

Energy Consumption and Economic Growth in South Sudan

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Abstract

This study analyzes the link between energy consumption and its impact on South Sudan's economic growth. The specific objective is to determine the impact of energy consumption on South Sudan's economic growth from 2010 to 2024. Endogenous growth theory was adopted as a grounding theory for the study, and the model was specified. An explanatory research design was employed to examine the short-run and long-run effects of energy consumption on economic growth in South Sudan. An ARDL model was used to check the effects of the dependent variables on the independent variable in the short run and long run. The ARDL bounds test produced an F-statistic of 1.985, which was less than the critical value for the upper bound $I(1)$ at a 5% significance level (4.78), hence insignificant. The results show no cointegration between the variables; hence, there is no long-run relationship, confirming the existence of a short-run relationship. In contrast, in the short run, energy consumption shows a negative and insignificant relationship with GDP, attributed to oil fluctuations. In terms of policy, the South Sudanese government should encourage the use of renewable energy and adopt energy-saving measures, thereby reducing costs and increasing efficiency. Renewable energy and energy conservation policies should be adopted by the government to increase energy generation and support economic development, given that South Sudan is a growing nation.

Keywords: Economic Growth, Energy Consumption, South Sudan.

1. Introduction

Energy consumption and economic growth have been among the most contentious debates in many developing and developed countries. South Sudan, the world's youngest nation, faces significant challenges in energy infrastructure and economic development. Despite abundant natural resources, the country's energy sector remains critically underdeveloped, directly impacting its economic growth potential. According to [\(Erbaykal, 2008\)](#) the petroleum crisis in the 1970s displayed the importance of energy as a production factor. Since then, energy has

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emerged as a production factor alongside labour and capital. The global population is increasing rapidly, particularly in developing countries.

South Sudan exemplifies an irony in the global energy sector: it possesses substantial natural resources, yet poverty constrains its development. Since gaining independence in 2011, South Sudan has struggled to transform its abundant oil reserves into sustainable energy development

The nation's energy challenges stem from prolonged internal conflict, government inefficiencies, and economic constraints. Despite possessing an estimated 3.5 billion barrels of proven oil reserves and significant renewable energy potential, South Sudan remains trapped in a cycle of energy underdevelopment that directly undermines its economic growth, social progress, and human capital development. This research critically examines the relationship between energy consumption and economic growth. The research will demonstrate by addressing energy poverty for economic development to the nation's post-independence experience.

South Sudan's economy has a total GDP of \$4.15 billion, and GDP per capita is approximately \$350. In terms of electricity access rate, the population has 7.3% access, with an annual energy consumption per capita of 0.12 Tonnes of Oil Equivalent. South Sudan is heavily dependent on oil exports, with the oil sector accounting for 98% of economic output. South Sudan is one of Eastern Africa's major oil resource holders, but exported more than 85% of its production in 2014. Only 1% of the population had access to electricity in the country in 2017. (International Energy Agency).

South Sudan's energy consumption represents more than a technical infrastructure problem. It is a multidimensional challenge that intersects economic, social, political, and technological domains. By examining this landscape, we gain crucial insights into the complex relationship between energy access and national economic development. The journey of energy transformation in South Sudan is not merely about generating electricity; it is about creating fundamental possibilities for human progress, economic opportunity, and national reconstruction.

Unresolved political instability and violence have had negative economic consequences for South Sudan, and all the gains the country had made since the 2005 peace agreement in the past years vanished after the December 2013 political uprising. Conflict and violence have been a major concern for the people of South Sudan, and insecurity includes the number of displaced persons, food insecurity, increased poverty, higher inflation rate, and unemployment (SSDP 2013). Essential Infrastructure is destroyed, including schools, hospitals, and social cohesion. Political instability brings poverty and human suffering and increases illiteracy in society. As schools are destroyed and learning stops, the nation lacks matching skills and education, leading to a high rate of unemployment that negatively affects economic development.

The relationship between energy consumption and economic growth in South Sudan represents a critical area of study, given the country's complex economic landscape and significant energy challenges. This research aims to explore how energy consumption patterns impact economic growth in one of the world's youngest and most energy-vulnerable nations.

The general objective of the study was to analyze the impact of energy consumption on economic growth in South Sudan. Specifically, the study sought to achieve. To assess the

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nature of the relationship between energy consumption and economic growth, and hence improve policy measures in energy consumption to improve economic growth.

The study postulated the following hypotheses:

H₀₁: Energy consumption does not significantly affect economic growth in Kenya.

Furthermore, the study is expected to benefit scholars and Academicians who may wish to use it as a reference for further research, and to address the knowledge gap in this area.

2. Literature Review

2.1 Theoretical Literature

2.1.1 Neutrality Hypothesis

The Neutrality Hypothesis proposes that there is no significant causal relationship between energy consumption and economic growth. This hypothesis posits a causal relationship between these variables. The fundamental proposition of the Neutrality Hypothesis is that energy consumption and economic growth are Independent of each other. The theory is connected through such minimal linkages that policy changes affecting one variable have a negligible impact on the other, and both are influenced by common third factors but are not directly related to each other ([Payne, 2010](#)).

2.1.2 Energy Growth Nexus Hypothesis.

The Energy-Growth Nexus hypothesis emerged from empirical observations of how economies develop their energy systems. These hypotheses have profound implications for policy formulation, particularly in developing economies like South Sudan, where energy infrastructure decisions can significantly impact development trajectories. The Energy-Growth Nexus represents a fundamental theoretical framework for understanding the relationship between energy consumption and economic development. The Growth Hypothesis posits that energy consumption is a fundamental driver of economic growth, with causality running unidirectionally from energy to economic output.

[\(Kraft, 1978\)](#) examined the causal relationship that existed between energy consumption and economic growth in the United States. A unidirectional causal relationship between GNP to energy consumption was identified for the United States. No statistically significant causal relationship was found in the reverse direction (from energy to GNP).

2.1.3 Endogenous Growth Theory.

The endogenous growth model [\(Romer P. , Capital Accumulation in the Theory of the long run., 1989\)](#) recognized human capital as one of the key determinants of paramount development in a nation. In the dynamic economic environment, human capital, finance, technology, and energy are tightly interlinked globally. In the globalized regime, mobility of human resources, finance, energy and technology from one economic region to the rest of the world (mostly from the West to the East) is a stylized fact. The recent paradigm shift from traditional [Solow \(1956\)](#)-type analysis to new growth theories has resulted in factors such as energy, technology, human capital, and finance **being brought into** the limelight, playing decisive roles in fixing production and productivity rather than the conventional factors of production.

According to endogenous growth theory, energy consumption can contribute to long-term economic growth by facilitating technological advancements and human capital development, essentially suggesting that energy is not just an input but can also be a driver of innovation and productivity gains, allowing for sustained economic growth over time; this is particularly relevant when considering investments in energy efficiency and renewable technologies that can promote sustainable development.

We can derive the aggregate production function of the endogenous theory as follows:

$$Y=F(A, K, L)$$

Where;

Y = Aggregate real output.

K = Stock of capital.

L = Stock of labour.

A = Technology (or technological advancement)

It is worth noting that technological advancement is based on investment in research and development.

Technology is seen as an endogenous factor that could be related to energy.

Most technology, over time, depends on the availability of usable energy to power it. Energy is not the sole determinant of technology, but it is a necessary factor for ensuring its utilization. Conversion of energy in its raw state. Significant investments must then be made in energy, not only to produce energy but also to achieve energy efficiency. To justify the endogenous growth model, capital and labor will be used alongside various energy sources in the model specification.

2.2 Empirical Literature

2.2.1 Energy Consumption and Economic Growth

[\(Wietze Lise, 2007\)](#) Conducted a study on the relationship between energy consumption and GDP in Turkey with annual data over the period 1970-2003. The analysis showed that energy consumption and GDP were co-integrated. They established unidirectional causality running from GDP to energy consumption, indicating that energy conservation would not harm economic growth in Turkey.

According to [Khalid Eltayeb Elfaki1, A. \(2018\)](#), an investigation of the dynamic relationship between energy consumption and economic growth in Sudan, covering time-series data from 1984 to 2014, used the autoregressive distributed lag (ARDL) cointegration approach. The study found that energy consumption has a negative impact on economic growth in the long run.

[\(Goodarzy, 2015\)](#) examined the causal relationship between energy consumption and GDP in 7 Asian countries using a panel cointegration. Using the error correction models from annual data during the period 1980 to 2010. The results revealed that there is a significant positive relationship between GDP and energy consumption in Asian countries.

[\(Kibunyi, 2018\)](#) explored the effect of crude oil GDP growth and selected macroeconomic variables in Kenya using time series data from 1970 to 2016. The study estimated three

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autoregressive distributed lag (ARDL). They found out that crude oil prices have a long-run positive relationship with GDP growth, and the study attributed this to Kenya's imports of oil and re-exports of the same oil to Uganda, South Sudan, and Rwanda.

[\(Inglesi-Lotz, 2013\)](#) estimated the impact of renewable energy consumption on economic growth using annual data from 1990 to 2010, comprising 34 countries that are members of the OECD. The study used a [Cobb-Douglas production function](#) framework. The findings indicated that a 1% increase in renewable energy consumption would raise GDP by 0.022% and GDP per capita by 0.333%.

2.3 Research Gap

Most studies employed alternative methods for data analysis to assess the relationship between energy consumption and economic growth. In the empirical studies, there are shortcomings, as results differ across studies. Most studies report positive, insignificant effects, whereas others report positive, significant effects, with a few finding no effect of energy consumption on economic growth. To bridge this gap, the study will employ OLS regression to analyze data from 2010 to 2024, examine the relationship between energy consumption and economic growth, and conduct integration, Vector Error Correction, and Unit Root tests.

This study sought to fill a knowledge gap by examining energy consumption in South Sudan, given the insufficient number of studies conducted in the country. This study employed the ARDL model due to the small sample size to analyze the relationship between the independent and dependent variables. This is a gap that exists and needs to be filled as inquisitive in the South Sudan case.

3. Research Method

3.1 Area of Study

The study focused on the analysis of energy consumption on economic growth. Consequently, South Sudan was the geographical area of study. South Sudan is a landlocked country in East Africa, located in Sub-Saharan Africa.

3.2 Empirical Model

The study employed an explanatory research design. The econometric model used was based on the theoretical framework of the endogenous growth model. The study used GDP as the dependent variable and energy consumption as the independent variable. The model was specified from the theoretical framework as energy is taken as an independent variable.

$$Y = f(K, L, E)$$

Where:

Y = Output

K= Capital Formation

L = Labour Force

E = Energy

The model is specified as

$$Y = \beta_0 + \beta_1 x_1 \dots \dots \dots (3.1)$$

Where y is GDP; x_1 is energy expenditure

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The estimated model was then transformed into log-linear models reducing the equation as natural logs to avoid the problem of multicollinearity among the variables in the model and also helps to reduce the variability of data and enables direct estimation of elasticities.

$$\ln GDP_t = \beta_0 + \beta_1 \ln EXE_t + \varepsilon_t \dots \dots \dots (3.2)$$

Where $\ln GDP_t$ = Log of Gross Domestic Product (a proxy for economic growth) in period t

$\ln EXE_t$ = Log of Energy Expenditure in period t $\ln EXE_t$; ε_t = Error Term, which captures all factors that affect GDP but are not taken into account (Gujarati, 2004); β_0 = Intercept $\beta_1, \beta_2, \beta_3, \beta_4$ = Coefficient of the Independent Variables.

3.3 ARDL Model Specification

This study used the bound testing approach for cointegration, within an Auto-Regressive Distributed Lag (ARDL) framework, developed by [Pesaran and Shin \(1999\)](#) A simple ARDL model is given as;

$$Y_t = \delta_0 + \sum_{j=1}^p \delta_{1j} Y_{t-j} + \sum_{j=0}^q \delta_{2j} X_{t-j} + \varepsilon_t \dots \dots \dots (3.3)$$

Incorporating the short-run and long-run dynamics, equation (3.1) is transformed into bound testing approach as;

$$\Delta Y_t = \beta_0 + \sum_{j=1}^p \beta_{1j} \Delta Y_{t-j} + \sum_{j=0}^q \alpha_{1j} \Delta X_{t-j} + \theta_0 Y_{t-1} + \theta_1 X_{t-1} + \varepsilon_t \dots \dots (3.4)$$

In this framework, the dependent variable is explained by lagged values of itself and current and lagged values of independent variables. The method has several advantages; first, it is applicable when the regressors are $I(0)$, $I(1)$, or mutually cointegrated. Secondly, it's relatively more efficient in small or finite sample sizes. Thirdly, it allows the co-integration relationship to be estimated by OLS once the model's lag order is identified.

3.4 Data Source and Type

This study used secondary data covering the period (2010-2024), depending on the availability of data from the government's database. Data were obtained from the Ministry of Finance and Economic Planning of South Sudan, the World Bank, and the Ministry of Energy of South Sudan for the period 2010 to 2024. The choice of data depended on the availability of data to be included in the study.

4. Results and Discussion

The study assessed multicollinearity using a rule of thumb and computed a VIF for each explanatory variable in the model. The results indicated that the null hypothesis of no multicollinearity was supported, as the VIF was less than 10.

4.1 Results of the Augmented [Dickey-Fuller Unit Root](#)

Table 1: Augmented Dickey-Fuller after Differencing

Variable	ADF t-statistic	1% level	5% level	10% level	Conclusion
lnGDP	-4.869	-4.380	-3.600	-3.240	I(0) Stationary
lnEC	-4.842	-4.380	-3.600	-3.240	I(0) Stationary

From the results in Table 1, after differencing the ADF t-statistics log of GDP was -4.869 log of energy consumption is -4.842, which were greater than the critical values at 5%. This implied

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that the variables were stationary after differencing at a 5% level of significance and concluded that there was no unit root.

4.2 Plot for variables after Differencing

The plot of the log of InGDP after the first differencing is shown below.

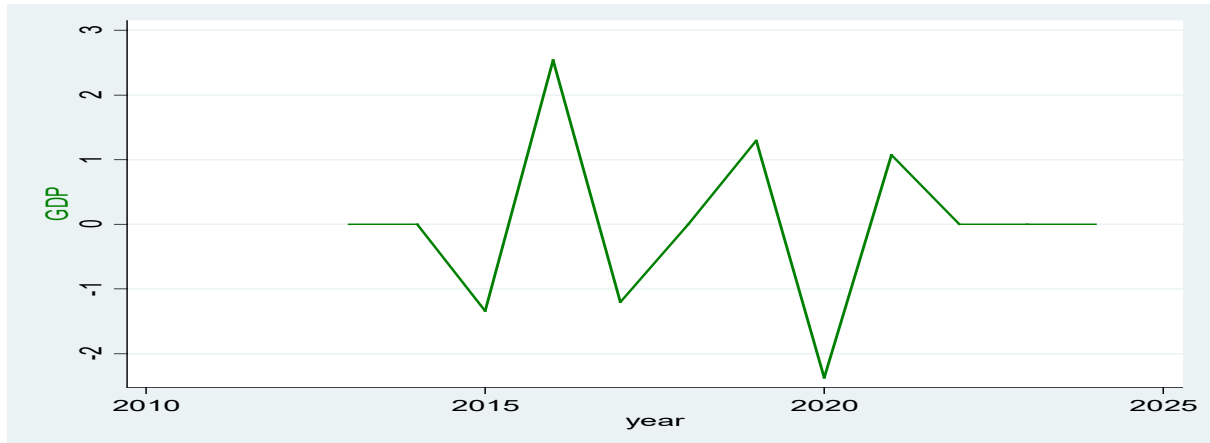


Figure 1: GDP

Source: Author (2025)

The first differenced variable was stationary around a trend or mean. The variable GDP was integrated into order 1 since it became stationary after being differenced once.

The plot of the log of EC (InEC) after the second differencing is shown below in Figure 2.

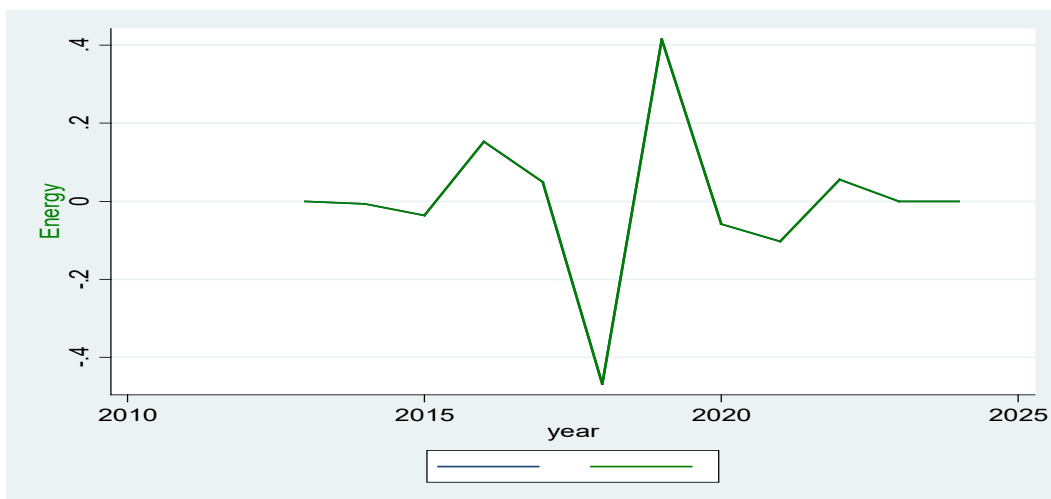


Figure 2: Energy Consumption

Source: Author (2025)

The second differenced variable was stationary around a trend or mean. The variable EC was integrated into order 2 since it became stationary after being differenced twice.

4.3 Results from ARDL bounds test of cointegration using the Bounds test

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The ARDL estimation results with a maximum lag length of 1 gave the following results on the ARDL estimation results.

Table 2: ARDL Estimation Results

Variable	Coefficient	Std Error	Prob
LnGDP	-0,181	0,193	0,370
LnEC	-1,359	2,333	0,573
C	-12,377	10,189	0,252
R ²	0,0899		

Source: Author 2025

4.4 ARDL Bounds test results

After establishing the presence of a long-run association among the variables, both the short-run (ARDL) and long run (ECM) were estimated.

The ARDL model was subjected to the bounds test for long-run association among the variables. This yielded the results in table 4.5 that follows. The null hypothesis for the bounds test was that no long-run association exists among the variables.

Table 4.3: Bounds test results

Dependent Variable	F-Statistic	F-Critical I(0)	Accept/Reject I(1)	Cointegration Exist
Ln GDP	1,985	4,04***	4,78***	No

Source: (Author 2025)

Since the F-statistic (1.985) was less than the critical value for the upper bound

I(1) at a 5% significance level(4.78), the null hypothesis of no cointegration was accepted and the alternative of the presence of short-run co-integration is accepted. This indicates that real GDP and its determinants are not cointegrated at 5 percent significance level. Therefore, the study went on to estimate the short run model.

4.5 Short run Ardl Model

Variable	Coefficient	Std. Error	Prob.
LnGDP	0.8192	0.1926	0.002
LnEC	1.3591	2.3301	0.573
C	-12.3770	10.1888	0.252
R-Squared 0.6603			
F-Statistics 6.48			
P(F) 0.0104			

Source: Author (2025)

The estimated coefficient of the Error Correction Term ECTt-1 was -12.377 with and p-value of 0.252. The coefficient was negative and insignificant at a 5 per cent significance level since the p-value was more than 0.05. In the short run energy consumption is statistically insignificant in explaining the short-run behavior of GDP. The R2 of the model is 0.6603. This indicates the strength of the relationship between LNGDP and its explanatory variables LnEC

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jointly. It suggests that about 66% of the variations in LNGDP are caused jointly by variations in LnEC in the short run.

The size of the coefficient of the error correction term (ECT_{t-1}) indicates the speed of adjustment of the equilibrium towards a long-run stable state. The deviation of the constant from the mean was not statistically significant. The constant term being statistically insignificant implies that GDP growth does not depend on its value in the previous period in the short run.

5. Conclusion

From the study findings, this paper concludes that there is no relationship between economic growth and energy consumption since the coefficient of energy consumption was insignificant. From the ARDL analysis in the short run, the study found that the coefficients of the variables were insignificant at the 5% level. Hence the study showed no long term relationship between energy consumption and economic growth.

The results of the short-run studies found that energy consumption and economic growth are insignificant. The analysis showed that energy consumption and economic growth are not co-integrated. [\(Wietze Lise, 2007\)](#) their analysis showed that energy consumption and economic growth were co-integrated which did not conform to this study. [\(Khalid Eltayeb Elfaki1, A., 2018\)](#) On the other hand, the study found that energy consumption negatively affected economic growth in the long run, whereas this study found no long-run relationship. The ARDL was used as a study limitation due to the lack of long-term datasets.

In terms of policy, the South Sudanese government should encourage the use of renewable energy and adopt energy-saving measures, thereby reducing costs and increasing efficiency. Renewable energy policy and energy saving policy should be adopted by the government to provide more energy generation to increase economic growth since South Sudan is a growing nation.

The government and other multi-stakeholder agencies should focus on infrastructure development, policy reform, reduce dependency on oil revenues, promote agriculture and small-scale manufacturing sectors, and develop human capital through vocational training and sustainable energy development which are essential for future progress.

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