ELECTRICITY ACCESS AND CONSUMPTION IN GHANA

Samuel Osei-Gyebi

Department of Economics, Faculty of Social Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana

Department of Economics, University of Ibadan, Oyo, Nigeria

ABSTRACT

The importance of electricity infrastructure has encouraged countries to improve their access and enhance their consumption. Ghana has made a lot of improvements in expanding its electricity infrastructure. Yet, the actual effect of increasing electricity access on electricity consumption in Ghana is unknown. This study employed a vector error correction model to estimate the effect of electricity access on electricity consumption using data from 1990 to 2020. Results show that a one percent increase in the access rate of electricity increases its consumption by 10.46 kWh per capita and 61.02 kWh per capita in the short-run and long run respectively. Factors such as national income, population, and human development index (HDI) were also found to increase electricity consumption in Ghana. The recommendation is that lingering lapses in the country's electricity infrastructure must be resolved to make the increased access more profitable.

Keywords: Ghana, Electricity access, Electricity consumption

JEL classification: C13, E21, Q41

1. Introduction

The consumption of energy such as electricity has been cited as a driving force that powers the growth of an economy. Kraft and Kraft (1978) documented a positive relationship between energy consumption and the growth of national income in the United States of America. Although Kraft and Kraft found unidirectional causality running from national income to energy consumption, subsequent studies have found evidence of how the consumption of energy like electricity drives productive activities and influences economic growth. Yoo (2006) found positive effects of electricity consumption on growth in Singapore and Malaysia, Aytac and Guran (2011) found evidence in Turkey, and Wolde-Rufael (2004) found the same in seventeen African countries.

The essence of electricity consumption to growth has led to various state-sponsored policies and programmes to expand and extend electricity to as many Ghanaians as possible. The National Electrification Programme and the Self-Help Electrification projects are major projects that have been rolled out to meet Ghana’s goal of achieving universal access to electricity by the year 2030. Consequently, the access rate to electricity increased from 30.6 percent in 1993 to 60.5 percent in 2008 and further to 82.39 percent in 2020 (Energy Commission of Ghana, 2020). The rate of access to electricity in Ghana saw a 169% increase over the past 27 years which is considered remarkable for a developing country in Africa. Although Ghana still has a long way to go concerning achieving a universal access rate, the majority of Ghanaians have been brought to the light and presented with an opportunity to better their lives.

However, the consumption of electricity per capita in Ghana reduced from 336.07 kWh per capita in 1993 to 261.29 kWh per capita in 2008 but bounced back to 358.53 kWh per capita in 2020 (World Bank Development Indicators, 2020). Essentially, the consumption of electricity only grew by 6.6% which is significantly low compared to the growth in electricity access over the same period. Factors such as erratic power outages experienced from 2010 to 2015 have been cited as reasons for this low consumption of electricity (Mensah, 2016). Of course, power outages cannot wholly explain why the massive improvement in electricity access has not been reflected in the consumption of electricity in Ghana and this demands an empirical study to estimate the effect of electricity access on electricity consumption in Ghana. Perhaps, the needed and expected increase in electricity consumption despite massive electrification has not been seen due to an improvement in the efficiency of power use in Ghana (Bhattacharyya, 2011).

From an extensive search of the literature, this is the first study to empirically examine the influence of electricity access on electricity consumption in Ghana as extant studies such as Twerefo et al. (2008), Ackah, Adu and Takyi (2015), and Sarkodie (2017) only concentrated on the growth-electricity consumption nexus. Access to electricity is considered essential because it is the first step to the consumption of electricity which further leads to growth. As a matter of fact, consumption of electricity will be limited if its access is inadequate. It is therefore imperative to examine the link between electricity access and electricity consumption in Ghana. The objective of this paper is twofold: first is to estimate the effect of electricity access on electricity consumption in Ghana for the last thirty years and second, to estimate the other factors that influenced electricity consumption in Ghana for the same period.

2. Literature Review

2.1 Theoretical review

This study is underpinned by the theory of demand which states that the demand and consumption of any particular good are determined by the good's own price and other factors such as the income of the consumer, consumers' tastes and preferences, and changes in the prices of its substitutes and compliments (Slowman and Wride, 2009). Central to the theory of demand is the law of demand which postulates an inverse relationship between the price of a commodity and the quantity demanded of that commodity. Essentially, an increase in the price of the commodity reduces the quantity demanded while a fall in the price of the good increases the quantity of the commodity demanded, all other things being equal. The demand for electricity is a derived one which means electricity is not demanded for its own sake but for the benefits it gives.

Demand for electricity consists of two parts. The part that is satisfied is the amount of electricity consumed and the unfulfilled part is known as the unmet demand which is largely due to inadequate access. Essentially, unmet demand represents the number of individuals who would want to consume electricity for their various needs but are unable to do so because the energy resource is not readily available to them (Bhattacharyya, 2011). In the end, it is the fulfilled part of electricity demand, which is the total amount of electricity consumed over a given period, that is measured. Electricity price changes permeate throughout the entire economy to influence the prices of other goods and services. This largely stems from the fact that electricity enters into the production function of almost all goods and services and it follows that a change in its price is bound to affect the demand and supply of such goods and services (Aytac and Guran, 2011).

2.2 Empirical review

After the influential paper by Kraft and Kraft (1978) on the positive effect of electricity consumption on economic growth in the United States (US), several studies have confirmed this finding in many jurisdictions (Aytac and Guran, 2011; Yoo, 2006; and Wolde-Rufael, 2004). A group of studies has also focused on electricity consumption and other indicators. Sami (2011), for example, investigated the relationship between electricity consumption, exports, and national income per capita in Japan. The final group of empirical studies mostly on Ghana, have focused on different aspects of electricity supply and demand as well as the myriad of issues that comes with them.

For instance, Ackah et al. (2014) explored the exogenous and endogenous factors of electricity demand and found that increased level of education of consumers reduced their electricity consumption because such consumers were energy efficient. Sarkodie (2017) forecast the consumption of electricity in Ghana by the year 2030 and revealed that the country's consumption will grow from 8.52 billion kWh in 2012 to 9.56 billion kWh by the year 2030. While Kumi (2017) reviewed the electricity situation in Ghana, Kemausuor and Ackom (2017) revealed that the disparity between rural and urban access to electricity, inadequate electricity supply, and low generation capacity are some of the shortfalls obstructing Ghana's goal of universal electrification. Kwakwa (2018) found education, electricity price, income, and population to be some of the factors that determine electricity power losses in Ghana. Yakubu, Babu and Adjei (2018) also examined the influence of electricity theft on the income generation capacity of utility companies in Ghana. Twerefou and Abeney (2020) investigated the efficiency of electricity consumption for households in Ghana and found that the low educational level of some consumers and power outages reduce efficiency. This finding confirmed the conclusions of Ackah et al. (2014) and Kwakwa (2018) who found that high level of education improves the efficiency of electricity use. Other factors such as appliance use, location, load, and regional zones were found to influence electricity demand in Ghana. Most recently, Abeberese, Ackah and Asuming (2021) examined how Ghanaian firms respond to electricity outages and how it influences their productivity. They concluded that changing the production mix to less electricity-intensive ones can help firms to mitigate the effects of electricity outages.

The foregoing review of empirical literature reveals limited studies that link electricity access to the consumption of electricity, especially in Ghana. It is essential to establish the effect of electricity access on electricity consumption because the benefits of electricity will not be manifested without access to the energy resource in the first place. We build on this by finding out how the rate of access to electricity affects its consumption, especially considering the aim of the Ghanaian government to achieve universal access to electricity by 2030. Does increasing electricity access necessarily promote its consumption? This is the main question this study sought to answer.

3. Methodology

3.1 Model specification

The purpose of this paper is to estimate the effect of electricity access on the consumption of electricity in Ghana using data from 1990 to 2020. The study acknowledges the importance of electricity consumption to economic growth as suggested by Kraft and Kraft (1978). However, access to electricity is a prerequisite for the consumption of electricity. Consequently, the study regresses the consumption of electricity on the rate of its access plus other significant factors such as price, income, and population. The functional form of the model is specified as follows:

$$EC_t = f(\,EA_t, POP_t, GDP_t, HDI_t, CPI_t) \qquad (1)$$

The econometric form of equation 1 can be written as:

$$EC_t = \beta_0 + \beta_1 EA_t + \beta_2 lnPOP_t + \beta_3 lnGDP_t + \beta_4 HDI_t + \beta_5 lnCPI_t + \mu_t \ldots\ldots (2)$$

where:

EC_t	=	electricity consumption
EA_t	=	access rate measured as a percentage of the population
GDP_t	=	gross domestic product
POP_t	=	total population
HDI_t	=	Ghana's human development index
CPI_t	=	consumer price index which is the proxy for electricity price
β_0	=	the intercept
μ_t	=	stochastic error term
β_1 to β_5	=	coefficients of the independent variables.

3.2 Type and source of data

The study used annual data from the World Bank Development Indicators (WDI) datasets from 1990 to 2020. The choice of variables stems from the theory of demand which states that the demand and consumption of any particular good are influenced by the price and the income of the consumer among other factors (Slowman and Wride, 2009). Electricity consumption is measured in kilowatt per hour (KWh) per capita. Electricity access is measured as the percentage of the population with access to electric power. An increase in electricity access is expected to increase the number of individuals connected to the national grid and hence increase the consumption of electricity. The study hence expects electricity access to have a positive effect on electricity consumption, holding all other factors constant. Also, the price of any commodity is postulated to have an inverse relationship with that commodity and it is therefore expected that the consumer price index which is a proxy for electricity prices will have a negative effect on its consumption.

The consumer price index is used as a proxy for electricity price due to limited data.

Again, income is measured as the yearly gross domestic product for Ghana. Income is expected to have a positive effect on electricity consumption because evidence from Kraft and Kraft (1978) suggests that higher levels of income are accompanied by higher levels of electricity consumption. An increase in population increases the total demand and consumption of electricity which informs the study to expect a positive relationship between them. The human development index (HDI) measures the level of development of a country taking into consideration its educational, health, and income aspects. As a development indicator, it is expected that increases in it signal the development of a country and suggest a fall in the use of energy such as electricity as indicated by the Kuznets curve. Essentially, a country shifts from the use of less efficient production technology and equipment to more efficient ones as they experience structural and technological development (Zhao et al., 2017). The efficiency of modern technology reduces the intensity of electricity use and it is therefore expected that a negative relationship exists between HDI and the consumption of electricity.

3.3 Estimation strategy

The study follows Sims (1980) and used a vector error correction (VEC) model to achieve its objectives. The VEC model implies that each variable in the system is explained by its lagged values and the lags of other variables plus the error correction term. The empirical model to be estimated with the six (6) variables is expressed as:

$$\Delta EC_t = \beta_0 + \sum_{i=1}^{k-1} \theta_i \Delta EC_{t-i} + \sum_{j=1}^{k-1} \alpha_j \Delta EA_{t-j} + \sum_{p=1}^{k-1} \delta_p \Delta lnGDP_{t-p} + \sum_{m=1}^{k-1} \gamma_m \Delta lnCPI_{t-m} + \sum_{g=1}^{k-1} \lambda_g \Delta HDI_{t-g} + \sum_{f=1}^{k-1} \psi_f \Delta lnPOP_{t-f} + \phi_1 ECT_{t-1} + \varepsilon_{1t} \quad (3)$$

$$\Delta EA_t = \beta_0 + \sum_{i=1}^{k-1} \theta_i \Delta EC_{t-i} + \sum_{j=1}^{k-1} \alpha_j \Delta EA_{t-j} + \sum_{p=1}^{k-1} \delta_p \Delta lnGDP_{t-p} + \sum_{m=1}^{k-1} \gamma_m \Delta lnCPI_{t-m} + \sum_{g=1}^{k-1} \lambda_g \Delta HDI_{t-g} + \sum_{f=1}^{k-1} \psi_f \Delta lnPOP_{t-f} + \phi_2 ECT_{t-1} + \varepsilon_{2t} \quad (4)$$

$$\Delta lnGDP_t = \beta_0 + \sum_{i=1}^{k-1} \theta_i \Delta EC_{t-i} + \sum_{j=1}^{k-1} \alpha_j \Delta EA_{t-j} + \sum_{p=1}^{k-1} \delta_p \Delta lnGDP_{t-p} + \sum_{m=1}^{k-1} \gamma_m \Delta lnCPI_{t-m} + \sum_{g=1}^{k-1} \lambda_g \Delta HDI_{t-g} + \sum_{f=1}^{k-1} \psi_f \Delta lnPOP_{t-f} + \phi_3 ECT_{t-1} + \varepsilon_{3t} \quad (5)$$

$$lnCPI_t = \beta_0 + \sum_{i=1}^{k-1} \theta_i \Delta EC_{t-i} + \sum_{j=1}^{k-1} \alpha_j \Delta EA_{t-j} + \sum_{p=1}^{k-1} \delta_p \Delta lnGDP_{t-p} + \sum_{m=1}^{k-1} \gamma_m \Delta lnCPI_{t-m} + \sum_{g=1}^{k-1} \lambda_g \Delta HDI_{t-g} + \sum_{f=1}^{k-1} \psi_f \Delta lnPOP_{t-f} + \phi_4 ECT_{t-1} + \varepsilon_{4t} \quad (6)$$

$$\Delta HDI_t = \beta_0 + \sum_{i=1}^{k-1} \theta_i \Delta\, EC_{t-i} + \sum_{j=1}^{k-1} \alpha_j \Delta\, EA_{t-j} + \sum_{p=1}^{k-1} \delta_p \Delta\, lnGDP_{t-p} + \sum_{m=1}^{k-1} \gamma_m \Delta\, lnCPI_{t-m} + \sum_{g=1}^{k-1} \lambda_g \Delta\, HDI_{t-g} + \sum_{f=1}^{k-1} \psi_f \Delta\, lnPOP_{t-f} + \phi_5 ECT_{t-1} + \varepsilon_{5t} \tag{7}$$

$$\Delta lnPOP_t = \beta_0 + \sum_{i=1}^{k-1} \theta_i \Delta\, EC_{t-i} + \sum_{j=1}^{k-1} \alpha_j \Delta\, EA_{t-j} + \sum_{p=1}^{k-1} \delta_p \Delta\, lnGDP_{t-p} + \sum_{m=1}^{k-1} \gamma_m \Delta\, lnCPI_{t-m} + \sum_{g=1}^{k-1} \lambda_g \Delta\, HDI_{t-g} + \sum_{f=1}^{k-1} \psi_f \Delta\, lnPOP_{t-f} + \phi_6 ECT_{t-1} + \varepsilon_{6t} \tag{8}$$

where: β_0 is the constant term, and θ, α, δ, γ, λ, ψ, ϕ are the coefficients of electricity consumption, electricity access, income, price level, HDI, population, and the error correction term respectively. ε_t is the white noise error term and all variables are as already defined.

4. Empirical Results

4.1 Descriptive statistics and pre-estimation tests

Part A of Table 1 shows electricity consumption per capita over the study period, averaged 319.83 kWh with a standard deviation of 47.96 kWh, while the access rate to electricity in Ghana averaged 54.78% with a standard deviation of just 18.44%. The consumer price index which is a proxy for electricity price was quite high with an average of about 81% while Ghana's index for HDI over the same period had a mean of 0.523, which shows that the country is doing relatively well. Ghana's national income averaged 28.2 million GHS and a population with a mean of 22.2 million people.

Table 1. Descriptive Statistics of Variables and the Results of Stationary Tests

Var	Mean	Std. Dev.	Min.	Max
EC (kwh)	319.83	47.96	216.90	386.79
EA (%)	54.78	18.44	25	84
GDP	28.2	13.8	12.0	53.8
CPI (%)	81.51	81.65	2.16	255
HDI	0.523	0.053	0.45	0.61
POP (mil.)	22.2	4.79	14.8	29.8
Notes: GDP measured in million GHS.				

Var	ADF test		Philip-Perron Test		Order of Integration
	CONST	CONST + T	CONST	CONST + T	
Panel A: Levels					
EC	-2.175	-2.16	-2.128	-2.091	-
EA	-0.791	-3.08	-0.921	-4.149	-
GDP	0.881	-1.76	0.668	-1.797	-
CPI	1.612	-1.54	1.144	-1.603	-
HDI	0.352	-1.81	0.395	-1.800	-
POP	-0.459	-1.45	-0.437	-1.784	-

Var	ADF test		Philip-Perron Test		Order of Integration
	CONST	CONST + T	CONST	CONST + T	
Panel B: First Difference					
EC	-7.251***	-7.193***	-7.472***	-7.506***	I(1)
EA	-8.567***	-8.404***	-9.146***	-8.922***	I(1)
GDP	-3.180***	-3.548***	-3.121***	-3.584***	I(1)
CPI	-2.993***	-3.584***	-2.990***	-3.608***	I(1)
HDI	-6.281***	-6.408***	-6.241***	-6.353***	I(1)
POP	-3.185***	-3.963***	-3.100***	-4.038***	I(1)

Source: Author's estimation based on data from WDI & STATA estimation based on data from WDI

Table 2. Results of Selection Order Criteria and Johansen Cointegration Test

	Part A: Results of the selection order Criteria								Part B: Results of Johansen Co-Integration Test					
Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC	Maximum Rank	Parms	LL	Eigenvalue	Trace statistic	5% critical value
0	85.072				9.2e-11	-6.08246	-5.99886	-5.79213	0	42	105.87779	.	115.5360	94.15
1	123.156	76.169	36	0.000	8.5e-11	-6.2428	-5.65757	-4.21049	1	53	125.6154	0.75582	76.0607	68.52
2	157.765	69.217	36	0.001	1.6e-11	-6.13578	-5.04892	-2.36149	2	62	139.57489	0.63105	48.1418	47.21
3	226.565	137.6	36	0.000	7.7e-11	-8.65884	-7.07035	-3.14257	3	69	149.84822	0.51992	27.5951*	29.68
4	2740.75	5028.4*	36	0.000	1.9e-11*	-199.288*	-197.19*	-192.03*	4	74	156.39922	0.37370	14.4931	15.41
	Endogenous: dE, dEA, dHDI Dpop dGDP Dlcpi								5	77	162.37383	0.34738	2.5439	3.76
	Exogenous: _cons								6	78	163.64577	0.08685		

Source: STATA estimation based on data from WDI.

According to Part B of Table 1, all the variables were not stable at the level for both tests, as can be seen in panel A. The study then proceeded with the first difference. The results show that all variables became stationary after the first difference. Hence, all the series in the model are integrated of order one and therefore justify the estimation of the VEC model.

Part A of Table 2 shows that all the criteria supported a lag length of 4. The study, therefore, proceeded to carry out the co-integration test. From the B part of the same table, the trace statistics show that there are at least three co-integrating equations. This is because the trace statistics for lags 1 to 3 exceeded their 5% critical values and led to the rejection of the null hypothesis that there is no co-integration. The long-run relationship among the variables validates the use of a VEC model.

4.2 Influence of electricity access on electricity consumption in Ghana

The short-run and long-run effects of electricity access and other relevant factors on Ghana's electricity consumption and the post-estimation test results are presented in Table 3. This presentation helps explain how access to electricity influenced Ghana's consumption of electricity from 1990 to 2020.

Table 3. Effect of Electricity Access on Electricity Consumption in Ghana

Electricity consumption	Short-run	Long run
Speed of Adjustment	-0.418***	-
	(0.159)	
Electricity access	-10.46*	-61.02***
	(5.465)	(9.084)
National income (ln)	8.59**	-1.33
	(4.38)	(4.75)
Human development index	-13.66	13.11***
	(1.050)	(2.62)
Population (ln)	-32.50**	-5.47*
	(18.23)	(43.94)
Price level (ln)	1.74	0.824
	(1.13)	(1.20)
Constant	-0.00246	131.79
	(9.03)	

Electricity consumption	Short-run	Long run
Post-estimation test	**Test statistic**	**Probability value**
Autocorrelation test	27.2565	0.849
Normality test	262.509	0.000

Source: Author's estimation based on data from WDI, standard error in parenthesis, ***, ** & * represents 1%, 5% & 10% significance level.

The speed of adjustment was negative, significant, and less than one, which confirms that a long-run relationship exists between the variables and hence justifies the use of the VEC model. It must be emphasized that the sign of coefficients of the normalized cointegration is interpreted in the opposite.

The null hypothesis of no autocorrelation cannot be rejected as the probability value is greater than the 5 percent significance level. This means that the model used to estimate the results of the study does not suffer from autocorrelation. The Jarque-Bera test which combines the tests of normality however indicates that the data is not normally distributed. This notwithstanding is due to the fact that the Ghanaian economy experienced a structural break during the period studied (Dramani, Tandoh & Tewari, 2012).

The findings presented in Table 3 show that electricity consumption in Ghana increased by 10.46 kWh per capita and 61.02 kWh per capita respectively in the short and the long run respectively, for a percentage increase in the rate of access. This conforms to the apriori expectation of electricity access increasing the consumption of electric power despite the low uptake of electricity power in Ghana. However, Blimpo & Cosgrove-Davies (2019) found that increasing electricity access alone is not enough for people to actually connect to it. They explained that other economic and social factors contribute to the decision of the individual to consume electricity if they have access. The majority of individuals have access to electricity but still cannot connect because they simply cannot afford it. Mensah (2016) also asserted that erratic power outages make power from the electricity grid unattractive and some consumers will rather invest in self-generation for their power needs. Resolving these challenges will enhance electricity consumption and make the increase in access rate more profitable in Ghana.

Table 3 also shows a fall of 8.59 kWh per capita in electricity consumption when national income increases in the short run but does not influence it in the long run. This result contradicts the expected sign but can be explained by the fact that higher income levels mean the country is advancing with better productive technologies which improve efficiency and reduce the consumption of electricity (Bhattacharyya, 2011).

The human development index (HDI) only influenced the consumption of electricity in the long run. This is explained by the fact that development takes time to manifest and it is mostly a long-run phenomenon. It shows that an increase in Ghana's HDI improved the consumption of electric power by 13.1 kWh per capita. This finding presupposes that advances in Ghana's development will improve its electricity infrastructure, increase access rate and enhance electricity consumption.

The population of Ghana had a positive effect on electricity consumption in both the short and the long run. The result shows that a percentage increase in Ghana's population increased the consumption of electricity by 32.50 kWh per capita and 5.47 kWh per capita respectively for the short and the long run. This is expected as increases in population increase the total demand and load on electricity. In the end, more electricity would have to be consumed with each increase in population.

5. Conclusion

This study concludes that there is a positive nexus between electricity consumption and electricity access in Ghana despite the low uptake and erratic power supply. Again, increases in national income reduce electricity consumption while increases in HDI and population increase it. Despite the positive nexus between Ghana's electricity access and its electricity consumption, efforts must be made to eliminate other barriers that prevent Ghanaians from actually connecting to power. It is also recommended that policies that encourage education among women must be enhanced to reduce their childbearing years, reduce population growth and reduce pressure on electricity infrastructure. The use of efficient electric appliances must also be encouraged to save electricity and increase productivity.

References

Abeberese, A.B., Ackah, C.G., & Asuming, P.O. (2021). Productivity losses and firm responses to electricity shortages: Evidence from Ghana. *The World Bank Economic Review*, *35*(1), 1-18.

Ackah, I., Adu, F., & Takyi, R.O. (2014). On the demand dynamics of electricity in Ghana: Do exogenous non-economic variables count? *International Journal of Energy Economics and Policy*, *4*(2), 149.

AytaÇ, D., & Guran, M.C. (2011). The relationship between electricity consumption, electricity price and economic growth in Turkey: 1984–2007. *Argumenta Oeconomica*, *2*(27), 101-123.

Bhattacharyya, S. (2011). Energy Economics: Concepts, Issues, Markets and Governance. Springer-Verlag London Limited.

Blimpo, M.P & Cosgrove-Davies, M. (2019). Electricity Access in Sub-Saharan Africa: Uptake, reliability, and complementary factors for economic impact. International Bank for Reconstruction and Development / The World Bank, Washington, DC.

Dramani, J.B., Tandoh, F. & Tewari, D.D. (2012). Structural breaks, electricity consumption and economic growth: Evidence from Ghana. *African Journal of Business Management*, *6*(22), 6709-6720.

Energy Commission of Ghana (2020). Annual Report for 2020. Accra, Ghana.

Kemausuor, F., & Ackom, E. (2017). Toward universal electrification in Ghana. *Wiley Interdisciplinary Reviews: Energy and Environment*, *6*(1), e225.

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development*, 401-403.

Kumi, E.N. (2017). The Electricity Situation in Ghana: Challenges and opportunities (p. 30). Washington, DC: Center for Global Development.

Kwakwa, P.A. (2018). On the determinants of electricity power losses: Empirics from Ghana. *OPEC Energy Review*, *42*(1), 3-21.

Mensah, J.T. (2016). Bring back our light: Power outages and industrial performance in sub-Saharan Africa (No. 333-2016-14636).

Sami, J. (2011). Multivariate cointegration and causality between exports, electricity consumption, and real income per capita: Recent evidence from Japan. *International Journal of Energy Economics and Policy*, *1*(3), 59-68.

Sarkodie, S.A. (2017). Estimating Ghana's electricity consumption by 2030: An ARIMA forecast. *Energy Sources, Part B: Economics, Planning, and Policy*, 12(10), 936-944.

Sims, C.A. (1980). Macroeconomics and reality. *Econometrica: Journal of the Econometric Society*, 1-48.

Slowman, J., and Wride, A. (2009). Elements of Economics. Seventh Edition, Prentice Hall.

Twerefo, D.K., Akoena, S.K.K., Egyir-Tettey, F.K., and Mawutor, G. (2008). Energy consumption and economic growth: Evidence from Ghana. Department of Economics, University of Ghana, Ghana.

Twerefou, D.K., & Abeney, J. O. (2020). Efficiency of household electricity consumption in Ghana. *Energy Policy*, 144, 111661.

Wolde-Rufael, Y. (2006). Electricity consumption and economic growth: a time series experience for 17 African countries. *Energy Policy 34*(1), 1106–14.

World Bank Development Indicators (2020).

Yakubu, O., Babu, N., & Adjei, O. (2018). Electricity theft: Analysis of the underlying contributory factors in Ghana. *Energy Policy*, *123*, 611-618.

Yoo, S. H. (2006). The causal relationship between electricity consumption and economic growth in the ASEAN countries. *Energy Policy*, *34*(18), 3573-3582.

Zhao, Q., Chen, Q., Xiao, Y., Tian, G., Chu, X., & Liu, Q. (2017). Saving forests through development? Fuelwood consumption and the energy-ladder hypothesis in rural southern china. *Transformations in Business & Economics*, *16*(3).