoma, T. F., Nwachukwu, E. I., Ezeonye, C. S., & Osatemple, M. (2023). A study on the impact of energy consumption on the Nigerian economy. *Journal of Energy Technology and Environment, 5*(1), 40 – 52.

[20]. Onyekachi, O. G., Osabohien, R., & Olubiyi, E. A. (2025). Energy consumption and economic growth in Nigeria. *Energy Policy, 176*, 113487.

[21]. Sovacool, B. J. (2012). The political economy of energy poverty: A review of key challenges. *Energy for Sustainable Development*, *16*(3), 272–282.

[22]. Umeh A. C., Ochuba C. D. & Ugwo, C. E. (2019). Impact of energy consumption on economic growth in Nigeria: An approach of time series econometric model. *International Journal of Academic Research Economics and Management Sciences, 8*(2), 65-77.

[23]. Veli Y., Emel, İ., Sinem, Y., & Gökçe C. (2020). the relationship between unemployment rates and renewable energy consumption: Evidence from fourier ADL cointegration test. *The Journal of Operations Research, Statistics, Econometrics and Management Information Systems, 8*(1), 18-28.

[24]. Wajid, A., Solomon, P. N., Ibrahim, A. A., & Bezon, K. (2022). Energy consumption and economic growth linkage: Global evidence from symmetric and asymmetric simulations. Quaestiones Geographicae, *41*(2), 67-82.

[25]. Wang, Q., Wang, X., & Li, R. (2022). Does urbanization redefine the environmental Kuznets curve? An empirical analysis of 134 countries. *Sustainable Cities and Society, 76*, 103-382.