Asian Bulletin of Energy Economics and Technology
ISSN : 2313-819X
Vol. 1, No. 1, 1-6, 2014
http://www.asianonlinejournals.com/index.php/ABEE

Energy Consumption in Ghana and the Story of Economic Growth, Industrialization, Trade Openness and Urbanization

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Abstract

Energy has become increasingly very essential for the growth and development of every nation. However, in Ghana there is a shortfall of energy supply amidst growing demand. Using data from the World Bank Indicators, the study therefore investigates the impact of growth, industrialization, urbanization and trade openness on the energy consumption in Ghana. A Johansen cointegration test shows a long-run relationship exist among all the variables. In the short run, trade openness reduces energy consumption, while income and industrialization increases consumption. The coefficient of urbanization was found to be positive though was not significant. In the long-run trade openness and urbanization increased energy consumption while income reduces energy consumption. The error correction term shows an average or moderate speed of adjustment implying that after a shock from previous year; approximately 50% of the disequilibria from the previous year's shock converge back to the long-run equilibrium in the current year. Conclusions and policy recommendations are provided.

Keywords: Energy demand/consumption, Trade openness, Industrialization, Income, Urbanization, Cointegration
JEL Classification: C3, O4, Q43, Q4, Q5.

1. Introduction

The importance of energy to the growth of an economy is well known in the literature that has examined the energy-growth nexus. At the economy wide level, energy is needed by the transport sector, agricultural sector, public and commercial services and industrial sector for their operation. Energy provides a means for households to achieve basic economic needs from cooking, lighting and washing to entertainment. Thus, energy has been recognized by Garg and Halsnæs (2008), United Nations (2005) and Mensah and Adu (2013) to play important role in achieving the MDGs. In this regard, the availability and reliability of energy supply in an economy cannot be overlooked.
However, in many developing countries like Ghana the energy supply has been very insufficient to meet the growing demand.

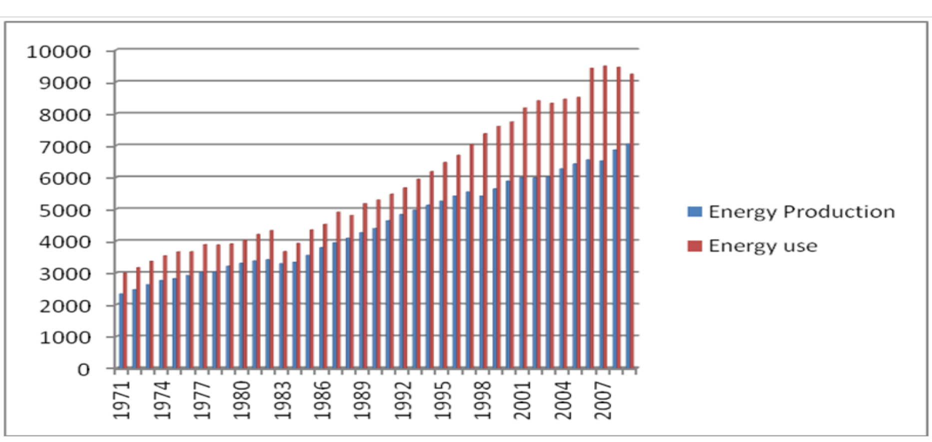

Figure-1. Energy production versus energy use in Ghana
Source: World Bank (2012)

Available data from the World development indicators by the World Bank shows that from 1970 to 2009 Ghana's energy usage has always been higher than what is produced (see figure 1). On the average, while energy production level in Ghana has been 4521.33, energy use has been 5819.137 indicating Ghana is unable to meet her demand for energy. At a time that efforts are being made to increase the number of people that have access to electricity in Ghana, electricity supply has been bedeviled with the problem of inadequate supply which has manifested itself in series of power rationing over the years.

The inadequate supply of oil, petroleum and natural gas products in the country manifest itself the long queues at various filling stations. The present situation does not paint a good picture about the energy security for the country in the future and this calls for measures that will help meet the growing demand for energy. To manage the demand side it is imperative to know what determine what may be driving energy demand over the years in Ghana. Few studies including Mensah and Adu (2013), Ackah and Adu (2014), Kwakwa *et al.* (2013), Adom and Bekoe (2012), Adom *et al.* (2012), Adom (2013) and Adom and Bekoe (2013) have examined the factors influencing energy demand in the country. However, these studies examined demand for a particular energy either at the household level (Kwakwa *et al.*, 2013), Mensah and Adu (2013), or at the national level (Adom and Bekoe (2012), Adom *et al.* (2012), Adom (2013) and Adom and Bekoe (2013), Ackah and Adu (2014)) and thus, do not provide information on the total energy demand situation for the country. This therefore calls for need for further studies that will unravel what determine total energy demand for Ghana. Following the above revelation, the current study aims at finding out the effect of some demographic and economic variables on the demand for energy in Ghana.

The outcome of this study is relevant for policy making. The reason is that it provides evidence on the need to come out with measures that will reduce energy consumption as countries open themselves up for international trade and as many developing countries are becoming more urbanized. It again offers the need to increase income so that in the long-run efficient usage of energy is met. This paper also contributes to the literature on demand for energy. The first is that though very little studies on aggregate demand for energy exist in Ghana, they have focused on electricity and gasoline. Studies that examine aggregate energy demand are limited and thus, the evidence from this study will add up to the existing literature which will be helpful for future studies.

The rest of this paper is organized as follows. In Section 2, we review literature on previous energy demand studies. In Section 3, we consider the data type and source and the method employed in the analysis. Lastly in Section 4, we provide a discussion of the empirical results; compares our result with others; make conclusions and policy recommendations in Section 5.

2. Brief Literature Review

This section reviews previous studies that have examined the determinants of energy for various economies. A survey of the literature shows scanty studies exist on aggregate energy but a plethora on various energy type at the national level. For instance De Vital *et al.* (2006) studied the determinants of aggregate and specific energy for Namibia using data for the period 1980 to 2002. Relying on the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration, it was found that energy consumption responds positively to changes in GDP and negatively to changes in energy price and air temperature.

Erdogdu (2007) examined aggregate electricity demand for Turkey. The author employed the cointegration analysis and autoregressive integrated moving average (ARIMA) modeling for a quarterly time series data (1984-2004). The conclusion from the study was that consumers respond to price and income charges is quite limited and also there has been over estimation of the electricity demand in Turkey. Again, Amusa *et al.* (2009) examined aggregate demand for electricity for South Africa and found that demand for electricity is greatly affected by changes in income; however, changes in the price of electricity had no effect on the demand for electricity. Ekpo *et al.* (2011) analyzed the demand for electricity in Nigeria using annual data for the period 1970-1980. The estimation from the ARDL model shows that in the long-run real GDP per capita, population and industrial output significantly drives electricity consumption but in the short-run while electricity price is not a significant determinant. Again, in the short-run, industrial output has a crowding out effect on the demand for electricity. A study by Alter and Syed (2011) for Pakistan concluded that effective price and income policies, group pricing policy and peak-load pricing policy should be exercised for electricity demand. The author used the Johansen cointegration test and the data was annual data 1970 to 2010.

Studies on the demand for aggregate crude oil and gasoline also exist. For instance Tsirimokos (2011)estimated the short-run and long-run price and income elasticities of crude oil demand in ten IEA member-countries for the time period 1980-2009. An econometric estimation showed that the consumption of oil in these countries is highly price inelastic both in short-run and long-run. In the long-run, income elasticities were found to be more elastic than price elasticities. Altinay (2007) study examined the short and long-run elasticities of demand for crude oil in Turkey for the time-span 1980-2005. The author relied on the autoregressive distributed lag (ARDL) bounds testing approach to cointegration and found that price has a negative effect on demand though it is inelastic for both short and long run periods. A positive income value was also found in the short and long-run periods. Dées *et al.* (2007) used the dynamic ordinary least-squares and error correction model to analyze the short run and long run demand respectively for the world oil market. They found that long-run income elasticities range from 0.17 to 0.98 while in the short-run those elasticities range from 0.0001 to 0.82. On the other hand the short-run price elasticities are very inelastic approaching zero. Also, Ramanathan (1999) study used the ECM to estimate the demand for gasoline in India and found that there is an elastic long and short run elasticities of income (1.12 and 2.68 respectively) but an inelastic price elasticities value of -0.32 in the long-run and -0.21 in the short-run.

In the case of Ghana, couple of studies on demand for energy exists. At the macro level Adom and Bekoe (2012), Adom *et al.* (2012), Adom (2013) and Adom and Bekoe (2013) found that demand for electricity in Ghana is determined by urbanization, income, industrial efficiency and economic structural change. Ackah and Adu (2014) also study also found that the long run price and income elasticities for gasoline demand to be -0.065 and 5.129

respectively. It is worth mentioning that earlier studies (see (Adom, 2011); (Kwakwa, 2012)) on energy at the aggregate level in Ghana focused on the energy-growth nexus.

3. Methodology

3.1. Model Estimation for Energy Consumption

The study specifies Ghana's energy consumption as a function of urbanization, economic growth, industrialization and trade openness based on previous energy demand models as follows:

$$EC=f\,(URB,\ Y,\ IND,\ TOP) \ \ldots\ldots\ldots\ldots\ldots\ (1)$$

Where, EC is energy consumption, URB is urbanization, Y is economic growth, IND is industrialization and TOP is trade openness.

Expressing equation (1) in log linear form gives:

$$LFC = B_0 + B_1 LURB + B_2 LY + B_3 LIND + B_4 LTOP \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

The $B_0$is the intercept term and the other *B's* are the estimated coefficient of the explanatory variables.The income variable is measured by annual growth rate of per capita income. This is expected to have a positive effect on energy consumption. Industrialization (industry share of GDP) thrives on energy and it is expected to positively increase energy demand. Urbanization is measured as the annual growth rate of the urban population and this is expected to increase and trade openness, the sum of export and import as share of GDP is expected to have positive effect on energy demandAnnual time series data spanning from 1971 to 2009 is used for the study. All variables namely income, urbanization, level of industrialization, trade openness and energy consumption are sourced from WDI 2012. The choice of the period and variables is determined by data availability.

3.2. Econometric Techniques

3.2.1. Unit Root/Stationarity and Cointegration Tests

"A stochastic process is said to be stationary, if its Mean, and Variance are constant overtime and the value of Covariance between two time periods depends only on the distance between the two time periods and not on the actual time at which the Covariance is computed" (Gujarati, 2003). The study tests the stationarity properties of the time series variables employed. This is to avoid the occurrence of unrelated regressions, sometimes known as spurious regressions. After all the variables are known to be stationary, then the cointegration test is conducted. This (cointegration) test is done to examine if there is a long run relationship among the variables. In the econometric literature; various approaches are employed in investigating the long-run equilibrium relationship among variables. However, the study used the approach by Johansen (1988) and Johansen and Juselius (1990) since that procedure is known to be the most reliable test for cointegration (Li *et al.*, 2013).

4. Analysis of Results

4.1. Unit Root ADF Test

The results of the unit root test as shown in Table1 indicate that all the variables are non-stationary in levels at both 1% and 5% critical levels. However, both levels conclude that all variables are stationary after their first difference. Thus, the time series variables are integrated of order one i.e. I (1) variables.

Table-1. ADF for Unit Root

Variable	t-statistic	1% critical value	5% critical value	Prob.	Order of Integration
LEC	-2.044560	-3.615588	-2.941145	0.2674	I (0)
LIND	-1.493458	-3.626784	-2.945842	0.5255	I (0)
LTOP	-1.008754	-3.626784	-2.945842	0.7397	I (0)
LURB	-1.323178	-3.615588	-2.941145	0.6088	I (0)
LY	-1.414031	-3.646342	-2.954021	0.5635	I (0)
DLEC	-6.395348	-3.621023	-2.943427	0.0000	I (1)
DLIND	-4.667842	-3.626784	-2.945842	0.0006	I (1)
DLTOP	-4.045630	-3.621023	-2.943427	0.0033	I (1)
DLURB	-3.975102	-3.621023	-2.943427	0.0040	I (1)
DLY	-6.005521	-3.646342	-2.954021	0.0000	I (1)

4.2. Cointegration

As reported in Table 2 and 3, both tests indicate that there is a consistently and stable cointegration among the variables. This implies that a long-run relationship exists among variables employed for the study during the sample period. Based on this confirmation, an error correction model (ECM) is used for the estimation.

Table-2. Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.666911	86.14180	69.81889	0.0015
At most 1	0.502622	46.56533	47.85613	0.0658
At most 2	0.261058	21.42272	29.79707	0.3318
At most 3	0.207866	10.53142	15.49471	0.2420
At most 4	0.057779	2.142540	3.841466	0.1433

Trace test indicates 1 cointegration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon *et al.* (1999) p-values

Table-3. Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalues	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.666911	39.57647	33.87687	0.0094
At most 1	0.502622	25.14261	27.58434	0.0995
At most 2	0.261058	10.89129	21.13162	0.6582
At most 3	0.207866	8.388883	14.26460	0.3405
At most 4	0.057779	2.142540	3.841466	0.1433

Max-eigenvalue test indicates 1 cointegration eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon *et al.* (1999) p-values

4.3. Short Run and Long Run Estimations for Energy Consumption

The result of the short run cointegration relationship between energy consumption on one hand and income, urbanization, trade openness and industrial activities on the other hand reveals that in the short run greater openness to trade will be associated with reduction in energy consumption while increases in industrial activities and national income levels will be accompanied by a rise in energy demand/consumption. Urbanization is however not statistically significant in the short run though it has a positive relationship with energy demand. In particular, the trade openness elasticity of energy demand is -0.072 implying that a 1% move towards greater openness to trade will require a 0.072% fall in energy demand in Ghana. However, 1% rise in industrial activities and national income levels respectively will be accompanied by a 0.0812%, and 0.0045% rise in energy demand/consumption. The sign on the income variable is consistent with Erdogdu (2007), Altinay (2007), Amusa *et al.* (2009), Alter and Syed (2011) and Ekpo *et al.* (2011) but disagrees with Dées *et al.* (2007). Also it satisfies the a-priori expectation and consistent with the theory that an increase in income will stimulate an increase in the demand for goods and services which are powered by various energy type such electricity, fossil, LPG etc. Similarly, the sign on the industrialization variable satisfies the a-priori expectation that an increase in industrial activities will demand for more energy to power the various plants and machinery employed in any industrial activity. This finding agrees with that of Ekpo *et al.* (2011), Adom *et al.* (2012), Adom (2013) and Adom and Bekoe (2013) who found industrial activities as significant drivers of energy.

Table-4. Short run impact on energy consumption in Ghana

Variable	Coefficient	Standard error	t- ratio	Probability
DLTO	-0.0720	0.0187	-3.8443	0.0006
DLIND(-1)	0.0812	0.0347	2.3444	0.0256
DLY (-1)	0.0045	0.0021	2.0823	0.0457
DURB(-1)	0.0260	0.01754	1.4846	0.1477
C	0.0055	0.0045	1.2339	0.2265
ECT(-1)	-0.4899	0.1078	-4.5448	0.0001

R-squared = 0.68; Adj. R-squared= 0.63; DW stat =1.73; F-stat= 13.45; Prob. (F-stat)= 0.0000

A detailed analysis of the results reveal that, the cointegration relationship established in the short run is reversed in the long run with the exception of urbanization which continues to have a positive relationship with energy demand and now significant in long run. That is, in the long run, higher income levels and industrial activities are associated with a fall in energy demand/consumption while greater openness to trade and greater urbanization will call for more energy demand consumption. Thus a 1% increase in trade openness and urbanization will increase energy consumption by 0.218% and 0.040% respectively whiles a 1% increase in income and industrialization will reduce energy consumption by 0.063% and 0.076% respectively. The long run impact of trade openness and urbanization is in line with Adom and Bekoe (2012), Adom *et al.* (2012), Adom (2013) and Adom and Bekoe (2013).

It is also crucial to note that the extent at which greater openness to trade increase energy demand in the long run is much higher than the extent to which it reduces energy demand in the short run (i.e. 0.2182 > /-0.0072/). Similarly, the positive income elasticity of energy demand in the short run is considerably larger than the negative long run elasticities (i.e.0.0045 > /-0.0759/). Further, the positive elasticity on industrial activities with respect to energy demand in the short run slightly larger than the negative long run elasticities (i.e. 0.0812 >/ -0.0626/). In the short run, the magnitude of industrial activities exceeds that of other variables; hence, we deduce that industrial activities constitute a major driver of energy consumption in Ghana particularly in the short run.

Table-5. Long run impact on energy consumption in Ghana

Variable	Coefficient	Standard error	t- ratio
Industrialization	-0.0626	0.16738	-0.3740
Trade openness	0.2182***	0.08442	2.5853
Urbanization	0.0395**	0.0198	1.9950
Income	-0.0759***	0.0150	-5.0600

Log likelihood = 95.41933

The urbanization parameter has a positively signed coefficient of 0.026 and 0.0395 in the short-run and long–run respectively, but statistically significant only in the long run. This implies that greater urbanization will increase the demand for energy but only in the long run by approximately 0.04%. The coefficient on the error-correction term is -0.4899 and its statically significant at 1% with the expected sign, suggesting that when there are fluctuations in energy demand (i.e. above or below its equilibrium level), consumption adjusts by approximately 49% within the first year to ensure full convergence to its equilibrium level. A speed rate of almost 50% in restoring equilibrium resulting from fluctuation/disequilibrium can be said to be moderately advantageous. Also, the statistical significance of the error-correction term renders double evidence confirming that a long-run equilibrium relationship exists between the variables. The values of the R-squared and adjusted R-squared 0.68 and 0.63 respectively implying that the model employed explained 63% of the variations in energy consumption. The DW statistic of 1.73 suggests that the model is free from serial correlation while the entire model is significant at 1%.

Finally, to ensure that the models satisfy the stability test, we apply the cumulative sum of recursive residuals CUSUM of squares (CUSUMSQ) test to the residuals of the error correction model. Figure 2 present plots of the CUSUMSQ test statistics that fall inside the critical bounds of 5% significance. This implies that the estimated parameters are stable over the sample period. Based on these findings some recommendations are offered

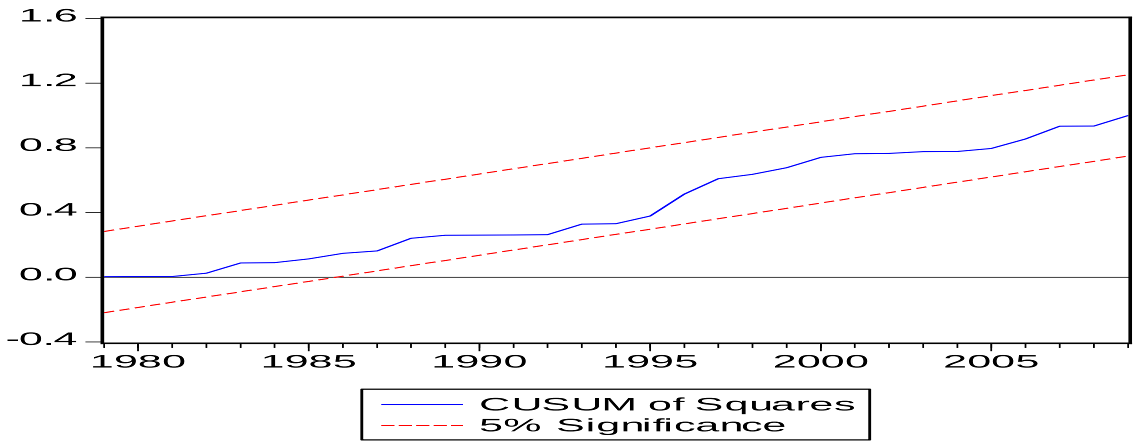

Figure-2. CUSUM Squares Test

5. Conclusion and Policy Implications

This paper investigates the long-run and short-run effect of trade openness, income levels, industrialization and urbanization amidst its quest to grow in the presence of energy shortage in Ghana. A Johansen cointegration test shows a long run relationship exist among all the variables. In the short run trade openness reduces energy consumption, while income and industrialization increases consumption. The impact of urbanization though positive is not significant in the short run. In the long run trade openness and urbanization increased energy consumption while income reduces energy consumption. In particular, the short-run positive effects of income, industrial activities and urbanization on energy consumption are estimated approximately respectively at 0.0045%, 0.026% and 0.081% Ghana while the short-run negative effect s of greater openness to trade on energy consumption is estimated approximately at -0.072%. Thus, the paper has revealed among other things that industrialization, urbanization, income levels and trade openness are among the key drivers of energy demand/consumption in Ghana. The error correction term shows an average or moderate speed of adjustment after a shock from previous year, i.e., approximately 50% of disequilibria from the previous year's shock converge back to the long-run equilibrium in the current year. Also various diagnostics tests such as the serial correlation (given by the DW statistic), Adjusted R-squared, CUSUM of squares among other validates the appropriateness of the methods employed in this current study.

As long as Ghana's development challenges remains an issue of immense concern, the country would continue to implement various policies to achieve sustainable growth. To achieve this objective alongside with increased industrialization which is usually accompanied by rapid urbanization, it is not only prudent but also imperative that energy is made available in sufficient quantities in order to power these sectors of the economy especially in the short. Thus, government is advised to intensify her demand-side management programmes. Specifically government should renew her effort in improving industry efficiency and awareness creation in energy efficiency. However, in the long run the country can practice some energy conservation policies as sustained growth and industrialization would imply a fall in energy demand pressures though trade openness and urbanization would require considerable among of energy availability. Accordingly, the Ghanaian government should be committed to developing the rural areas so that the rural folks are not compelled to move to the urban areas a way of slowing the pace of rapid urbanization in the country. Thus, spread-out growth rather than urban-concentrated growth has the tendency of mitigating urbanization which is known to positively drive energy consumption.

Furthermore, the study recommends that Ghana should, if practically and legally feasible, revise its trade policies especially by identify aspects that require excessive energy consumption. This implies that some energy savings potential exists for the country if they are able to achieve greater growth, embark on massive industrialization, restructure trade policies and minimize urbanization in the long run. However, a lot of caution should be exercised in attempts to implements these recommendations as further studies are still required to delve deep to uncover which aspects of industrialization and economic growth are more likely to ensure reduced energy demand; and which aspects of trade and urbanizations need to be tackled to ensure that their demand for energy is brought to the least plausible. Perhaps, a structural shift away from more energy intensive sectors to less energy intensive sectors could reduce energy consumption significantly.

Further, the study reveals that almost all four elements whose effects on energy consumption are examined in the current paper suggest considerable rise in the domestic consumption levels of future energy particularly in the short run. This requires that immediate and urgent huge capital investment would have to be made in additional plant capacity and to explore alternative energy source to meet the huge demand pressures.

Also, as a matter of intervention, government can encourage private sector participation in the generation, transmission, and distribution of some energy sources such as electrical power to make up for the shortages created whenever government runs out resources to make enough energy available for consumption. Not only will this provide the appropriate alternative investment source in new generating facilities but also ensure efficiency in the energy sector. Although some efforts have been made in this light, government should provide additional economic incentives which are absent in existing agencies. This will further encourage more private sector involvement in the generation of electricity to provide the needed physical redundancies needed in generation.

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