Energy Consumption and Life Expectancy in Nigeria

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Abstract
This study determined the effect of energy consumption on life expectancy in Nigeria from 1990 to 2023. Energy consumption was proxied by electricity consumption, natural gas consumption, solar energy consumption, and hydropower energy. The study made use of time series data sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin, World Development Indicators of the World Bank, National Bureau of Statistics (NBS), Africa Energy Portal (AEP), and International Energy Agency (IEA). The main data analysis techniques adopted include Augmented Dickey-Fuller (ADF) unit root test, correlation matrix, bounds cointegration test, and the Autoregressive Distributive Lag (ARDL) approach. The major findings showed that electricity consumption, natural gas consumption, and solar energy consumption have positive and significant effects on life expectancy in Nigeria, while hydropower energy has a positive and non-significant effect on life expectancy. Premised on the findings, the study concluded that energy consumption plays a significant vital role in enhancing life expectancy in Nigeria. It was recommended among others that the Nigerian government should invest heavily in expanding access to modern energy services, particularly renewable energy sources, to support healthcare delivery, improve environmental quality, and ultimately extend the life expectancy of Nigerians.

Keywords: *Energy Consumption, Life Expectancy, Electricity Consumption, Natural Gas Consumption, Solar Energy Consumption, Hydropower Energy, Nigeria*

1.0 Introduction

Life expectancy is widely recognized as one of the most comprehensive indicators of a population's health and overall well-being. It reflects the cumulative effects of healthcare quality, environmental conditions, nutritional standards, income levels, and access to social services. Among the factors that influence life expectancy, access to reliable and modern energy services has increasingly been identified as a critical determinant, particularly in developing countries (Global Burden of Disease Study, 2019). Energy powers healthcare facilities, supports refrigeration of vaccines and medicines, enables clean cooking—reducing indoor air pollution—and facilitates lighting and heating, all of which have direct and measurable effects on population health and longevity. In Nigeria, life expectancy has historically been among the lowest globally, averaging around 49 to 54 years over the study period, well below the global average of over 72 years (World Bank, 2024). This is partly attributable to inadequate healthcare infrastructure, high disease burden, poor sanitation, and limited access to clean and modern energy services. More than two-thirds of Nigerians lack reliable access to electricity, and a large proportion of the population—especially in rural areas—continues to rely on traditional biomass fuels such as firewood and charcoal for cooking and heating. The combustion of these fuels releases toxic

pollutants that cause respiratory diseases, contributing significantly to premature death and reduced life expectancy (International Energy Agency, 2015). Improving access to cleaner energy sources—including electricity, natural gas, solar energy, and hydropower—is therefore not merely an economic imperative but a public health and human development priority.

The empirical literature on the energy-health nexus has grown considerably in recent years. Wang, Wang and Li (2022) found that fossil energy consumption, particularly natural gas, follows an inverted U-shaped relationship with the Human Development Index—which includes life expectancy as a component—suggesting that at moderate levels, energy consumption enhances health outcomes. Olufunmilayo, Henry, Hassan and Oluwatoyin (2020) found that a one percent increase in government health investments enhances GDP per capita by 0.008%, while energy consumption directly influences per capita GDP—both of which have downstream effects on health outcomes including life expectancy. These studies underscore the multifaceted channels through which energy consumption affects life expectancy and motivate the need for a focused empirical investigation in the Nigerian context. Despite the growing literature on energy consumption and economic growth, few studies have specifically examined the disaggregated effect of electricity, natural gas, solar energy, and hydropower on life expectancy in Nigeria. Existing studies largely use aggregate energy consumption variables and focus primarily on GDP or income measures, overlooking health outcomes such as life expectancy. This study bridges that gap by providing a comprehensive empirical analysis of how each energy source specifically affects life expectancy in Nigeria from 1990 to 2023. Specifically, the study sought to: determine the effect of electricity consumption on life expectancy in Nigeria; ascertain the effect of natural gas consumption on life expectancy in Nigeria; examine the effect of solar energy consumption on life expectancy in Nigeria; and - investigate the effect of hydropower energy on life expectancy in Nigeria.

2.0 Literature Review

Theoretical Literature Review

The following theories provide the theoretical foundation of this study:

a. Energy Transition Theory

The Energy Transition Theory, associated with Hosier and Dowd (1987) and Leach (1992), provides a foundational framework for understanding how shifts in the type of energy consumed affect development outcomes, including health and life expectancy. The theory posits that as income levels and living standards improve, individuals and societies transition from traditional, inferior energy sources—such as biomass and charcoal—to modern, cleaner, and more efficient energy forms such as electricity, natural gas, and solar energy. This transition has profound health implications: the shift away from biomass combustion reduces indoor air pollution, which is a major cause of respiratory diseases and premature death, particularly among women and children in developing countries. In the Nigerian context, the Energy Transition Theory is particularly relevant because a substantial proportion of households—especially in rural communities—still rely on traditional biomass fuels. The health consequences of this reliance are severe: exposure to particulate matter and carbon monoxide from burning biomass is linked to pneumonia, chronic obstructive pulmonary disease, lung cancer, and cardiovascular diseases, all of which reduce life expectancy. As Nigeria transitions toward more modern energy sources, including electricity generated from natural gas, solar panels, and hydroelectric facilities, the theory predicts that life expectancy will improve through reduced pollution exposure, better health facility operations (powered by reliable electricity), and improved general living conditions. The theory thus provides

both theoretical justification for expecting a positive relationship between energy consumption and life expectancy and a policy rationale for accelerating Nigeria's energy transition.

b. Biophysical Theory of Economic Growth

The Biophysical Theory, developed by Kardashev (1964), posits that energy is the fundamental driver of all economic and social activity, without which no meaningful development—including improvements in health and human welfare—is possible. The theory argues that energy is not merely a commodity but a prerequisite for the functioning of modern economies and societies. In the context of life expectancy, the Biophysical Theory implies that energy access is a necessary condition for maintaining and operating healthcare infrastructure, including hospitals, clinics, cold chain systems for vaccines, diagnostic equipment, and surgical facilities. Without reliable energy, healthcare systems cannot function effectively, and health outcomes deteriorate.

Applied to the Nigerian context, the Biophysical Theory suggests that the chronic energy deficits experienced in Nigeria, marked by inadequate electricity supply, limited natural gas utilization, underdeveloped solar energy capacity, and underutilized hydropower potential, are partly responsible for the country's low life expectancy. Hospitals and health clinics frequently operate without reliable power, compromising the quality and reliability of medical services. Vaccines spoil due to lack of refrigeration. Emergency surgeries cannot be performed during power outages. These energy-related failures in healthcare delivery directly contribute to preventable deaths and shortened life expectancy. The Biophysical Theory therefore supports the expectation that increases in each form of energy consumption will positively influence life expectancy by enabling more functional and responsive healthcare systems in Nigeria.

Empirical Literature Review

Mmbaga, Kulindwa and Kazungu (2023) found that energy consumption has a negative impact on economic growth when energy prices are unstable, indirectly affecting health expenditures and life expectancy outcomes. Haliru (2023) found a positive and statistically significant relationship between electricity consumption and green growth in Nigeria, with implications for environmental quality and health outcomes. Iyabo and Segun (2022) found that a one percent increase in energy consumption engenders economic growth by 1.3 percent in Sub-Saharan Africa, providing resources for health investments that improve life expectancy.

Wang, Wang and Li (2022) found that natural gas consumption follows an inverted U-shaped relationship with the Human Development Index—of which life expectancy is a core component—in BRICS countries. This finding suggests that at moderate levels of consumption, natural gas enhances health and development outcomes. Somoye, Ozdeser and Seraj (2022) found a positive relationship between renewable energy consumption—including hydro energy—and economic development, which encompasses health indicators such as life expectancy. Lawrence, Alexander, Johnson, Uchechukwu, Felix, Benjamin and Gideon (2021) found that electricity consumption is a positive predictor of economic growth in Nigeria, which in turn generates income for health investments and welfare improvements associated with longer life expectancy. Abner, Izuchukwu, Eneoli and Udo (2021) confirmed that energy consumption significantly drives economic value addition in Nigeria, with positive downstream effects on social welfare indicators including health and longevity. Olufunmilayo, Henry, Hassan and Oluwatoyin (2020) examined the joint effect of carbon emission and health investment on economic development in Nigeria from 1980 to 2017. The study found that a one percent increase in carbon dioxide (CO2) reduces GDP per capita by 0.1%, while increased energy consumption directly influences per capita GDP. The study also

found unidirectional causality from health outcomes—proxied by life expectancy—to CO2, confirming that energy consumption and health outcomes are closely interrelated in Nigeria. The findings suggest that cleaner energy is associated with better health outcomes, reinforcing the case for energy diversification. Ekone and Amaghionyeodiwe (2020) found that renewable energy consumption positively contributes to economic development in Nigeria, with implications for improved living conditions and health outcomes. Qudrat-Ullah and Chinedu (2021) reported that renewable energy consumption positively influences economic growth across Africa, which enables governments to invest more in health systems and thereby improve life expectancy.
Maji, Chindo, and Abdul-Rahim (2019) further confirmed that renewable energy consumption has a significant positive effect on economic development in West Africa, with broader human development implications.

3.0 Methodology

The research design adopted in this study is the ex-post facto research design. This research design is appropriate because the study is non-experimental and seeks to investigate causal relationships between energy consumption (independent variables) and life expectancy in Nigeria (dependent variable), using already existing secondary data which cannot be controlled or manipulated. The data were sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin, World Development Indicators of the World Bank, National Bureau of Statistics (NBS), Africa Energy Portal (AEP), and International Energy Agency (IEA), covering the period 1990 to 2023 (34 years).

Model Specification

Theoretically, the analytical framework of this study is anchored on the Energy Transition Theory and the Biophysical Theory. The model for this study was built on the work of Ishioro (2020), with modifications to accommodate the variables of this study. The functional form of the model is specified as follows:

$$LEX = f(ELC, NGC, SEC, HYP) \quad (1)$$

The model above is mathematically specified as follows:

$$LEX_t = \beta_0 + \beta_1 ELC_t + \beta_2 NGC_t + \beta_3 SEC_t + \beta_4 HYP_t + \mu_t \quad (2)$$

The model above is specified in log linear form as follows:

$$LEX_t = \beta_0 + \beta_1 InELC_t + \beta_2 InNGC_t + \beta_3 InSEC_t + \beta_4 InHYP_t + \mu_t \quad (3)$$

The long-run ARDL specification of the model is expressed as:

$$\Delta lnLEXt = \beta_0 + \beta_{1i}\Delta lnLEX_{t-1} + \beta_{2i}\Delta lnELC_{t-1} + \beta_{3i}\Delta lnNGC_{t-1} + \beta_{4i}\Delta lnSEC_{t-1} + \beta_{5i}\Delta lnHYP_{t-1} + \Sigma\delta 1i\Delta ln(LEX_{t-1}) + \Sigma\delta_{2i}\Delta ln(ELC_{t-1}) + \Sigma\delta 3i\Delta ln(NGC_{t-1}) + \Sigma\delta_{4i}\Delta ln(SEC_{t-1}) + \Sigma\delta_{5i}\Delta ln(HYP_{t-1}) + \varepsilon 2i \quad (4)$$

The short-run ARDL specification of the model is expressed as:

$$\Delta lnLEXt = \delta_0 + \Sigma\delta_{1i}\Delta ln(LEX_{t-1}) + \Sigma\delta_{2i}\Delta ln(ELC_{t-1}) + \Sigma\delta_{3i}\Delta ln(NGC_{t-1}) + \Sigma\delta_{4i}\Delta ln(SEC_{t-1}) + \Sigma\delta_{5i}\Delta ln(HYP_{t-1}) + \lambda ECM_{t-1} + \varepsilon_{2i} \quad (5)$$

Where: LEX = Life Expectancy; ELC = Electricity Consumption; NGC = Natural Gas Consumption; SEC = Solar Energy Consumption; HYP = Hydropower Energy; β0 = Regression Intercept; β1 – β4 = Parameters; t = Time subscript; μt = Error component.

A Priori Expectation

The *a priori expectation* of this study is specified below:

- ✓ Electricity consumption is expected to contribute positively to life expectancy, that is, $\beta_1 > 0$.
- ✓ Natural gas consumption is expected to contribute positively to life expectancy, that is, $\beta_2 > 0$.
- ✓ Solar energy consumption is expected to contribute positively to life expectancy, that is, $\beta_3 > 0$.
- ✓ Hydropower energy is expected to contribute positively to life expectancy, that is, $\beta_4 > 0$.

Data Analysis Techniques

The data analysis technique adopted in this study is Autoregressive Distributed Lag (ARDL) technique. The ARDL approach, developed by Pesaran, Shin and Smith (2001), is appropriate because the study variables exhibit a mixed order of integration [I(0) and I(1)], which precludes the use of conventional cointegration techniques. The ARDL approach allows for simultaneous estimation of long-run equilibrium and short-run adjustments, is robust in small sample sizes, and accommodates different lag lengths for each variable. Unit root tests using the Augmented Dickey-Fuller (ADF) technique were conducted to determine the stationarity properties of all variables. Diagnostic tests including the Jarque-Bera normality test, Breusch-Godfrey serial correlation test, Breusch-Pagan-Godfrey heteroscedasticity test, Ramsey RESET test, and CUSUM stability test were conducted to validate the reliability of the model.

4.0 Results and Discussion

Descriptive Analysis

Descriptive statistics of this study considered the mean, median, maximum value, minimum value and standard deviation of the dataset. Whereas, the mean reports the average value for each data series, the median explains the middle or centre point for each data series in the model. The maximum value presents the highest value for each data set, while minimum value shows the least value for each data set. Standard deviation was used to measure the dispersion or spread in each data series. It shows how volatile or stable each variable is. However, the descriptive statistics for the study variables are summarized in Table 1:

Table 1: Descriptive Statistics

	LEX	ELC	NGP	SEC	HYP
Mean	49.41771	118.1766	103993.8	91.32353	6338.824
Median	49.88150	122.2813	116814.0	86.50000	5995.000
Maximum	53.91800	178.5351	190075.0	147.0000	8349.000
Minimum	45.48700	74.49060	30326.00	76.00000	4387.000
Std. Dev.	2.861535	29.25249	60702.63	14.48661	1066.157
Skewness	-0.101900	0.076978	-0.015277	2.340719	0.452437
Kurtosis	1.524285	1.938516	1.284973	8.528872	2.290589
Jarque-Bera	3.143965	1.629805	4.168191	74.35273	1.872922
Probability	0.207633	0.442682	0.124420	0.000000	0.392013
Sum	1680.202	4018.003	3535788.	3105.000	215520.0
Sum Sq. Dev.	270.2166	28238.37	1.22E+11	6925.441	37510773
Observations	34	**34**	**34**	**34**	**34**

Source: *Authors' Computation, 2026.*

The descriptive statistics in Table 1 present the distributional properties of the study variables over the 1990–2023 period. Life expectancy (LEX) recorded a mean of 49.42 years, with a maximum of 53.92 years and minimum of 45.49 years, reflecting the modest but steady improvements in Nigerian health outcomes over the study period. The standard deviation of 2.86 indicates relatively low volatility. The Jarque-Bera probability of 0.208 confirms that life expectancy is normally distributed. Electricity consumption (ELC) had a mean of 118.18, with a standard deviation of 29.25 and a Jarque-Bera probability of 0.443, confirming normality. Natural gas consumption (NGC) had a mean of 103,993.80, with high variability (standard deviation of 60,702.63) and a Jarque-Bera probability of 0.124, confirming normality. Solar energy consumption (SEC) is highly positively skewed (2.341) and leptokurtic (8.529), with a Jarque-Bera probability of 0.000, indicating non-normality due to the concentration of large solar consumption values in recent years. Hydropower energy (HYP) had a mean of 6,338.82 and is normally distributed (probability of 0.392). These distributional properties validate the use of ARDL, which is robust to non-normality in individual variables.

Unit Root Test

Table 2: Augmented Dickey-Fuller (ADF) Unit Root Test Results

Augmented Dickey-Fuller (ADF)						
Variables	**Level**	**5% Critical Value**	**1st Difference**	**5% Critical Value**	**Order of Integration**	**Stationary @**
LOG(LEX)	-0.641544	-2.957110	-2.991083	-2.957110	I(1)	1st Difference
LOG(ELC)	-0.905291	-2.954021	-6.621155	-2.957110	I(1)	1st Difference
LOG(NGP)	-1.331578	-2.954021	-6.373521	-2.957110	I(1)	1st Difference
LOG(SEC)	-0.394927	-2.957110	-9.066614	-2.957110	I(1)	1st Difference
LOG(HYP)	-2.959383	-2.954021	-	-	I(0)	Level

Source: *Authors' Computation, 2026.*

The ADF unit root test results in Table 2 show that hydropower energy (HYP) is stationary at level [I(0)], while life expectancy (LEX), electricity consumption (ELC), natural gas consumption (NGC), and solar energy consumption (SEC) are stationary only after first differencing [I(1)]. This mixed order of integration validates the adoption of the ARDL bounds testing approach for estimating the long-run and short-run relationship between energy consumption and life expectancy in Nigeria.

Multicollinearity Test

In econometrics, the correlation matrix is a popular tool for examining the relationships between variables. It gives a correlation coefficient matrix that quantifies the degree of linear relationship between two variables. For the purpose of this study, correlation matrix was used to detect multicollinearity. Detecting multicollinearity using a correlation matrix involves examining the correlation coefficients between pairs of independent variables. The result of the correlation matrix is presented in Table 3

Table 3: Correlation Matrix

	LOG(LEX)	LOG(ELC)	LOG(NGP)	LOG(SEC)	LOG(HYP)
LOG(LEX)	1				
LOG(ELC)	0.3011	1			
LOG(NGP)	0.200349	0.141785	1		
LOG(SEC)	0.489899	0.411302	0.412742	1	
LOG(HYP)	0.390829	0.398903	0.495306	0.476514	1

Source: *Authors' Computation, 2026.*

The correlation matrix in Table 3 shows that all pairwise correlations among the independent variables are below the 0.6 threshold, confirming the absence of serious multicollinearity. The highest inter-variable correlation among the regressors is between hydropower energy and natural gas consumption (0.495), which is well below the critical level. The positive correlations between life expectancy and each energy variable—ranging from 0.200 (natural gas) to 0.490 (solar energy)—suggest generally positive bivariate associations, though the significance of these relationships is examined through ARDL estimation. The absence of multicollinearity gives confidence in the reliability of the estimated coefficients.

ARDL Bounds Cointegration Test

Since the variables of this study have mixed stationarity, that is, integrated of order zero [I(0)] and integrated of order one [I(1)], we therefore proceed to establish or ascertain the existence or nonexistence of long-run cointegrating relationship among the variables in the equation using cointegration test. This test was carried out using Autoregressive Distributed Lag (ARDL) bound approach:

Table 4: ARDL Bounds Cointegration Test Results

Significant Level	**I(0) Bound**	**I(1) Bound**	**Hypothesis**	**F-Statistics**
10%	2.08	3	**H0:** There is long run relationship	5.492258
5%	2.39	3.38		
2.5%	2.7	3.73		
1%	3.06	4.15		
F_{LEX}(LEX/ELC, NGC, SEC, HYP)				K = 4

Source: *Authors' Computation, 2026.*

Table 4 presents the ARDL bounds cointegration test result for the LEX model. The computed F-statistic of 5.492258 comfortably exceeds the upper bound critical values of 3.00, 3.38, 3.73, and 4.15 at the 10%, 5%, 2.5%, and 1% levels of significance respectively. This strongly confirms the rejection of the null hypothesis of no cointegration. Hence, there is a robust long-run cointegrating relationship among life expectancy, electricity consumption, natural gas consumption, solar energy consumption, and hydropower energy in Nigeria.

Estimation of ARDL Long-Run and Short-Run Dynamics

Table 5: ARDL Long-Run and Short-Run Estimation Results

Dependent Variable = LOG(LEX)
Selected Model: ARDL(3, 3, 3, 2, 2)

ARDL Long-Run Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(ELC)	0.153427	0.044589	3.440933	0.0021
LOG(NGP)	0.204042	0.047054	4.336336	0.0002
LOG(SEC)	1.030471	0.032231	31.97165	0.0000
LOG(HYP)	8.923944	8.822529	1.011495	0.3382
C	45.71116	43.78502	1.043991	0.3237

EC = LOG(LEX) - (0.1534*LOG(ELC) + 0.2040*LOG(NGP) + 1.0305*LOG(SEC) + 8.9239*LOG(HYP) + 45.7112*)*

ARDL Short-Run Results

DLOG(LEX(-1))	-1.316214	0.313755	-4.195030	0.0023
DLOG(LEX(-2))	-0.726935	0.271277	-2.679679	0.0252
DLOG(ELC)	0.204710	0.043593	4.695925	0.0011
DLOG(ELC(-1))	0.343892	0.066335	5.184133	0.0006
DLOG(ELC(-2))	0.139442	0.049336	2.826352	0.0198
DLOG(NGP)	0.090822	0.024306	3.736548	0.0047
DLOG(NGP(-1))	-0.057890	0.014776	-3.917889	0.0035
DLOG(NGP(-2))	-0.054449	0.014275	-3.814267	0.0041
DLOG(SEC)	0.369776	0.062067	5.957681	0.0002
DLOG(SEC(-1))	-0.181807	0.059759	-3.042351	0.0140
DLOG(HYP)	0.062095	0.032710	1.898328	0.0901
DLOG(HYP(-1))	0.022584	0.037665	0.599599	0.5544
CointEq(-1)*	-0.051197	0.008021	-6.383025	0.0001

Adjusted R^2 = 0.781294
Durbin-Watson stat = 2.375091

Source: *Authors' Computation, 2026.*

Electricity Consumption (ELC) and Life Expectancy (LEX)

The long-run estimates of the ARDL model revealed that electricity consumption has a positive and significant effect on life expectancy in Nigeria. The positive coefficient value (0.153427) and p-value (0.0021), which is less than 0.05, imply that an increase in electricity consumption by a unit leads to a 0.153427 increase in life expectancy in the long run. Also, the short-run estimates revealed that electricity consumption has a positive and significant effect on life expectancy in Nigeria at the initial level and at lags one and two. The positive coefficient value (0.204710) and p-value (0.0011), which is less than 0.05, imply that an increase in electricity consumption by a unit leads to a 0.204710 increase in life expectancy in the short run. The sustained positive effects across lags confirm that improved electricity access has persistent and compounding beneficial effects on health outcomes in Nigeria.

Natural Gas Consumption (NGC) and Life Expectancy (LEX)

The long-run estimates revealed that natural gas consumption has a positive and significant long-run relationship with life expectancy in Nigeria. The positive coefficient value (0.204042) and p-value (0.0002), which is less than 0.05, imply that an increase in natural gas consumption by a unit leads to a 0.204042 increase in life expectancy in the long run. In the short run, natural gas consumption has a significant positive effect at the initial level (0.090822, p = 0.0047). The negative coefficients at lags one and two, while statistically significant, reflect a dynamic adjustment process in which the initial positive health impact is partially moderated in subsequent periods. The net long-run effect remains strongly positive, confirming the beneficial role of natural gas consumption in improving life expectancy in Nigeria.

Solar Energy Consumption (SEC) and Life Expectancy (LEX)

The long-run estimates revealed that solar energy consumption has a highly significant positive long-run relationship with life expectancy in Nigeria. The positive coefficient value (1.030471) and p-value (0.0000) indicate that an increase in solar energy consumption by one unit leads to a 1.030471 increase in life expectancy in the long run—the largest effect among all energy variables. This underscores the transformative potential of solar energy in improving health outcomes. In the short run, solar energy consumption has a significant positive effect at the initial level (0.369776, p = 0.0002), though the lagged effect at one period is negative and significant (-0.181807, p = 0.0140), reflecting partial dynamic adjustment. The strong long-run positive relationship highlights the critical role of solar energy in powering health facilities, reducing indoor air pollution from biomass combustion, and enabling better living conditions that improve life expectancy.

Hydropower Energy (HYP) and Life Expectancy (LEX)

The long-run estimates revealed that hydropower energy has a positive but non-significant long-run relationship with life expectancy in Nigeria. The positive coefficient value (8.923944) and p-value (0.3382), which is greater than 0.05, indicate that while an increase in hydropower energy is associated with improvements in life expectancy, the effect is not statistically reliable in the long run. Similarly, the short-run estimates revealed that hydropower energy has a positive but non-significant short-run relationship with life expectancy (coefficient: 0.062095, p-value: 0.0901). The non-significance likely reflects the underdevelopment of Nigeria's hydropower sector relative to its potential, the inconsistency of hydroelectric supply, and the limited reach of hydropower-generated electricity to communities most in need of health-supporting energy services.

Interpretation of CointEq(-1) Result

The estimated error correction coefficient of -0.051197 (with p-value of 0.0001) is highly significant and has the correct negative sign. This implies that approximately 5.12% of disequilibria from the previous year's shock in the relationship between energy consumption and life expectancy converge back to long-run equilibrium in the current year. While the adjustment speed is slow, it reflects the biological and institutional reality that improvements in population health outcomes such as life expectancy occur gradually over long periods, as sustained energy access cumulatively affects healthcare quality, nutrition, and living conditions.

Interpretation of Adjusted R-Squared Value

The Adjusted R-squared value of 0.781294 indicates that approximately 78 percent of the variation in life expectancy is explained by the systematic changes in electricity consumption, natural gas consumption, solar energy consumption, and hydropower energy. The remaining 22% is accounted for by other determinants of life expectancy outside the model, such as government health expenditure, income levels, and access to clean water. The high explanatory power confirms the model's strong fitness and robustness.

Interpretation of Durbin-Watson Statistic

The Durbin-Watson statistic of 2.375091, which is greater than 2, indicates the absence of serial autocorrelation in the model residuals, confirming the dynamic adequacy of the model specification.

Post-Estimation Tests

The results of the post-estimation tests are presented in Table 6:

Table 6: Post-Estimation Test Results

Test	Null Hypothesis (H_0)	Test Type	F-stat.	Prob.
Normality Test	Normal distribution exists	Jarque-Bera Test	2.282120	0.31948
Serial Correlation Test	Serial correlation does not exist	Breusch-Godfrey LM Test	1.315930	0.3272
Heteroscedasticity Test	Homoscedasticity exists	Breusch-Pagan-Godfrey	0.497514	0.9099
Functional form Test	Model is stable	Ramsey RESET	0.642549	0.4948

Source: *Authors' Computation, 2026.*

The Jarque-Bera normality test probability value of 0.31948 exceeds 0.05, confirming that the model residuals are normally distributed. The Breusch-Godfrey Serial Correlation LM test probability value of 0.3272 exceeds 0.05, confirming the absence of serial correlation. The Breusch-Pagan-Godfrey heteroscedasticity test probability value of 0.9099 exceeds 0.05, confirming homoscedasticity—that the variance of residuals is constant and that relevant variables were not omitted from the model. The Ramsey RESET test probability value of 0.4948 exceeds 0.05, confirming that the model is correctly specified and free from functional form misspecification. Collectively, these post-estimation diagnostics validate the reliability and robustness of the empirical findings.

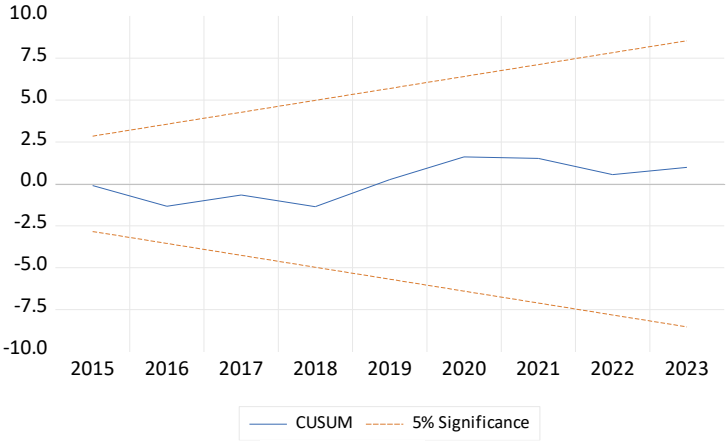

Figure 1: Stability Cusum Test

The cumulative sum (CUSUM) stability test indicates that the CUSUM line remained within the 5 percent critical bounds throughout the study period, confirming the stability of the long-run coefficients. This implies that the estimated relationship between energy consumption and life expectancy in Nigeria is structurally stable and has not been subject to parameter instability or structural breaks that would invalidate the empirical findings.

Discussion of Findings

This study has empirically analyzed the time series data to determine the effect of energy consumption on life expectancy in Nigeria from 1990 to 2023, using the ARDL estimation technique. The results are discussed below.

First, electricity consumption has a positive and significant effect on life expectancy in Nigeria in both the short run and long run. This finding implies that electricity consumption has made a positive and meaningful contribution to improving life expectancy in Nigeria. This finding is consistent with the empirical results of Yahaya and Bakare (2018), who found that electricity consumption has a significant positive impact on economic growth in Nigeria, which generates the income and fiscal capacity needed to invest in health systems. The finding also aligns with Haliru (2023), who found a positive relationship between electricity consumption and green growth, with implications for environmental quality and health outcomes. Moreover, Cordelia and Uwuigbe (2021) confirmed that electricity consumption has a positive effect on economic performance in Nigeria, with downstream benefits for health and longevity. Reliable electricity powers health facilities, supports refrigeration for vaccines, enables diagnostic equipment, and reduces reliance on polluting biomass fuels—all of which directly improve health outcomes and life expectancy.

Second, natural gas consumption has a positive and significant effect on life expectancy in Nigeria in both the short run and long run. This implies that natural gas consumption has contributed meaningfully to improving health outcomes in Nigeria. This finding conforms to the results of Akokaike, Adenikinju, Ekpe, Eleri, Ajulo and Gini (2021), who found that natural gas consumption is positively related to economic development in African countries including Nigeria. The finding is also consistent with Wang, Wang and Li (2022), who found that natural gas consumption positively influences the Human Development Index in BRICS countries at moderate levels. Natural gas, as a cleaner alternative to biomass fuels, reduces indoor air pollution and associated respiratory diseases, while also powering industrial and medical processes that support better health outcomes. Third, solar energy consumption has a positive and significant effect on life expectancy in Nigeria in both the short run and long run, recording the largest coefficient

among all energy variables (1.030471 in the long run). This finding is consistent with Ekone and Amaghionyeodiwe (2020), who found that renewable energy consumption, including solar energy, positively contributes to economic development in Nigeria. It also aligns with Qudrat-Ullah and Chinedu (2021), who found that renewable energy consumption significantly drives economic growth in Africa, generating resources for health investments. Solar energy directly improves life expectancy by powering rural health clinics that lack grid electricity, enabling reliable refrigeration for vaccines, supporting clean cooking solutions that reduce toxic indoor air pollution, and providing lighting for schools and health facilities. These pathways make solar energy the most potent energy source for improving life expectancy in Nigeria, given the country's high solar radiation endowment and large off-grid population.

Fourth, hydropower energy has a positive but non-significant effect on life expectancy in Nigeria in both the short run and long run. This finding conforms to Somoye, Ozdeser and Seraj (2022), who found a positive but not always statistically significant relationship between hydro energy consumption and economic development. It also aligns with Ogochukwu and Keghter (2024), who found a weak positive association between hydropower energy and sectoral performance. The non-significance of hydropower energy's effect on life expectancy likely reflects the limited and often unreliable nature of hydroelectric power generation in Nigeria, its concentration in urban grid areas that are already relatively better served, and the slow expansion of hydropower-related benefits to underserved communities that bear the greatest health burdens.

5.0 Conclusion and Recommendations

Conclusion

This study empirically examined the effect of energy consumption on life expectancy in Nigeria from 1990 to 2023, using the ARDL bounds testing approach. The bounds cointegration test confirmed a robust long-run equilibrium relationship among life expectancy, electricity consumption, natural gas consumption, solar energy consumption, and hydropower energy. The estimation results demonstrated that electricity consumption, natural gas consumption, and solar energy consumption have positive and significant effects on life expectancy in both the short run and long run, while hydropower energy has a positive but statistically non-significant effect. The empirical evidence supports the Energy Transition Theory and the Biophysical Theory, confirming that the availability of modern, clean energy sources directly enhances health outcomes and longevity in Nigeria. Premised on these findings, the study concluded that energy consumption plays a significant and vital role in enhancing life expectancy in Nigeria, with solar energy consumption exerting the largest positive effect. Realizing the full health potential of energy in Nigeria will require sustained investments in energy infrastructure, regulatory reforms, and targeted programmes that ensure modern energy access reaches the most health-vulnerable populations.

Recommendations

The following recommendations are proffered based on the findings of this study:

i. Government should prioritize expanding electricity access to healthcare facilities across Nigeria, particularly at the primary healthcare level. Investment in dedicated electricity infrastructure for hospitals, clinics, diagnostic centers, and maternity wards will ensure that medical equipment, refrigeration for vaccines and blood products, and emergency care remain functional at all times. Programmes such as the Energizing Healthcare Initiative should be scaled

up to cover all public health facilities in rural and peri-urban areas, thereby directly improving the quality of healthcare delivery and extending life expectancy.

ii. Policymakers should accelerate the development of gas-to-power infrastructure and promote the substitution of biomass fuels with cleaner liquefied natural gas (LPG) and compressed natural gas (CNG) for household cooking and commercial use. The Nigerian government should strengthen gas distribution networks and implement targeted LPG subsidy programmes for low-income households, particularly in rural and northern communities where biomass fuel use is highest. Reducing biomass combustion through natural gas substitution will significantly reduce indoor air pollution, respiratory diseases, and associated premature mortality, thereby improving life expectancy.

iii. There should be aggressive national investment in solar energy infrastructure, particularly for healthcare and community welfare applications. Solar-powered health clinics, solar vaccine cold chains, solar-powered water pumping systems, and solar lighting for homes should be prioritized in rural and off-grid communities. The government should partner with international development organizations and the private sector to establish large-scale solar deployment programmes. Given that solar energy recorded the largest long-run coefficient in this study, it should be treated as the highest-priority energy source for improving health outcomes in Nigeria.

iv. To enhance the contribution of hydropower energy to life expectancy, government should increase investment in the rehabilitation of existing hydroelectric facilities and expand small-scale run-of-river hydropower projects across Nigeria's river systems. Integrating hydropower into rural health centre electrification and community water supply systems will translate hydropower capacity into tangible health benefits. Dedicated hydropower facilities for hospital campuses in underserved riverine areas will ensure consistent medical power supply and contribute to improved life expectancy among the most vulnerable populations.

References

Abner, I. P., Izuchukwu, O., Eneoli, O. C., & Udo, E. S. (2021). Energy consumption effect on economic growth in Nigeria: Multivariate framework. *International Journal of Economics, Management and Accounting, 29*(2), 519–542.

Akokaike, M. N., Adenikinju, A., Ekpe, A. N., Eleri, A. I., Ajulo, K. D., & Gini, K. B. (2021). Natural gas consumption and economic growth in Africa. *Natural Gas Consumption and Economic Growth in Africa, 8*(6), 104–113.

Cordelia, O., & Uwuigbe, O. (2021). The influence of carbon dioxide emission and energy consumption on the economic growth of Nigeria from 2008 to 2019. *Covenant Journal of Business and Social Sciences, 12*(1), 15–29.

Ekone, F. A., & Amaghionyeodiwe, L. (2020). Renewable energy consumption and economic growth in Nigeria: Any causal relationship? *The Business and Management Review, 11*(1), 59–76.

Global Burden of Disease Study. (2019). *Environmental factors' impact on environmental quality*. Global Report.

Haliru, B. (2023). Analysis on the impact of energy consumption and green growth in Nigeria. *Energy Policy, 38*(1), 656–660.

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

International Energy Agency. (2015). *Key world energy statistics*. IEA Publications.

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.

Iyabo, I., & Segun, B. (2022). Assessing the nexus among energy consumption, foreign direct investment and economic growth in Sub-Saharan Africa. *Economic Modelling, 22*(3), 423–438.

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

Lawrence, U. O., Alexander, E. O., Johnson, I. O., Uchechukwu, E. O., Felix, N. E., Benjamin, I. E., & Gideon, K. E. (2021). Effect of energy utilization and financial development on economic growth in Nigeria. *International Journal of Energy Economics and Policy, 11*(2), 392–401.

Leach, G. (1992). The energy transition. *Energy Policy, 20*(2), 116–123.

Maji, I., Chindo, S., & Abdul-Rahim, A. S. (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. *Energy Reports, 5,* 384–392.

Mmbaga, F., Kulindwa, Y., & Kazungu, I. (2023). Energy consumption and economic growth nexus in East African Sub-Region. *African Journal of Economic Review, 11*(5), 50–69.

Ogochukwu, E., & Keghter, L. (2024). Renewable energy consumption and industrial sector performance in Nigeria. *Energy Economics Research Journal, 12*(1), 55–72.

Olufunmilayo, A., Henry, N., Hassan, A., & Oluwatoyin, A. (2020). Joint effect of carbon emission and health investment on economic development in Nigeria. *International Journal of Environmental Research and Public Health, 17*(16), 1–18.

Pachauri, S., & Spreng, D. (2004). Energy use and energy access in relation to poverty. *Economic and Political Weekly, 39*(6), 271–278.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16*(3), 289–326.

Qudrat-Ullah, H., & Chinedu, O. (2021). Renewable energy consumption and environmental sustainability on economic growth across Africa. *Energy, Sustainability and Society, 11*(1), 1–14.

Somoye, O. A., Ozdeser, H., & Seraj, M. (2022). Renewable energy and economic development nexus. *Frontiers in Energy Research, 10,* 891839.

Wang, J., Wang, J., & Li, Q. (2022). Effects of fossil energy on human development. Energy Reports, 8, 5709–5721.

World Bank. (2024). *World development indicators.* The World Bank Group.

Yahaya, H., & Bakare, A. S. (2018). Electric power consumption and economic growth in Nigeria: A causality analysis. *African Journal of Economic Review, 6*(2), 112–127.