



## Renewable, Non-Renewable Energy, and Economic Growth: Evidence from West African Countries.

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### Abstract

The study investigated the relationship between renewable, non-renewable energy consumption energy consumption and economic growth in West Africa countries using World Bank Development Indicator (WDI) data between 2010-2020. The study employed General Method of Moment (GMM) to estimate the relationship. The findings revealed that both renewable and non-renewable energy consumption have significant impact on the economic growth of West African countries within the period under sample. It was revealed that non-renewable energy exerts more influence on the economic growth as compared to renewable energy consumption. The study further revealed that trade openness exerts a positive influence on renewable energy consumption validating earlier literature that concludes that economies with more openness tends to enjoy more technology diffusion as compared to economies with less economic openness.

### 1. Introduction

There is a growing shift in energy consumption from non-renewable energy sources like fossil fuel to renewable energy sources like solar energy among others (Rodríguez-Monroy, Mármol-Acitores, Nilsson-Cifuentes, 2018; Ntanos, Ziatas, Merkouri, 2015). The gradual shift has been attributed to the negative environmental effects of conventional energy forms of production and usage, and the finite yields of conventional sources of energy, the need for renewable energy sources (RESs) usage is becoming urgent (Emir and Bekun, 2019). Tonuchi and Ariolu (2021) have argued that renewable energy is the most significant source of energy in terms of its sustainability, availability, and environmental friendliness. This feature of renewable energy has made it a sort after form of energy to save the environment from CO<sub>2</sub> emissions and other environmental degradation. This explains the reason why special policies are developed to further promote the expansion of renewable energy consumption across the globe including Africa.

Despite its rising importance and usage level, renewable energy still does not have a large share in the world's energy portfolio compared to non-renewable sources. For instance, oil is the most important non-renewable source and remains the world's leading fuel, constituting 34.2% of global energy consumption in 2017 (Ozcana and Ozturk, 2019). However, in 2016, modern renewable energy sources

excluding traditional usage of biomass accounted for only ten percent of total final energy consumption (Ozcana and Ozturk, 2019; Rahman and Velayutham, 2020). Different factors contributed to the development or shift of policies towards promoting the growth of renewable energy consumption. These developments include growing concerns over energy security, climate change, political and social pressure to curb greenhouse gas (GHGs) emissions, high and volatile oil prices, and high dependency on foreign energy sources (Rahman and Velayutham, 2020).

One of the arguments against renewable energy is that it is costly to maintain and sustain which explain why some governments are giving tax exception and other forms of subsidy to renewable energy generation and consumption. The government often invests in their clean energy sectors and supports them with various national policies such as tax credits for renewable energy supply, discounts for installing renewable energy mechanisms, renewable energy portfolio measures, and creating markets for renewable energy certificates to secure the energy supply and to diversify the energy mix (Ozcana and Ozturk, 2019; Rahman and Velayutham, 2020). Given the importance of renewable energy to the sustenance of the environment and to economic growth at large, several literatures have investigated the relationship between economic growth and renewable energy either within a specific country, selected country, or region. Regardless, literature on renewable energy remains inconclusive particularly as it relates to the moderating role of trade openness. Therefore, this study aims to address this issue which is still an under-researched area. As there is a lack of studies that investigate the relationship between Trade openness, renewable energy consumption and economics. In addition, there is no evidence to the best of the researcher's knowledge who has investigated the relationship between renewable energy, trade openness, and economic growth particularly in West African countries where reliance on renewable energy to support to delapidated conventional energy are growing.

Thus, the study major contribution includes (i) this study explores the differential effects of renewable and non-renewable energy consumption on economic growth while most of the earlier studies looked at the linkage taking the total energy consumption; this disaggregation helps us to understand the relative strength of both types of energy use in the growth process following the example of Rahman and Velayutham (2020). (ii) this study is mostly the first study within West Africa to examine the joint contribution or disaggregated effect of renewable and non-renewable energy alongside trade openness in West Africa. (iii) to address the potential omitted variable bias, this study has added the three additional variables including the main variables of neoclassical production function: capital and labour in a multivariate framework; (iv) as trade openness is interrelated to economic growth, the study has also considered this variable as a control variable to examine the dynamic energy-growth nexus; (v) in line with Tonuchi and Ariolu (2021) the study used General Method of Moment panel data that address the issue of endogeneity and multicollinearity. The rest of the paper is grouped into literature review, methodology, analysis and discussion, and conclusion.

## **2. Literature Review**

There is growing literature on the relationship between renewable energy consumption and economic growth across the globe. While some literature has found strong supporting evidence to conclude that renewable energy has positive significant impact on renewable energy (Tonuchi and Ariolu, 2021; Rodríguez-Monroy et al, 2018), some other earlier studies have suggested (Can & Korkmaz, 2018) others simply did not found strong evidence to reach a conclusion (Bozkurt & Destek, 2015; Marinaş, Dinu, Socol, & Socol, 2018). Some other studies focus more on the causality between renewable energy consumption and economic growth with the aim of establishing which is granger causing the other (Ozcana and Ozturk, 2019). Yet some studies have also focused on what policies can be put in place to promote the consumption of renewable energy (Tonuchi, 2019). The author suggested several policy measures to tackle the low or dwindling growth of renewable energy consumption in Africa and even in developed countries like United State of America.

In general, few conclusions can be drawn from the literature reviewed, on the studies investigating renewable energy consumption and economic growth, the following general conclusion was mostly drawn from the studies. i., four hypotheses or generalizations can be reached from these studies namely the growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis. ii., that energy consumption whether renewable or non-renewable energy consumption has a direct or indirect effect on economic growth as it complements to labor and capital. As such policies targeting drastic reduction in non-renewable energy consumption without equal percentage increase in renewable energy consumption may adversely affect economic performance level by causing a fall in output and a rise in unemployment (Bozoklu and Yilanci, 2013).

iii., If there exists a unidirectional causality running from economic growth to renewable energy consumption then the conservation hypothesis is supported. The conservation hypothesis asserts that energy-saving policies planned to curb energy demand may not negatively affect economic performance. Therefore, precautions such as cutting GHGs emissions, increasing energy efficiency or management of energy demand will probably have just a small influence on economic growth because economy is relatively less dependent on energy. iv., Another scenario is where there is bilateral relationship between economic growth and renewable energy consumption in Nigeria. Several studies This hypothesis is confirmed in the presence of a bidirectional (mutual) relationship between renewable energy consumption and economic growth.

In specific terms, Tonuchi and Ariolu (2021) who investigated the nexus between renewable energy consumption and economic growth in developing countries and the role of environmental sustainability in the nexus between renewable energy consumption and economic growth using GMM. The authors argued that renewable energy consumption has a positive but weak impact on economic growth in developing countries but when environmental sustainability is accounted for, the impact of renewable energy consumption improves. This is consistent with the findings of Lee (2019) finds enough evidence to support a link between renewable energy consumption, economic growth, industrialization, and CO2 emissions in the long-run and short-run. The study notes that while renewable energy consumption has been increasing with growth, CO2 emissions have been declining in the region. However, the result also suggests that both economic growth and industrialization have been achieved at the cost of harming the environment. The increased consumption of renewable energy tends to play an important role in curbing carbon emissions in the region.

This is also consistent with Atems and Hotaling (2018) who employed a General Method of Moment to estimate the impact of renewable and non-renewable electricity generation on economic growth in 174 countries. The study demonstrates that both renewable and non-renewable energy consumption has a positive significant impact on economic growth, but the former appears to have a stronger positive impact on economic growth. Most econometric studies document a bi-directional relationship between renewable energy and economic growth on the direction of causality between renewable energy consumption and economic growth.

**Table 1: Summary of Review of Literature**

Study	Countries	Methodology used	Findings: hypotheses
Tonuchi and Ariolu (2021)	Developing Countries	General Method of Moment (GMM)	Feedback/Bilateral
Ntanos et al (2018)	25 European Countries	Autoregressive Distributed Lag Model (ARDL)	Feedback/Bilateral
Apergis and Payne 2010	20 OECD countries	Vector error correction	Feedback/Bilateral
Rahman and Velayutham (2020)	5 South Asian Countries	Fully Modified OLS and Panel Dynamic OLS	Unidirectional; Growth to Energy
Emir and Bekun (2019)	Romania	Autoregressive Distributed Lag Model (ARDL)	Feedback, Growth

Apergis and Payne (2012)	80 countries	Vector error correction model	Bilateral Relationship
Tugcu et al. (2012)	G7 countries	Panel vector autoregressive model	Bilateral Relationship
Al-mulali et al (2014)	18 Latin American countries	Vector error correction model	Unidirectional; Growth to Energy
Salim et al. (2014)	OECD countries	Pool mean group	Bilateral Relationship
Tiwari et al. (2015)	12 Sub-Saharan African countries	Linear and hidden co-integration method	Growth, conservation
Bhattacharya et al. (2016)	38 countries	Heterogeneous panel causality test	Unidirectional; Growth to Energy
Ohlan (2016)	India	Vector error correction model	Bilateral Relationship
Aneja et al. (2016)	BRICS countries	Panel error correction model	Bilateral Relationship
Tugcu and Topcu (2018)	G7 countries	A nonlinear ARDL model	Bilateral Relationship
Fan and Hao (2020)	China	Granger causality test	No relationship

Source: Author

### III. Methodology

#### 3.1 Data and Model

The data are sourced from World Bank Development (WDI) indicators 2020. Panel data between the period of 2010 to 2020 for 14 countries with complete data set was used for the analysis. Countries with incomplete data set was not included as the list of countries included in the study are listed in Appendix 1. The neoclassical growth models identified two major factors that drives economic growth in the long-run including labour and capital (Joseph and Obikaonu, 2021). To this end, the growth equation can be represented as thus in equation (1),

$$Y_{i,t} = K_{i,t}^{\alpha} L_{i,t}^{\eta} \dots\dots\dots (1)$$

where; Y = growth rate of income per capita, L = labour force employed at age 15 and above, K = Stock of physical capital. If we follow the work of Tonuchi and Ariolu (2021), Rahman and Velayutham (2020), and Atems and Hotaling (2018), equation (1) can be modified to include other variables that impact economic growth including renewable and non-renewable energy. This is as presented in equation (2).

$$Y_{i,t} = K_{i,t}^{\alpha} L_{i,t}^{\eta} NREN_{i,t}^{\rho} REN_{i,t}^{\theta} \varepsilon_{i,t} \dots\dots\dots (2)$$

REn = Renewable energy consumption, and NREn = Non-renewable energy consumption, and  $\varepsilon$  is the error term, other variables remain as defined earlier. If we further argue that technology diffusion resulting from investment in renewable energy from the developed countries to developing countries takes place through trade openness, then the study can follow the step of Rahman and Velayutham (2020) and other novel studies to account for trade openness in the model and establish the behaviour of the model when the series is introduced into the model.

$$Y_{i,t} = K_{i,t}^{\alpha} L_{i,t}^{\eta} NREN_{i,t}^{\rho} REN_{i,t}^{\theta} TO_{i,t}^{\delta} \varepsilon_{i,t} \dots\dots\dots (3)$$

Where TO = trade openness, and other variables remains as defined earlier.

To reduce the effect of outliers and the presence of heteroscedasticity, the study takes the logarithms of all the variables in equation (3). This approach affords the researcher the ability to estimate the elasticities of the regression slopes and consistent with earlier studies (Tonuchi and Ariolu (2021), Rahman and Velayutham, 2020; Atems and Hotaling, 2018).

$$\ln y_{i,t} = \beta_0 + \beta_1 \ln K_{i,t} + \beta_2 \ln TO_{i,t} + \beta_3 \ln L_{i,t} + \beta_4 \ln REN_{i,t} + \beta_5 \ln NREN_{i,t} + \beta_6 \ln y_{i,t-1} + \lambda_i + \varepsilon_{i,t} \dots\dots\dots (4)$$

### 3.2 Estimation Technique

The study followed the work of Tonuchi and Ariolu (2021) who used General Method of Moments (GMM) to estimate the relationship between energy consumption and economic growth. The choice of the method is influenced by the fact that GMM can solve endogeneity and another estimation issue. GMM is an econometric method that integrate information from both the observed time series and the population moment conditions to generate parameter estimates. It uses the first four population moments; mean, variance, skewness and kurtosis to generate estimation. The dynamic GMM framework of equation 4 can be respecified in its GMM form as in equation (5);

$$Y_{it} = \alpha + \gamma_1 \ln Y_{it-1} + \beta' [X]_{it} + \lambda_i + \varepsilon_{it} \quad \dots\dots\dots (5)$$

Where;  $y_{it}$  is the growth rate of income per capita (used to capture economic growth) as the dependent variable and  $\ln y_{it-1}$  is the endogenous variable meant to solve the endogeneity issues common in growth equation, and  $X_{it}$  is the vector of exogenous variables including renewable energy consumption  $\varepsilon_{it}$  error term that has constant means,  $E[\varepsilon_{it}] = 0$ . Other variables remain as defined earlier. And  $i = 1, \dots, N$ , and  $t = 2, \dots, T$ , also,  $[\lambda_i + \varepsilon_{it}]$  is the standard error component. We assume that,  $E[\lambda_i] = 0$ ,  $E[\varepsilon_{it}] = 0$   $[\lambda_i + \varepsilon_{it}] = 0$ . System GMM is chosen over difference GMM in our case because of possible downward bias resulting from weak instrument in difference GMM. Notice that if we take the first difference of equation (5) as in equation (6);

$$\Delta y_{it} = \alpha + \gamma_1 \Delta \ln y_{it-1} + \beta' [X]_{it} + \lambda_i + \Delta \varepsilon_{it} \quad \dots\dots\dots (6)$$

From equation (6), lagged dependent variable  $\Delta y_{it}$  has a correlation with the error term  $\Delta \varepsilon_{it}$ , this implies that there is potential endogenous problem that may render parameter estimate from equation (6) not consistent, as such, first difference instrument cannot sufficiently be used to address potential issues in the model and may generate downward bias (Bond, Hoeffler, & Temple, 2001). Therefore, a system GMM becomes the only option to address the potential endogeneity problem in the equation.

### 4. Result and Discussion

To examine the relationship, the study first subjects the series to panel unit root test as presented in Table 2. Given that the data are strongly balanced, and the number of observation (N) is less than the time frame (T) it can be argued that the study will likely not have the issue of unit root (Im, Pesaran & Shin, 2001; Bai & Ng, 2004; Moon & Perron, 2004; Tonuchi and Ariolu, 2021). As suggested in literature, the study however proceeds to subject the data to a unit root test to clear all possible doubt on the data using the first generation unit root tests. Both Im, Pesaran & Shin (IPS) and Fisher based approach was employed to check for stationarity.

Table 2: Panel Unit Root test Using IPS and Fisher Approach/ AIC Criteria

	IPS @ Level Statistics/P-value	IPS @ First Diff. Statistics/P-value	Fisher @ Level Statistic/ P-value	Fisher @ First Diff. Statistics/ P-value
Ln $y$	2.48 (0.740)	-7.44 (0.000)***	2.744 (0.695)	-8.623 (0.000)***
LnK	1.409 (0.410)	-5.37 (0.000)***	2.43 (0.890)	-7.329 (0.000)***
LnL	4.23 (0.874)	-5.37 (0.000)***	-2.38 (0.208)	-9.162 (0.000)***
LnRen	-1.41 (1.000)	-8.97 (0.000)***	-2.536 (0.443)	-11.102 (0.000)***
LnNREn	-4.073 (0.040)**	-9.62 (0.000)***	-3.382 (0.062)*	-8.314 (0.000)***
LnTO	-4.213(0.027)**	-11.51 (0.000)***	-5.57 (0.004)***	-12.175 (0.000)***

**Notes:** The P-value is enclosed in the parentheses. All variables are logged, and significance is indicated as follows: \*\*\*, \*\* and \* for 1%, 5%, and 10%, respectively.

The result in table 2 revealed that both trade openness and non-renewable energy consumption are stationary at level using IPS and Fisher based approach while other variables are not stationary at level. At first difference all the series were stationary using both IPS and Fisher-based Approach. Since the variables are differenced to achieve stationarity, the study subjected the data to a cointegration test to ensure there exist long-run relationship among the series under investigation. To this end, Westerlund co-integration test was employed to determine if there is long-run relationship among the series (Tonuchi and Ariolu, 2021; Joseph and Obikaonu, 2021).

**Table 3: Westerlund Cointegration test**

H<sub>0</sub>: no cointegration with 14 series and 1 covariate

Statistics	Value	Z-value	P-value
<b>Gt</b>	-4.54	-7.41	0.000
<b>Ga</b>	-14.53	-11.42	0.000
<b>Pt</b>	-13.02	-10.63	0.000
<b>Pa</b>	-17.38	-14.32	0.000

The result in table 3 revealed that the series is cointegrated at 5 percent level of significance. The Westerlund result revealed the existence of long-run among the series. As revealed in table 3, all the series categories from Gt to Pa are all significant at 5 percent level significance, which means that a longrun relationship among the series can be established at 5 percent level of significance.

**Table 4: System GMM result**

Variables	(Fixed Effect)	System GMM Coeff./P-value
	Coeff./P-value	
Lny_1	0.785 (0.000)***	0.734 (0.000)***
Lnk	0.521 (0.000)***	0.512 (0.000)***
LnL	0.102 (0.000)***	0.112 (0.000)***
LnTO	0.034 (0.034)**	0.045 (0.005)***
LnRen	0.028 (0.001)***	0.035 (0.006)***
LnNRen	0.261 (0.000)***	0.311(0.000)***
AR(2)		0.861
Hansen test		0.421
F-stat; P-value	(0.000)***	(0.000)***

**Notes:** The P-value is enclosed in the parentheses. All variables are logged and significance is indicated as follows: \*\*\*, \*\* and \* for 1%, 5% and 10% respectively.

**Source:** Author computation from Stata output

The data from table 4 revealed among others that renewable energy consumption has significant impact on the economic growth of the West African countries within the sampled period. For instance, it was

revealed that a one percent increase in renewable energy will lead to about 2.8 percent increase on economic growth which is consistent with the findings of the earlier researcher (Rahman and Velayutham, 2020; Emir and Bekun, 2019; Ntanos et al, 2018; Apergis and Payne, 2012; Apergis and Payne, 2010). It was also revealed that non-renewable energy consumption has a significant impact on economic growth within same period under investigation. Specifically, it was revealed that a one percent rise on non-renewable energy consumption leads to 26.1 percent increase on economic growth from the fixed effect result. Other variables like trade openness, capital and labour have significant impact on the economic growth of the West African countries as expected.

The result of the system GMM which is similar to the findings from the fixed effect generally improves the relationship between renewable and non-renewable energy on the economic growth of the West African countries. Another noticeable feature from the result is that in both models, non-renewable energy appears to exert a greater influence on economic growth compared to renewable energy consumption at 5 percent level of significance. One possible explanation is the amount of investment required to go renewable. As Tonuchi (2019) argued that the average per-unit cost of consuming renewable energy is much higher than the average per-unit cost of consuming non-renewable energy consumption.

Our models are free from serial correlation as revealed by Arellano-Bond test of higher order serial correlation, the AR2 p-value are all greater than 0.5, as such we cannot reject the null hypothesis of serial correlation, thus our model is free from serial correlation. Hansen-Sargan test was also used to check for instrument validity and the result revealed that the instrument used are valid as the p-value are all above 1 percent level of significance.

## 5. Conclusion

The study found that renewable and non-renewable energy consumption has a significant impact on the economic growth of West African countries. The study employed GMM estimation approach to establish the existence of long-run relationship between renewable and non-renewable energy consumption on the economic growth of West Africa countries and the result revealed that both renewable and non-renewable energy consumption has a significant impact on the economic growth of the region. Specifically, the study revealed that non-renewable energy has a greater impact on the economic growth as compared to renewable energy. One possible explanation is that the region consumes more non-renewable energy like fossil fuel and gas more than renewable energy.

It was also revealed that trade openness has significant impact on the economic growth of the region an indication that the region is benefitting from the economic opening from the developed countries. In order word, technology diffusion from developed countries can benefit both the developed and developing countries within West African. The implication is that investment in renewable energy has the potential of achieving the economic objectives of the West African countries particularly if the region can adopt more economic openness through tariff reduction and tax rate for foreign direct investment in the region.

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