An Empirical Analysis of Electricity Demand in Sub-Saharan Africa

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Abstract:

Reliable power supply is required in order to achieve socio-economic growth and development in Sub-Saharan Africa (SSA). Recent statistics show that only one-third of the entire population in the region have access to electricity, making the region the highest in the world with people without access to modern energy. However, the region is endowed with abundant energy resources to provide the needed electricity. The purpose of this study is to identify and analyse the main determinants of electricity demand in SSA. Reliable secondary macroeconomic data were collected from publicly available and widely used sources. The data collected were analysed using Fixed Effects, Random Effects and Prais-Winsten panel data models. The results revealed that income, urbanisation and population are the main determinants of electricity demand in SSA. The study further revealed that population is the predominant factor behind electricity demand, with the highest elasticity. This study would be beneficial as an understanding of the factors that influence electricity demand through the reported elasticities, can help policymakers prepare evidence-based and more effective energy demand management, to meet the electricity need of consumers in the region. The study recommends the need for stringent energy conservation policies through effective energy efficiency practice, to ensure that increase in energy use does not lead to further greenhouse gas (GHG) emission, and the electricity produced is well utilised.

Keywords: Electricity demand, Energy demand, Panel data model, Renewables, SSA

Introduction

Energy demand modelling plays a crucial role in effective energy planning, strategy formulation and sound energy policy recommendations (Bhattacharyya and Timilsina, 2010). The theory of demand provides a useful account of how changes in income and other factors, which influence the demand for energy, can be modelled. This has been used to model energy demand in both developed and developing countries.

The need for a comprehensive and up-to-date electricity demand modelling in Sub-Saharan Africa (SSA) is due to many compelling reasons. First, the population of SSA is estimated by the World Bank to be 936.1million, which is 13% of the World population (Kebede *et al*., 2010). However, the stated population only accounts for 4% of the total global energy consumed (IEA, 2014). Most of the energy consumed is derived from solid biomass like fuelwood and charcoal which accounts for more than 75% of the total energy consumed in the region (Lambe *et al.*, 2015). Second, the majority of the population in SSA live in rural areas but the last few decades have recorded an increase in urban population, from 22.1% in 1980 to 37% in 2014 (World Bank, 2014). Third, the slump in commodity prices has reduced the GDP from an average of 6% recorded in the last decade to 3.5% in 2015 (Newiak, 2016). A slower growth rate of 3% is projected for 2016 due to low commodity prices, which is slightly under the global projection of 3.2% (IMF World Economic Outlook, 2016). Moreover, the region has remained the poorest region in the world due to a higher increase in population than GDP growth (Newiak, 2016). The top 10 countries with the highest fertility rates in the world are in SSA (PRB, 2013). The number of young people between the age of 10 and 24 in SSA are the highest in the world, currently at 324.5 million which is expected to increase to 436 million in 2025 (UNFPA, 2012).Third, the region is endowed with all the natural resources which can be used to provide the energy needed by consumers, however, the annual per capita electricity consumption of the 47 Sub-Saharan African countries is the lowest in the world at 518 kWh (Rosnes and Vennemo, 2012). This amounts to 25 days of electricity consumption in the OECD with 34 countries (IEA, 2008).

Fourth, low electrification rate across the region, also shows that the energy sources have not being utilised efficiently. Specifically, about 600 million people in Sub-Saharan Africa lack access to electricity (Onyeyi, 2014) and when compared to the rest of the world and other developing regions, the region has the highest number of people without access to electricity. In contrast to other regions such as Developing Asia, Latin America and Middle East, statistics shows access to electricity are 86%, 95% and 92% respectively (IEA, 2013).

Lastly, studies have also predicted that there will be a $15 increase in the SSA GDP for each dollar invested in the Sub-Saharan Africa power sector (IEA, 2014). This analysis supports the view that energy is a necessary but not a sufficient condition for the economic growth of a country, and also the fact that people shift towards modern energy sources as their income increases (Brew-Hammond, 2007). This may also suggest that the widespread poverty (70% of the people in Sub-Saharan Africa live on less than US$2 per day, UNICEF 2014), unemployment, deficient healthcare, struggling small and medium scale enterprises and the few industries in the region can all perform better to improve the social and economic development of the region, if there is adequate power supply. In other words, for a sustainable development in the region, reliable electricity supply is needed. The relationship between economic growth and energy consumption has been the focus of some research in developing countries, and Sub-Saharan African countries with several authors exploring the causality between economic growth and energy consumption (see, Kraft and Kraft, 1978; Kouakou, 2011; Akinlo, 2008; Adebola, 2011; Odhiambo, 2009).

The key objective of this paper therefore is to investigate the impact of the driving forces of electricity demand in SSA, in order to aid electricity demand management and planning. To achieve this goal, an up-to date electricity demand analysis in Sub-Saharan Africa is explored. In other words, the impact of income, urbanisation, population and economic structure on the demand for electric energy in SSA is investigated and presented in this study. The data for the study is a panel dataset over the period 1980 to 2013. The findings can facilitate the development of appropriate policy framework for meeting the energy need of consumers in SSA, while also enabling informed investment decisions in the development of interregional capital intensive energy systems in the region. In addition, the study will clarify for both policy makers and researchers as to whether self-sufficiency or regional integration and cooperation of energy supply, is the best policy target to end the energy crisis. Regional integration and cooperation of energy supply is proposed by the International Energy Agency (Africa Energy Outlook, 2014) as one of the ways to end energy poverty in SSA.

The remaining part of the paper proceeds as follows. In the section that follows, the literature review is presented. The first sub-section gives an account of the electricity generation sources in SSA, while the second part of Section 2 provides a brief review of the empirical literature on electricity demand. Section 3 discusses the econometric framework employed in the analysis. Section 4 discusses the findings. The paper is concluded in the last Section.

Literature review

Electricity generation sources in SSA

The construction of electricity generating plant is a highly capital intensive project which requires ample expertise and time. To be specific, an annual investment of US$40.8 billion in Sub-Saharan Africa's (SSA) power sector has been estimated to be required to meet the electricity need of consumers in the region (Eberhard *et al.,* 2016). However, availability of natural resources is important to make an informed decision on the generation method to be employed. The vast amount of renewable and non-renewable energy sources in Sub-Saharan Africa (SSA) have been identified by researchers and reports published by both private and public organisations in the region and globally. Most of them argue that the available energy resources are in abundance and could be employed to meet both the present and future energy need in the region (Kebede *et al.,* 2010, KPMG, 2013; Onyeji, 2014; IEA, 2014). A special report by the International Energy Agency on Africa's energy outlook (IEA, 2014) states that the proven oil, gas and coal reserves in the region would be sufficient for another 100, 600 and 400 years respectively. Oil production is led by Nigeria and Angola, but most of the oil and gas reserves are located in the western regions (Kebede *et al.,* 2010).

The river systems in Africa are among the largest in the world and account for about 13% of the total hydropower potential available globally. Likewise, there are large coal deposits in the Southern parts. Further, several studies support the fact that solid biomass is a dominant domestic fuel for cooking, drying and heating in Sub-Saharan Africa, and is also a key renewable energy source in the region (Kebede *et al.,* 2010; Brew-Hammond, 2007; Karekezi, 2002). This may be explained by the high use of traditional biomass by the majority of the population in the residential sector, and also the availability of forest resources, which is evident by the fact that 33% of the landmass in Sub-Saharan Africa is dominated by forest.

Considering that energy sources are not equally distributed across the countries in SSA, regional integration and cooperation of energy supply may help to reduce the financial burden on individual countries of building their own generation capacities. In addition, it offers the governments the opportunity to invest in the cheapest and cleanest source of electricity generation plants. Examples of renewable sources that could be used to produce clean energy include the huge hydro potential in the Central African region, coastal area vast wind energy and the eastern part huge geothermal sources.

Empirical literature

Several attempts have been made at estimating energy demand, with researchers using various methods and obtaining different results, which have either confirmed or contradicted earlier findings. The empirical model used in this study is based on the knowledge gained from the review of some of the existing literature on electricity demand. Specifically, various models which analyse electricity demand in developing regions are reviewed and used to provide a framework for the empirical analysis in this study. Energy models in the energy literature have been classified in several ways, such as static or dynamic, univariate or multivariate, top down or bottom up, identity versus structural or market share based approaches and forecasting models (see, Jebaraj and Iniyan, 2006; Urban *et al.*, 2007; Swan and Ugursal, 2009; Suganthi and Samuel, 2012). Pesaran *et al.* (1998) classified energy models into three main classes. The authors argued that the structural engineering approach, end-use approach or the econometric approach provide the best frameworks for the estimation of energy demand and associated analysis.

For brevity, **Table 1** presents the estimated price and income elasticities from existing studies in the literature. Most of the reviewed studies are either on electricity or disaggregated study of energy demand in individual countries. However, to fully implement an integrated and regional energy trade, it is important to understand fully the economic and non-economic determinants of electricity demand in SSA. In line with this, this study seeks to fill the identified gap in the literature by providing a comprehensive and up-to-date analysis of the determinants of electricity demand in SSA.

Table 1: Table showing the empirical results of selected studies on electricity demand

Reference	Fuel type	Regressors	Price LR	Income LR	Period	Method	Country
Diabi (1998)	Electricity	Price income Urbanisation Appliances price Weather	0.01	0.09	1980-1992	OLS	Saudi Arabia
Lundmark *et al.* (2001)	Electricity	Income Coal prices Electricity price	0.51	0.86	1980-1996	OLS	Namibia
De Vita *et al.* (2006)	Energy Electricity Petrol Diesel	Price Income Air temperature HIV/AIDS rate	-0.34 -0.30 -0.86 -0.11	1.27 0.59 1.08 2.08	1980-2005	ARDL	Namibia
Amusa *et al.* (2009)	Electricity	Price Income	-11.41	1.67	1960-2007	ARDL	South Africa

Reference	Fuel type	Regressors	Price LR	Income LR	Period	Method	Country
Adom (2013)	Electricity	Income Economic structure Industry electricity		2.12	1971-2008	Phillip-Hansen	Ghana
Adom and Bekoe (2013)	Electricity	Income Industry output Industry energy efficiency Urbanisation		0.81	1971-2008	Phillip-Hansen	Ghana
Dramani and Tewari (2014)	Residential Electricity	Price Income Urbanisation Intensity of residential consumption	-0.08 -0.15 -0.14	0.94 0.44 1.38	1970-2010	ARDL FMOLS DOLS	Ghana
Mensah *et al*. (2016)	Gasoline Diesel LPG Kerosene Biomass Electricity	Price Income Urbanisation Economic structure	-0.55 0.32 -0.26 -0.48 -0.76	1.32 3.56 2.77 -3.63 -0.59 2.71	1979-2013	ARDL	Ghana

Model specification, data and methodology

The main economic theory used by researchers for the study of energy demand, is based on the neo-classical economic theory of consumers utility optimising behaviour (Bhattacharyy and Timilsina, 2010; Dramani and Tewari, 2014). This is employed within utility theory and consumer behavior in a microeconomic context, in the form of a household production function, or utility maximisation function. The microeconomics concept is used as the framework for the analysis at the macro level. The traditional approach assumes a functional relationship between energy demand and the two key regressors of income and price. However, recent studies have employed different specifications of the model because the underlying theory does not give a definite structure of the function.

The demand function for electricity demand in SSA is analysed in the study, a log-linearized model implemented by De Vita *et al*. (2006), Zuresh and Peter (2007), Adom *et al*. (2012) and Mensah *et al*. (2016) is adapted. We specify the electricity demand function as:

$$lnEC_{it} = \alpha_0 + \alpha_1 lnY_{it} + \alpha_2 lnP_{it} + \alpha_3 lnUrB_{it} + \alpha_4 lnES_{it} + \rho_t \quad (1)$$

where $lnEC_{it}$ is the natural log transformation of electricity consumption in country i at time t; lnY, lnUrB, lnP and lnES stands for the logs of: income (GDP/Capita), urbanisation, population and economic structure in country i at time t, respectively. The demand elasticities are measured by parameter α while the white noise is captured $by\ \rho$. The model is analysed using the Statistical Software STATA 13.

A Prior, we expect the following in terms of the sign of the estimated parameters and hence the expected relationship between the variables analysed in the present study.

H1: We expect a positive income elasticity, as the income level of consumers goes up, they increase the amount of commodities in their consumption bundle which includes electric energy.

H2: Growth in urban population (urbanisation) is expected to have a positive impact on the amount of electricity consumed. This is because as people move from rural to urban areas, it is assumed that they switch from traditional forms of energy like solid biomass to modern energy types like electricity.

H3: A positive relationship is expected between electricity demand and economic structure. Considering that a country economic structure is derived by using the share of industrial value added to the service value added, which is used to measure the impact of structural changes in the countries. An increase in industrial share or output will increase the amount of electricity consumed.

H4: An increase in population will increase the amount of electricity used in SSA by consumers. Therefore, we expect a positive relationship between electricity demand and population.

Table 2**:** Description of the variables employed in the analysis for the period 1980-2013

Variable	Definition	Unit of measurement	Data source
Population (P)	Total population of a country	Number	World Bank (2015)
GDP per Capita (Y)	Gross domestic product divided by mid year population	US$ in PPP (2005 prices)	World Bank (2015)
Urbanisation (UrB)	The people living in the urban areas of a country out of the total population	Percent	World Bank (2015)
Economic Structure (ES)	Real value added in industry divided by that of the real value added in service sector	Percent	Calculated using data from World Bank (2015)
Electricity (EC) demand	Total electricity consumed by all sectors in the country	Gigawatt hour (GWh)	IEA (2015)

The following 12 countries are analysed for the period between 1980 and 2013 in SSA due to data constraints: Benin, Botswana, Cameroon, Congo, Democratic Republic of Congo, Ethiopia, Nigeria, Senegal, South Africa, Sudan, Togo and Zambia.

Table 3 presents the summary statistics of the variables employed in the analysis. The mean value of the log of population has the highest log mean value of 16.42 while the income variable proxy by real GDP per capita has a log mean value of 6.65.

Table 3**:** Summary statistics of the variables used in the regression analysis

Variable		Mean	Std Dev	Min	Max	Obs
lnIncome	Overall	6.65	1.00	4.74	8.92	407
	Between		0.12	6.45	6.95	
	Within		0.10	4.85	8.66	
lnUrban	Overall	1.34	0.40	0.09	2.66	408
	Between		0.17	1.15	1.62	
	Within		0.36	0.07	2.42	
lnEconomy	Overall	-0.44	0.76	-1.70	1.49	406
	Between		0.10	-0.67	-0.26	
	Within		0.75	-1.96	1.45	
lnPop	Overall	16.42	1.28	13.81	18.97	408
	Between		0.27	15.96	16.85	
	Within		1.25	14.09	18.58	
lnElect	Overall	7.71	1.73	4.23	12.25	406
	Between		0.44	7.02	8.57	
	Within		1.68	4.84	12.18	

Fig. 1 shows the plots of the data for electricity consumption series for the 12 analysed countries in SSA. The visual inspection of the plots suggests no major or persistent structural break is present in the series.

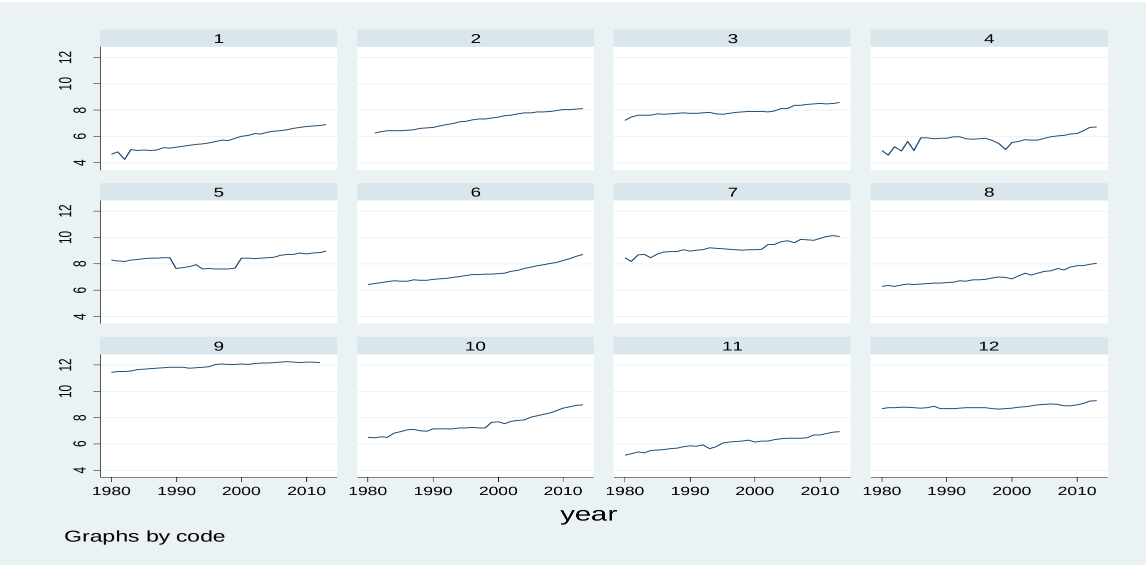

Fig. 1. Graphical illustration of electricity consumption variable series used in the analysis

The research analyses the determinants of electricity demand in SSA using three different estimation techniques: Fixed Effects (FE), Random Effects (RE) and Prais-Winsten (PW). The model in equation (1) above is analysed using three linear panel model techniques- FE, RE and PW models. The results are presented in the section that follows.

Estimation Results

The results of the linear panel models used to analyse the determinants of electricity demand in SSA are presented in a table in this section of the paper. The correlation matrix of the model is first presented to rule out any serious issue of multicollinearity. Table 4 indicates that there is no problem of multicollinearity among the variables analysed. Since none of the coefficient value is higher than 0.75 using the Tabachnich and Fidell's (2007) cut-off line, we do not have a multicollinearity issue. The highest correlation was between log of electricity and log of population (equal to 0.62).

Table 4: Correlation matrix of the variables used in the analysis

	lnIncome	**lnUrban**	**lnEconomy**	**lnPopulation**	**lnElectricity**
lnIncome	1.00				
lnUrban	-0.30	1.00			
lnEconomy	0.33	0.11	1.00		
lnPopulation	-0.32	0.02	-0.01	1.00	
lnElectricity	0.40	-0.33	0.09	0.62	1.00

Figure 2 shows that there is a positive relationship between the log of electricity consumption and the log of income from the analysed data in SSA. This is in line with our *a priori* assumption that electricity consumption will increase with an increase in income of the consumers in SSA.

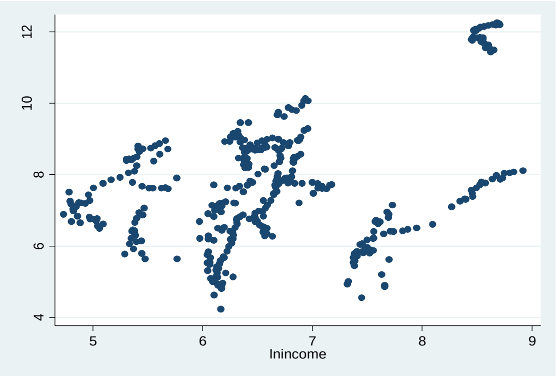

Fig. 2. Scatter plot of log of electricity consumption and log of income

In Table 5, Fixed Effects (FE) model was chosen over the Random Effects (RE) model by the Hausman test performed. Going with the test statistic of using fixed effects model if the p-value is < 0.05, and in the analysis result we had a p-value of 0.000. Since, the p-value of 0.000 is less than 0.05, we can safely accept the hypothesis that the fixed effects model is appropriate. However, despite the selection of the fixed effects model, its regression estimates may not be the best linear unbiased estimator (BLUE) because of the evidence of the presence of heteroscedasticity.

Table 5: Estimation results for electricity demand models

Variables	FE (1)	RE (2)	PW(3)
Constant	-20.951***	-20.39***	12.583***
	(-25.40)	(-24.07)	(-10.73)
lnY	0.545***	0.585***	0.595***
	(11.96)	(12.74)	(10.31)
inUrb	-0.113***	-0.121***	-0.242***
	(-3.10)	(-3.22)	(-2.63)
lnES	0.089***	0.085**	-0.009
	(2.60)	(2.41)	(-0.24)
lnPOP	1.537***	1.487***	1.015***
	(34.10)	(33.37)	(17.25)
R^2			0.8239
Within	0.822	0.821	
Between	0.595	0.618	
Overall	0.610	0.631	
Autocorrelation test		1.492	
Heteroscedasticity	869.52***		
Observations	404	404	404

Note: *** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$, FE stands for Fixed Effects, RE stands for Random Effects, PW represents Prais-Winsten estimation with heteroscedastic panel-corrected standard errors and ln stands for natural logarithm

Interestingly, from the result of the Wooldridge's test for autocorrelation, no autocorrelation was found in the model. This would suggest that the random effects model estimates may be efficient if chosen by the Hausman test. However, since the fixed effect model was chosen we need to use an estimator that can correct for heteroscedasticity found in the model. The Prais-Winsten (PW) model is adopted to obtain more efficient estimates.

According to the PW model shown in the last column of Table 5 above, the income elasticity of electricity demand is positive, inelastic and strongly significant. That is, a 1% increase in income increases electricity consumption by approximately 0.60%. But the degree of urbanisation elasticity is against our *a priori* assumptions. There was no increase in electricity consumption associated with urbanisation. Instead, we find that a unit increase in urbanisation reduces electricity consumption by 0.24%, and the estimated coefficient is significant at the 1% statistical level.

The results also show that population is a key and significant factor behind electricity consumption in SSA. Specifically, a 1% increase in population size is expected to lead to a 1.02% increase in energy demand. On the other hand, economic structure is not found to be a statistically significant factor driving electricity consumption in SSA.

These results suggest that the demand for electricity is relatively inelastic to changes in income and urbanisation, while it is has unit elasticity to changes in the size of the population.

Discussion of findings

This study sets out with the aim of estimating the coefficients of the identified driving forces of electricity demand in SSA. We found that the main significant driving forces of electricity demand in the long run for the analysed countries in SSA are income, degree of urbanisation and population. The positive relationship found between income and electricity demand is supported by the findings of several empirical studies in the literature. These results are consistent with those obtained by Expo *et al.* (2011), who reported an income elasticity of electricity of 0.58 in Ghana, and De Vita *et al.* (2006) who reported 0.59 as the income elasticity of electricity in Namibia. Clearly, the income elasticity of electricity demand is inelastic and positive in the long run in SSA.

The explanation given for the results by most of the studies mentioned above is that as the income of consumers' increases, they are able to buy more gadgets and appliances which need electric power to function and this eventually leads to an increase in the demand for electricity. This view is supported by the findings in this study and it further shows that as the standard of living improves, the population will consume more electricity.

Surprisingly, the degree of urbanisation was found to have a negative relationship with electricity demand in SSA in our analysis. Although, this result differs from some published studies in the literature (Zuresh and Peter, 2007; Adom *et al.*, 2012), it is consistent with that of Adom and Bekoe (2013). Considering that most of the countries analysed are in the low income group, it has been suggested that the negative sign of the urbanisation coefficient may be due to 'urban compaction' (Poumanyvong and Keneko, 2010). According to the authors, the negative sign is likely to be due to the fact that most of the countries lack access to public infrastructure which may need more energy if the number of access areas increases. This explanation is in line with our findings, as most public services like rail lines, well equipped hospitals, uninterrupted power supply, to name but a few, which are obtainable in most big cities in the world, are not available in most of the urban cities in SSA.

The result of the positive relationship between electricity consumption and population size confirms the association between energy use and population growth. The elasticity shows a relatively elastic relationship, which would mean that for every percentage increase in population; there will be 1.02% increase in the demand for electricity. This finding has many important implications for SSA countries because of the prevailing high fertility rates. The availability of electricity for the whole region will be a huge task because of the high amount of capital investment required, and the pace of providing electricity may not be able to meet up the high rate of population growth. A report by the World Bank asserts that the amount of power available per person in SSA has reduced in the last few decades because population growth has been higher than investments in generation capacity (World Bank, 2010). The result of the population elasticity presented is similar to Kebede *et al.* (2010) who also found a positive relationship between electricity demand and population in SSA.

Conclusion and policy implications

In this study we examined the determinants of electricity demand in Sub-Saharan Africa (SSA) over the period 1980 to 2013, for 12 countries in the region. Our results revealed that population is the predominant factor behind the increase in electricity demand in SSA, with the highest elasticity. Further, electricity demand in SSA conforms to *a priori* expectation of positive income elasticity. However, negative impact of urbanisation on electricity demand is found, against our expectation. Economic structure elasticity is found to be negative and statistically insignificant in the study.

Our findings appear to have important policy implications for a developing region such as SSA. First, there is need to promote regional integration and cooperation of energy supply to meet the need of consumers. As reviewed in the literature, by investing in regional power generation, the countries can benefit from economies of scale, lower investment costs and wider choice. The revenue needed for the projects can be generated from both private and public sources since consumers will demand for electricity if it is made available. Second, according to the findings, increase in population will increase electricity demand in the region. Therefore, there is need for stringent energy conservation policies through effective energy efficiency practice, to ensure that increase in energy use does not lead to more greenhouse gas (GHG) emission and the produced electricity is well utilised. For instance, the government should ensure that appliances and gadgets sold to consumers comply with recommended energy efficiency standards by the relevant agencies. Lastly, the countries in SSA can reduce their overall carbon emission by investing in cleaner sources of power generation techniques using the vast renewable sources available in the region.

REFERENCES

Adebola, S. (2011) 'Electricity consumption and economic growth: Trivariate investigation in Botswana with capital formation', *International Journal of Energy Economics and Policy*, 1 (2), pp. 32- 46.

Adom, P., and Bekoe, W. (2012) 'Modelling aggregate domestic electricity demand in Ghana: an autoregressive distributed lag bounds cointegration approach', *Energy Policy*, 42 pp. 530–537.

Adom, P., Bekoe, W., and Akoena, S. K. (2012) 'Modelling aggregate domestic electricity demand in Ghana: An autoregressive distributed lag bounds cointegration approach', *Energy Policy*, pp.530-537.

Amusa, H., Amusa, K., and Mabugu, R. (2009) 'Aggregate demand for electricity in South Africa: An analysis using the bounds testing approach to cointegration', *Energy Policy*, pp.4167- 4175.

Akinlo, A. E. (2008) 'Energy consumption and economic growth: evidence from 11 African Countries', *Energy Economics*, 30, pp.2391-2400.

Bhattacharyya, S., and Timilsina, R. (2010) 'Modelling energy demand of developing countries: Are the specific features adequately captured?' *Energy Policy*, pp.1979-1990.

Brew-Hammond, A. (2010) 'Energy access in Africa: challenges ahead', *Energy Policy*, 38, pp. 2291-2301.

De Vita, G., Endersen,, K., and Hunt, L. C. (2006) 'An empirical analysis of energy demand in Namibia', *Energy Policy*, 34(18), pp.3447-3463.

Dramani, J. B., and Tewari, D. (2014) 'An econometric analysis of residential electricity demand in Ghana', *Mediterranean Journal of Social Sciences*, pp.209-222.

Diabi, A. (1998) ‘The demand for electric energy in Saudi Arabia: an emprical investigation’, *OPEC Review*, pp13-24.

Eberhard, A., Gratwick, K., Morella, E. and Antmann, P. (2016) *Independent Power Projects in Sub-Saharan Africa; Lessons from Five Key Countries.* 1st ed. Washington DC: World Bank.

Expo, U., Chuku, C. A., and Effiong, E. L. (2011) ‘The dynamics of electricity demand and consumption in Nigeria: application of the bounds testing approac’. *Current REsearch Journal of Economic Theory’*, pp.43- 52.

IEA, 2008. In: World Energy Outlook. International Energy Agency (IEA), Paris.

IEA, 2012. In: World Energy Outlook. International Energy Agency (IEA), Paris.

IEA, 2015. In: World Energy Outlook. International Energy Agency (IEA), Paris.

IEA, 2014. In: World Energy Outlook 2014 Special Report: Africa Energy Outlook, International Energy Agency (IEA), Paris.

International Monetary Fund (2016): World Economic Outlook (2016).

Lundmark, R. (2001) ‘Changes in Namibia’s energy market’, *Scandinavian Journal of Development*, pp.103- 112.

Jebaraj, S., and Iniyan, S. (2006) ‘A review of energy models’, *Renewable and Sustainable Energy Reviews*, pp.281-311.

Karekezi, S. (2002) ‘Poverty and energy in Africa- A brief review’, *Journal of Energy Policy*, 30, pp. 915-919.

Kebede, E., kagochi, J. and Jolly, C. M. (2010) ‘Energy consumption and economic development in Sub- Sahara Africa’, *Energy Economics*, 32, pp. 532- 537.

Kessides, I. (2014) ‘Powering Africa's sustainable development: The potential role of nuclear energy’, *Energy Policy*, 74, pp. 557-570.

Kouakou, A. (2011) ‘Economic growth and electricity consumption in Cote d’Ivoire: Evidence from time series analysis’, *Energy Policy*, 39, pp. 3638-3644.

KPMG. (2013) Oil and gas in Africa, Africa’s Reserves, Potential and Prospects.

Kraft, J. and Kraft, A. (1978) ‘On the relationship between energy and GNP’, *Journal of Energy and Development’*, 3, pp. 401- 403.

Lambe, F., Jürisoo, M., Wanjiru, H., and Senyagwa, J. (2015) ‘Bringing clean, safe, affordable cooking energy to households across Africa: an agenda for action’, Prepared by the Stockholm Environment Institute, Stockholm and Nairobi, for the New Climate Economy. Available at: http://newclimateeconomy.report/misc/working-papers.

Mensah, J.T., Marbuah, G., and Amoah, A. (2016) ‘Energy demand in Ghana: A disaggregated analysis’, *Renewable and Sustainable Energy Reviews*, pp.924-935.

Newiak, M. (2016) Weakening Growth in Sub-Saharan Africa Calls for Policy Reset. IMFSurvey Magazine: Countries and Regions, 3 May.

Odhiambo, N. (2009) ‘Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach’, *Journal of Energy Policy*, 37, pp. 617-622.

Onjeyi, I. (2014) ‘Harnessing and integrating Africa’s renewable energy resources’, *New Energy Insights*, 3, pp. 27-38.

Pesaran, M., Smith, R., and Akiyama, T. (1998) Energy demand in Asian economies. Oxford: Oxford University Press.

Poumanyvong, P. and Kaneko, S. (2010) ‘Does Urbanisation lead to less energy use and lower CO2 emissions? A cross-country analysis’, *Ecological Economics*,70, pp. 434- 444.

Rosnes, O., and Vennemo, H. (2012) ‘The cost of providing electricity to Africa’, Energy Economics Journal, 34, pp. 1318-1328.

Suganthi, L., and Samuel, A. (2012) ‘Energy models for demand forecasting- A review’, *Renewable and Sustainable Energy Reviews*, pp.1223-1240.

Swan, L., and Ugursal, V. I. (2009) ‘Modeling of end-use energy consumption in the residential sector: A review of modeling techniques’, *Renewable and Sustainable Energy Reviews*, pp.1819-1835.

Tabachnick, B.G and Fidell, L.S. (2007) Using Multivariate Statistic, 5th edn. Boston: Pearson Education, Inc.

Urban, F., Benders, R. M., and Moll, H. C. (2007) ‘Modelling energy systems for developing countries’, *Energy Policy*, pp.3473-3482.

(UNFPA), U. N. P. F., 2012. Status Report, Adolescents and Young People in Sub-Saharan Africa; Opportunities and Challenges.

World Development Indicators, World Bank: http://data.worldbank.org/region/SSA, accessed 5 December, 2015.

Zuresh,A., and Peter, H.(2007). ‘Electricity demand in Kazakhstan’, *Energy policy*, 3729-3743.