KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

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THE EFFECT OF POPULATION GROWTH AND ENERGY INTENSITY ON ELECTRICITY CONSUMPTION IN GHANA.

BY

CRISPIN NWINNONGME BETERYEB
(BSc. Land Economy)

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of

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Science and that, to the best of my knowledge, it has no material which has been published by any individual or organization, nor has been accepted by any institution for the award of any degree, except where due acknowledgement has been made in that regards.

CRISPIN NWINNONGME BETERYEB	…………………………	………………
PG3742515	SIGNATURE	DATE

Certified by;

Dr. JOHN BOSCO DRAMANI	………………………	……………..
Name of Supervisor	SIGNATURE	DATE

Certified by;

Dr. E. F OTENG-ABAYIE	…………………….	…………….
Name of Internal Examiner	SIGNATURE	DATE

Certified by;

…………………...........	………………	………………
Name of Head of Department	SIGNATURE	DATE

ABSTRACT

Electricity use has become a necessary and key input and an engine for growth for most economies in the world. In this era of industrialization, the quantity of electricity consumed in a country has been linked closely with economic structure and the level of population growth. This study investigates the effect of population growth and electricity intensity on electricity consumption in Ghana. The study employed two methods to individually assess the impact of population growth and energy intensity on electricity consumption on one hand and the sector effect of electricity intensity on electricity consumption on the other hand. Vector autoregressive (VAR) model was employed to ascertain the impact of Ghana's growing population and energy intensity on electricity consumption using time series data from 1980 - 2015. Findings of the model reveal that population growth has a positive significant impact on electricity consumption whiles intensity has a significant negative effect on electricity consumption. The decomposition analysis also revealed that intensity impacts negatively on electricity consumption. The study further revealed that activity effect is the major contributor of electricity consumption. The study therefore recommends more rigorous energy conservation policies and that policies on efficient gadget use should be enforced to avoid energy loses. Also, it further recommends that households should be encouraged to use renewable energy as supplement, so as to cut back intensity on the national grid.

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God bless us all.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Energy is the lifeblood of the global economic setup; a necessary input to the production of virtually all modern day economic goods and services. It cannot be over-emphasized how significant energy or power is to the economy of any country. It manifests itself through key segments of the economy such as manufacturing, transport, education and mining which rely heavily on power supply to aid their proper functioning (Ackah et al, 2014). Energy is one among the major indicators of any country. It is the core factor for fiscal development of any country (Batliwana and Reddy, 1993). It is undoubtedly an engine of growth to the economies of the world and energy consumption tends to grow alongside with gross domestic product (GDP). Global energy consumption rose by 0.59 percent each year on average for every growth in percentage point of GDP between the years 1980 and 2008 (World Energy Outlook, 2010).

Electricity consumption has been used as an index for measuring the development of a particular region, country, and economy (Stern and Cleveland, 2004). The impact of energy use in an economy manifests through the major roles energy plays in servicing the various sectors of the economy. The Energy Information Administration (EIA) data (2012), reports that the industrial sector consumes about 51.7% of the total world energy followed by transport sector consuming about 26.6%. In Ghana however, the transport and industrial sectors alone consumes 14 and 20 percent of the total primary energy respectively. The rest of the 66 percent is consumed by other sectors including losses. A greater percentage of high consumption in the country is attributed to residential customers which resulted in unprecedented peak demand of 1423MW (Dramani, 2014).

In this era of industrialization, the quantity of electricity consumed in a country has been linked closely with the level of population growth. Population growth is central and a crucial determinant of electricity demand in terms of the quantity consumed in the sense that, as population increases, more electrical gadgets are acquired by the growing population and causing electricity consumption to rise. Also, a growing population means demand for general goods and services would increase. Industries are therefore compelled to consume more electricity so as to increase production to satisfy the rising demand.

Population and income are considered the key drivers of growing demand for electricity. The World Energy Outlook, (2016) projects that World population will reach 8.8 billion people by 2035. Rapid population growth does not only affect the current energy demand, but also has an implication on the future rate of energy consumption. Data from IEA/World Bank from the years 1990 to 2008 shows that, on the average, the per capita energy consumption increased by 10% while the world population increased by 27%. The world is estimated to increase its energy consumption from about 9000 million tonnes of oil equivalent (Mtoe), to between 15000 and 21,000 Mtoe when the population of the world reaches 12 billion people in the 22nd century (Sheffield, 1998). The IEA (2007), projects that, developing countries will experience a greater increase in energy consumption where the proportion of global consumption is expected to rise from 46 to 56 percent between 2004 and 2030. This can be attributed to the fact that developing countries are yet experiencing rapid population growth at the same time industrialization and other developing sectors requiring energy for goods production. For instance, China and India are highly populated countries and at the same time among the highest energy consumers of the world (Shashidan et al, 2013). According to UN (2014), the overall increase in world population will take place in urban centers as population in rural areas is expected to decline in most of the regions with notable exception of Africa.

Energy intensity is a measurement of the amount of energy that a country needs to generate for the production of a unit of GDP. Energy demand tends to be low where the income per capita is higher, because those economies would have switched from industrialization to more services and efficiency enhanced. Emerging economies on the other hand tend to have high energy consumption per capita as a result of growing GDP per capita. According to IEA, (2014) energy intensity has been declining for the past 22 years in many countries across the world and this has been attributed to faster growth in GDP than energy demand, the services sector taking center stage of the economy with energy efficiency programmes rolled out.

1.1.1 Electricity Demand in Ghana

Electricity is the dominant form of modern energy consumed in Ghana and constitutes about 65 percent of the power consumed by the industries and service sectors, allowing for about 36 percent to be used domestically. The country has been experiencing substantial increase in demand for power in recent times. As noted by Ackah et al, (2014), the country has recorded an uncurtailed increase in peak demand for power between just 2000 and 2009 alone representing an average growth rate of 44 percent. The desire of the country to industrialize rapidly so as to attain certain level of development, called for the construction of the Akosombo dam in 1962 which supplied enough for the country. However, following the massive industrialization, the likes of VALCO which will consume almost a third of the power supplied by Akosombo when in full operation, and the setting up of other factories, hospitals, schools etc, demand for power begun to rise. Demand for electricity peaked at 540 Gwh in 1968, and with demand estimated to be growing annually at 10 percent, domestic electricity use grew a six-fold to 3917 Gwh by

1976. This however declined to 3429 Gwh in 1979 and further to 1151 Gwh by 1984 (VRA Annual report, 1966- 1990). Electricity consumption however picked up under the auspices of the Economic Recovery Programme (ERP) together with rapid urbanization and industrialization. By 1990, electricity demand had reached 4780 Gwh and is perked at 9,258 Gwh with consumption per capita at 382 Gwh (see Figure 2.0)

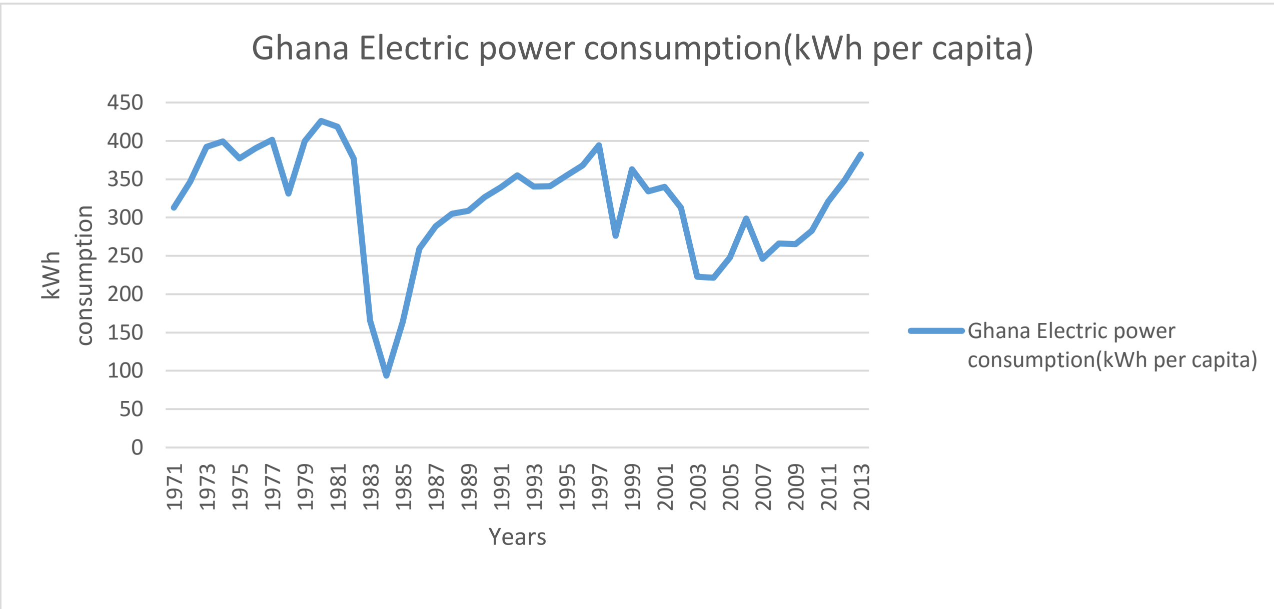

Figure 1.1 Ghana Electric Power Consumption

Source: World Bank (2014)

1.2 Problem Statement

Like many other African countries, Ghana is challenged with a persistent growth in energy consumption which left the country to be battling with perennial energy crisis. Energy crisis in Ghana dates years back, with the first crisis occurring in 1983 to 1985, followed by 1998 to 2000, 2006 to 2008 and the current energy crisis which started in 2012 to date. Over the years' there have been attempts by governments to increase the generation of electricity so as to close the demand-supply gap. However, these supply side measures are unable to meet the growing demand because of inadequate infrastructural investment (Adom et al, 2012), the over reliance on rainfall to power the hydro plants which constitutes 68 percent of the total installed electricity capacity, and the fluctuating crude oil prices on the international market making the operations of the thermal plants to be rather expensive and unreliable. The supply and availability of affordable energy, thereby, remains erratic and inconsistent (Ackah et al, 2014) as a result of persistent increase in demand for energy (Adom et al, 2012). In their study, Ackah et al (2014) and Adom et al (2011) revealed that, changes in population among other factors, are key determining factors of electricity consumption in the country.

Population is inextricably connected with energy consumption (Batliwana and Reddy, 1993). Energy consumption therefore exerts demand on energy resources making them scarce (Graham, 2009). Limited and or exhaustion of resources in any country stifles the country's anticipated economic growth (Shahidan et al, 2013). World population continues to increase especially in developing countries such as Ghana, and energy resources are increasingly required to support the numerous human activities. Over the years there has been rapid surge in Ghana's population from 6.7 million in 1960 to 18.9 million and 24.2 million in the years 2000 and 2010 respectively with growth rates averaging between 2.4 – 2.7 percent. The Ghana population council, (2011) estimates that, given the growth rate in the country is averagely 2.4, the population is expected to double in 29 years' time.

The generally accepted approach to the population-energy demand nexus is that the level of population determines the energy demand. This is to say with a larger population size, a greater quantity of total energy will be consumed, with the degree of this total energy consumption depending on the per person energy use (Batliwana and Reddy, 1993). Growing population consumes more energy as a result of industrialization, urbanization and population intensity. Ghana has experienced rapid urbanization over the past decades with a percentage of the population in urban community spanning from 23 percent to 43.8 percent in the years 1960 and 2000 respectively and is estimated to reach 62.9 percent by 2025. Persisting rapid urbanization will shoot up the consumption of modern energy services since they can readily be found in towns and cities. According to ISSER (2005), persistent and rapid urbanization will cause demand for electricity to grow faster than the general economic growth of the country. This will be as a result of newly urbanized sections of the population tapping electricity from the already existing electricity thereby expanding the total electricity consumption manifold. The concern therefore is that at current rate of exploding Ghana's population growth, energy consumption will rise very fast, raising the threats of energy security in the country.

Moreover, the state of industrial civilization in our current dispensation depends wholly on the ability to access large quantity of energy of varied types. As industrialization progresses as a result of increase in demand for goods and services, the per capita energy use will likely increase. The aspirations of developing countries to improve upon the living standards of their citizens can be achieved if efforts are focused on developing a sustainable electricity power market as part of the basic infrastructural requirement of the country. Given that population is increasing as well as population triggered demand factors, different sectors of the economy experience varied amount of energy use per production and the need to identify the most energy intensive of the economy for demand side management of energy under limited supply conditions.

1.3 Research Questions

The study aims at examining the dynamic linkage between population growth, energy intensity and energy consumption. Some envisaged questions for the study therefore include;

1.Does population growth have any effect on energy consumption in Ghana?

2.To what extend does energy intensity affect energy consumption in the country?

3.How does sector growth dynamics affect total changes in electricity consumption in the country?

1.4 Objectives of Study

Examining the effect of population growth and energy intensity on electricity consumption in the in Ghana is the main objective of this study. In order to achieve this, the study was designed specifically;

1.To examine the effect of population growth and electricity consumption in Ghana.

2. To examine the effect of energy intensity on electricity consumption.

3. To examine how sector growth dynamics affects total changes in electricity consumption.

1.5 Significance of the Study

The significance of this study is embedded on the notion that, energy use is an integral and complementary factor in the growth processes of economies which implies that the use of energy is very much dependent on the size and structure of the economy (Adom and Bekoe, 2013). The circumstances regarding electricity demand are topics of considerable interest in recent times for both developed and developing economies. Electricity has become the backbone of most economies. The Ghana Social Development Outlook (2014) estimates that power failures in the country is costing the economy between 2 to 6 percent of the GDP per year. Going by this, all studies that will empirically examine the factors affecting electricity consumption are necessary and in these times that countries desire to improve upon the standard of living of their citizens. Critical knowledge of the impact of population growth and energy intensity on electricity consumption will be crucial in the formulation of policies that will help in energy demand management.

Another factor that makes this study worth undertaking is the fact that most literature which have focused on population growth and energy intensity as determining variables and their effect on electricity consumption, are based on cross country studies. The conclusions from these studies therefore cannot wholly be applicable in the case of Ghana. In a Ghanaian perspective, literature which have been carried out concentrated on the causal relationship of electricity consumption and either income, economic growth, policy regime changes, etc. (Adom and Bekoe, 2013, Ackah et al 2013, Dramani et al 2012). This study is however different from the previous studies and necessary in the sense that, focus is on population growth and energy intensity as variables of interest and is employing a vector autoregressive (VAR) and decomposition methods to analyse the data.

The study therefore closes the obvious research gap existing in literature, on the above topic from a Ghana focused perspective. Moreover, it will be a point of departure for further research in addition to serving as reference point.

1.6 Organization of the Study

The study is organized into five chapters. The first chapter captures the introduction which covers the background to the study, problem statement, objectives, significance of the study and organization of the study. Chapter two present summary of the existing theoretical and empirical literature on population growth, energy intensity and energy consumption. Chapter three provides an overview of the methods employed for the study. Chapter four is focused on analysis and interpretation of results. Chapter five which is the last chapter of the study constitutes conclusions and policy recommendations.

1.7 Limitation of Study

One of the main drawbacks usually encountered in studies of this nature on developing countries like Ghana is the unavailability of reliable data. Lack of complete data sets from a single source meant that data used had to be taken from different sources, which usually involves some inconsistencies. As a result, the selection of a relatively small sample size for the analysis became inevitable. The selected model for the analysis was restricted to a set of variables and did not take into account price of electricity which is a key determinant of electricity consumption. Data on that variable could not be acquired on time.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter gives account of relevant theoretical and empirical literature regarding the relationship between population growth, energy intensity and energy consumption. It consists of two main sections. The first part presents the theoretical foundation of the study whiles the second part analyses the empirical literature relevant to the topic.

2.2 The Effect of Population Growth on Energy Consumption

Population growth is defined as the increase in population over a period. It depends on the balance of births, deaths and migration (Robinson, 2007). The theory of population growth and its pressure on energy resources can be traced to the early debate on the relationship between population growth and natural resources. Malthus (1798), in his essay on the principle of population, raised concerns about the rapid growing population which put pressure on the limited resources. It was argued that, population tends to increase at a geometric rate, which is much faster than the growth of natural resources and therefore needed to be checked. In contrast however, Boserup (1981) held the view that a growing population would push for technological breakthrough or advancement to boost production or make discoveries to support the growing population. Boserup (1981) further argued that a larger population is necessary to cause improvement of resources through technological innovation that would help increase productivity and enable the available energy resources to support larger population rather than small sized and stagnant population which would stick to primitive use of resources. Though these arguments do not explicitly mention energy, the relationship between population growth and energy consumption can be implied from these arguments. Morrison (2013) opined in his work that;

"Since the energy and resources consumed by our species already amounts to more than 1.6 times the bio-capacity of the entire planet, this means that we (world) are asset-stripping our cosmic home and shrinking its carrying capacity on a daily basis. If this growth in population and energy consumption continue, by 2050 we will need the combined resources of two earths just to sustain our population at its present level of consumption". Morrison (2013)

The demand for energy is a derived demand inasmuch as its consumption value is determined by its ability to provide some set of desired services. Hence population pressure on electricity is through the appliance stock, urban expansion and the demand for electricity as a factor of production of goods and services. The demand for population by a given population is hinged on the stock of appliance and the rate of usage of the appliances. In their work, Harman (1979) and Stevens (2000) outlined a three stage decision making process for a given population say household for commercial energy use. Firstly, a household must take a decision to switch to commercial energy or not. This is referred to as the switching decision. Secondly, it must decide on the type of appliances to acquire for use, and finally the household takes the consumption decision by adopting the usage pattern of each appliance. The stock of appliance and growth potential are important determinants of electricity demand. Hence a large household size with a large of stock of appliances would cause electricity consumption to rise.

In similar vein, a growing population results in rapid expansion of towns and cities and in dire need of electricity for day to day activities. Urbanization therefore exerts pressure on the existing electric power as a result of newly constructed houses and industries requiring electric power use.

Furthermore, the theoretical impact of population growth on electricity consumption can be traced to the neoclassical perspective of production function to examine the factors that could reduce or strengthen the linkage between energy use and economic activities over time. For instance, given a general production function as;

$$(Q_i \ldots\ldots Q_m)' = f(A, X_1 \ldots\ldots X_n, E_c) \ldots\ldots (2.1)$$

Where Q_i represents the various outputs such as goods and services, X_i are the different inputs such as capital, labour, etc., E_c refers to the energy input (electricity) and A is the state of technology as defined by the total factor productivity indicator. The resulting impact of population growth would be an increase in the demand for goods and services, and the relationship between energy and the aggregate output would motivate industries in their quest to maximize profits to consume more electricity to produce goods and services to satisfy the growing demand for goods.

2.3 Effect of Energy Intensity On Energy Consumption

Energy intensity refers to the ratio of energy consumption to GDP production of an economy. In other words, it measures the efficiency level of the country. The effect of energy intensity on electric power consumption depends greatly on the energy efficiency level, the stock of electric power appliances and the rate of use of the appliances. Energy efficiency refers to the activity or product that can be produced with a given amount of energy. Efficiency improvements in processes and equipment and other explanatory factors can contribute to observed changes in energy intensity. For instance, energy use of an appliance can be captured in the following expression;

$$E = \frac{U}{\varepsilon} K \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

where E denotes energy use, U denotes capacity utilization of appliance and ε = energy efficiency level. This is say that the amount of electricity an equipment consumes depends greatly on the level of efficiency and utilization capacity and on a larger picture the number of appliances in the economy.

And total energy intensity captured as;

$$= \frac{E_A}{Y_A} . \emptyset_A + \frac{E_I}{Y_I} . \emptyset_I + \frac{E_S}{Y_S} . \emptyset_S \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.4)$$

Combining both equations (2.2) and (2.4), we obtain;

$$\frac{E}{Y} = \frac{\left({U_A}/{\varepsilon_A}\right).\ K_A}{Y_A} . \emptyset_A + \frac{\left({U_I}/{\varepsilon_I}\right).\ K_I}{Y_I} . \emptyset_I + \frac{\left({U_S}/{\varepsilon_S}\right).\ K_S}{Y_S} . \emptyset_S \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

From equation (2.5) we can see that an increase in energy efficiency in any sector *i*, for instance through the adoption of a new technology, will lead to a decline in the energy intensity of sector *i*, and hence overall energy intensity. This is apparent by simply differentiating equation (2.5.) with respect to energy efficiency in sector *i*:

$$\frac{d\left({E}/{Y}\right)}{d\varepsilon_I} = \frac{\left({U_I}/{\varepsilon_I^2}\right) K_I}{Y_I} \emptyset_I < 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.6)$$

It is worth noting that, the impact of the technological change will have the greatest impact on intensity if it occurs in the sector with the largest share of total output. This has implications for the design of any policy directed at lowering energy intensity through raising energy efficiency.

In addition, since the second derivative of equation (2.5) is positive, the negative effect on energy intensity is increasing with the innovation. Thus, any innovation in the industrial sector that occurs in one country can have a substantial impact on energy intensity.

More also, the impact of intensity on electricity consumption can be altered by the structural changes occurring in the economy. For instance, in the industrial sector, a shift in manufacturing emphasis from the energy intensive industries such as primary metal industry, etc. to less energy intensive industries would cause a decline in the energy intensity index. In addition, the nature of the weather and the size of household can impact on the intensity of energy use. Changing weather conditions influences the use of some electrical gadgets. For instance, in the hot seasons, cooling equipment's such as air conditioners, fans, etc. are intensely used and during winter, heating equipment's such as electric heaters are intensely utilized.

2.4 The Effect of Structural Changes on Electricity Consumption

In the course of economic development, changes in the structure of GDP leads to increasing intensity at first and later declining energy intensity. This is especially because, industrialization results in large increases in commercial energy use. Then, as economies move into the post-industrial phase of economic development, the service sector grows faster than other sectors and energy demand grows at a slower rate for given increases in GDP. This pattern is consistent with the theory of dematerialization. Dematerialization refers to the reduction of raw material that is energy and material denoting a reduction in amount of energy to GDP production.

Structural changes in an economy are major movements in the composition of the economy and in any of the end use sectors that can affect energy use. This refers to an economic shift or transformation from say either manufacturing base to service base economy or changes in activities occurring in the various sectors of the economy. These changes can arise a result of factors such as global shifts in capital and labour, changes in economic development, discovery of a natural resource, etc. In general, as economies develop they move from being more rural and agricultural based to urban and industrial then service based. These economic shifts have consequences on the amount of electricity consumed. However, the central focus of the economic growth determines the amount of electricity required or to be consumed to support the economic growth. For instance, an economy making a shift from manufacturing economy to a service base economy would experience a drastic decline in the amount of electricity consumed as the intensity of energy use in the service is as minimal compared to that of manufacturing. Also, within an industrial sector, a transformation from very heavy industries to a light manufacturing company will alter the activity effect on electricity consumption. To illustrate how structural change can lead to changes in energy intensity, consider a three-sector economy (denoted as sectors *A*, *I* and *S).* Total energy consumption is given as the sum of energy use across all sectors, $E = E_A + E_I + E_S$. The energy intensity in each sector *i* can be given as *Ei*/*Yi*, where *Yi* is the output of sector *i*. Total output is given as $Y = Y_A + Y_I + Y_S$. Total energy intensity can be written as:

$$\frac{E_A}{Y_A} = \frac{E_{A+}\, E_{I+}\, E_S}{Y} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.7)}$$

$$= \frac{E_A}{Y_A} \cdot \frac{Y_A}{Y} + \frac{E_I}{Y_I} \cdot \frac{Y_I}{Y} + \frac{E_S}{Y_S} \cdot \frac{Y_S}{Y}$$

$$= \frac{E_A}{Y_A} .\emptyset_A + \frac{E_I}{Y_I} .\, \emptyset_I + \frac{E_S}{Y_S} .\, \emptyset_S \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2.8)}$$

where $\emptyset_i$ is the sector *i* share of total output. Thus, total energy intensity is a share weighted sum of energy intensity of each sector. Also, by definition $\emptyset_A + \emptyset_I + \emptyset_S = 1$

Assume that the energy intensity of each sector can be ordered such that:

$\frac{E_A}{Y_A} < \frac{E_S}{Y_S} < \frac{E_I}{Y_I}$

It follows that if sector *I* grows faster than sector *A*, holding the output share of sector *S* constant, energy intensity will increase. To see this, we can take the derivative of equation (5.2) with respect to the output share of industry:

$$\frac{d(E/_Y)}{d\emptyset_I} = -\left(\frac{E_A}{Y_A} . \frac{d\emptyset_A}{d\emptyset_I} + \frac{E_S}{Y_S} . \frac{d\emptyset_A}{d\emptyset_I}\right) + \frac{E_I}{Y_I} > 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.9)$$

We know equation (2.9) is positive because

$$\frac{E_A}{Y_A} . \frac{d\emptyset_A}{d\emptyset_I} + \frac{E_S}{Y_S} . \frac{d\emptyset_A}{d\emptyset_I} < \frac{E_I}{Y_I}$$

which follows from the fact that E_A/Y_A, E_S/Y_S, E_I/Y_I and $\Delta\emptyset_A + \Delta\emptyset_S + \Delta\emptyset_I = 0$

Thus, the impact on energy intensity of the aggregate shift to industry is positive. We can also show, in a similar manner, that growth in the less energy-intensive sectors results in declining energy intensity.

2.5 Energy Demand Theory

Demand for energy arises for a number of reasons. Different groups and units as well demand the use of energy for a different reasons and under varied circumstances. Commercial and industrial entities demand energy as an input for their production process with the main objective of minimizing cost. Households on the other hand, consume energy so as to satisfy their desires which they usually do by allocating a part of their income considering other needs so as to maximize satisfaction from total expenditure.

Demand for energy is a derived demand insofar as the value of energy is determined by its ability to satisfy some desired services of the consumer (Bhattacharyya, 2009). The wish of a consumer to achieve certain satisfaction compels the consumer to consume the particular energy resource. The energy commodity is not demanded for its sake, but for the ulterior services it offers. Energy demanded offers the desired services through the use of appliances. Demand for a good in basic microeconomics theory is represented by a demand function which depicts the relationship between the amount of a good to be consumed and the determinants of such amounts. Hence several factors such as the desired services, income level, efficiency rating of the appliance, the intensity of use, price of energy, conversion technologies, etc influences demand and the amount of energy consumed. For instance, consumers purchase electricity for the purposes of the services such as lighting, space heating, air conditioning, etc. it offers and per the qualities and usage rate of the appliance would determine the amount of electricity consumed.

Joanne and Hunt, (2009) reckoned that, in the long run at the macro level, energy demand and energy intensity is greatly affected by changing economic structure and technology. Energy intensity refers to the ratio of energy consumption to GDP. Economic development causes structural changes which determines the consumption rate of appliance stock. Sector consumption of energy and for that matter intensity, declines, as an economy transitions from manufacturing to a service economy. The relative energy required per unit of service output is less than what is required for manufacturing.

The concept of energy intensity, which is the ratio of energy consumption per GDP have widely been used to analyze and predict energy demand, compare efficiency in energy use and the effectiveness of technology in the country with regards to energy use. It has been regarded in literature as a global macro indicator of the link between energy consumption and income. In the technology world, energy intensity is seen as the measure of energy efficiency of an economy. A situation where a country records high energy intensity, it is read as high cost of converting energy to GDP. On the other hand, if the country records low energy intensity, it means the cost of converting energy to GDP is low.

2.6 Determinants of Energy Consumption

Generally, aggregate electricity demand is largely affected by economic, demographic, social, meteorological factors. The degree of impact of these explaining factors however vary with respect to regions and countries. For instance, the impact of meteorological factors on the aggregate electric power consumption is immense in the polar regions than in temperate regions. On a narrow basis, however, empirical studies such as Sa'ad (2009), Ziramba (2008) etc, have indicated that demand for electricity is primarily influenced by consumers' real income and prices of electricity. Other studies like Narayan and Smyth (2006), Adom and Bekoe (2013), etc have included such factors as population growth, industrial output, urbanization, efficiency enhancement, user lifestyle, etc. Filippini and Pachauri (2004) explains that all these factors have together been responsible for enhancing electricity consumption in the past and will further cause an increase in electricity consumption in the future. To enable a proper analysis of these determining variables, they have been categorized into economic and non-economic variables.

2.6.1 Economic Variables

Primarily, real income of consumers has been identified as the main determining variable of electricity consumption. The income level of consumers proxies the general level of economic activities in a country as well as the standard of living. In line with basic demand principles, more or less is demanded or consumed as income increases or decreases respectively, and changes in the disposable income of a consumer affects the magnitude of electricity consumed. The desire to acquire more electrical gadgets and appliances by consumers increases as their income levels increases, boosting their purchasing power. All things being equal, with respect to the efficiency and rate of use of an increasing appliance stock, will cause demand for electricity to increase. According to Ekpos et al (2011), real income level is perhaps the most important determinant of electricity consumption. This is because, as income level rises together with enhancing living standard, it drives people to desire more comfort, entertainment and convenience, resulting in the acquisition of more electricity consuming equipments.

More also, electricity price is another imperative variable in the function of electricity demand and has a significant influence on the amount of electricity being consumed. The price level of electricity determines the amount a consumers income would afford him to spend on electricity. A very high price of electricity will reduce the purchasing power of a consumer thereby reducing the amount a consumer would allocate for the consumption of electricity hence causing less electricity to be consumed. Consumers usually cut short the amount of electricity they consume in the short run as a result of price increase. They are however, stimulated to adopt more efficient electric appliances in the long run.

Furthermore, industrial output also has a greater impact on electricity consumption. The industrial base of an economy exerts significant pressure on electricity use. The industrial output measures the industrialization level of a country. An industrialized country tends to have a greater part of its electrical power consumed by the industries in the country. As the industrial base grows, demand for electricity also grows. Similarly, as demand for goods increases, industries will equally increase their production which will require more electricity for production of the goods. This variable can be used as a proxy measure of the economic structure of the country. An economic structure which is service based, tends to consume less electricity as compared to a largely industrialized country.

2.6.2 Non- Economic Factors

Enhancement in efficiency is a notable factor which influences the consumption or demand of electricity. As explained early on, demand for electricity is a derived demand, where its consumption is derived from the demand for services such as ironing, cooling, heating, etc through electricity powered gadgets such as irons, heaters, air conditioners, etc. The amount of electricity consumed by these appliances will therefore depend on the energy sophisticated technology embedded in them. Progress in technology gives consumers the opportunity to manage their electricity demand in the long run as more energy efficient appliances and proper techniques are developed.

Growing population has also been noted as a significant contributor to electricity consumption. Ackah et al (2014), Adom et al (2011), etc, in their studies have revealed that changes in population is a key determining factor of electricity consumption in Ghana. Batliwana and Reddy, (1993) indicated that, population is inextricably connected with energy consumption. This is to mean that there is a strong relationship between population growth the use of electricity, and as population grows, demand for electrical goods and services equally increases, triggering a surge in electricity use. Population dynamics; which consist of the trend and changes in population growth, urbanization, population density and age structure also contributes to changes in electricity consumption. For instance, age structure according to Ekpo et al (2011), has a significant influence on household electricity consumption. The aged who spend greater part of their days at home tend consume more electricity for cooling and heating than the working age. Urbanization and population density tends to exert pressure on electricity which the most common modern energy available in the urban towns.

Economic growth and electricity consumption have been identified to have bi-directional relationship. A growing economy requires more energy to sustain its economic growth. As an economy grows, demand for electricity begins to rise as a result of utilization of electric energy in both industrial and non-industrial sectors. This economic growth – energy consumption nexus underscores the energy intensity of the country. Electricity intensity explains and makes comparisons of the rates of economic growth and electricity consumption growth. In other words, energy intensity measures the amount of electricity required for a per unit of economic output production. It is also a measure of electricity efficiency level of the country. Aggregate energy intensity is obtained by finding the ratio of energy consumed for a unit of GDP produced.

2.7 Empirical Literature Review

Energy is generally defined to be the ability to carry out work or to produce heat. In Economic terminology, Sweeney (2000) defines,

"*energy" includes all energy commodities and energy resources, commodities or resources that embody significant amounts of physical energy and thus offer the ability to perform work".*

Energy commodities such as gasoline, diesel fuel, natural gas, propane, coal or electricity can be used to provide energy services for human activities such as lighting, space heating, etc. energy resources on the other hand includes crude oil, biomass, hydro, etc. can be harnessed to produce energy commodities (Sweeney, 2000). This allows for a derived demand relationship between these resources, commodities and final services they provide to the consumer. Study on energy has attracted attention in Ghana. This can be attributed to the significant role energy plays in the economic development of the country. There have been a number of studies on the key factors affecting demand for electricity amidst a bid of variation in findings which can be attributed to the different methodologies and the variables considered.

Using the ARDL bounds cointegration approach, Adom et al (2012) attempted to identify the short and long run key factors behind the historical growth trends of aggregate domestic electricity demand in Ghana. The study used the periods of 1975 and 2005 as their sample period, and revealed that real per capita income, efficiency in industry, structural economic changes and rate of urbanization are key determinants of electricity consumption in the long run. The study further revealed that, among all the determinants, industrial efficiency is the only factor with a negative effect on electricity demand. It is however insignificant to outweigh the effects of other determinants as changing demography and income levels.

Adom and Bekoe (2012), using data from 1971 to 2008, employed the ARDL and partial adjustment dynamic to estimate electricity requirement by 2020. The findings of their study showed that electricity demand is significantly affected by real income, industry output and rate of urbanization.

Furthermore, Dramani et al (2012) using the Unit root test and cointegration test incorporating structural breaks undertook a study to examine economic growth and electricity demand relationship in Ghana between the periods of 1970 and 2010. Their findings confirmed the growth hypothesis that, when income increases, consumers and firms increase their demand for electrical appliances thereby consuming more energy.

Also, using the Toda and Yomamoto Granger causality test on electricity consumption and economic growth data from 1971 to 2008, Adom (2011) arrived at the following findings. The study indicated that, results from the data supports the growth-led energy hypothesis. This means that electricity consumption is affected by economic growth

The literature surrounding the population, energy intensity and energy demand relationship has however been scanty. Ackah et al (2014) and Adom et al (2011) only recognized in their studies that population changes among other factors are key drivers of electricity demand in the country. There has not been a categorical study to investigate the relationship between population growth and energy demand in the Ghana. Hence the findings of the above studies have not been conclusive on the extent to which population growth and energy intensity matters in terms of electricity consumption in the Ghanaian setting.

Batliwana and Reddy, (1993) underscores that population and energy consumption are inextricably connected and buttressed by Hongmei and Fuyang (2010). They employed the cointegration method to analyze the impact of population growth on energy consumption in China. The study established that population growth affects energy consumption in the long run. However, its impact on energy consumption is insignificant in the short term.

On the contrary, Maazur (1994) disaggregated energy consumption into electricity and non-electricity consumption and by end use sectors. Analyzing the contribution of American population growth to the rising energy consumption between the periods of 1947 and 1991. This study observed that population growth was relatively unimportant in contributing to yearly fluctuations of energy consumption. It however recognized that population had a significant influence only when a particular energy sector is considered in the long run.

Kamaludin (2013) in his work looked at the cause of rapidly increasing consumption of electricity in some developing countries. Analyzing electricity consumption data for 32 developing countries using the econometrics panel data revealed that high technological electrical appliances used in daily activities consumption a lot of energy. He therefore noted that, rapidly growing population and increasing real income would call for the use of more electrical appliances hence causing more energy to be consumed.

In another vain, Jaehong and Byeongseon (2012) carried out a study and established that there exists a U-shaped relationship between population aging and per capita energy consumption. The study indicated that energy consumption increases as the working age rises and tends to decline with an aging population. O'Neill and Chen (2002) however noted that aging population would only cause a reduction in few areas like transport energy demand but would increase energy consumption through heating and cooling of space.

Hameed and Asad (2013) carried out a study in the Bahawalpur city of Pakistan on the effect of population growth on increasing electricity consumption. Using primary and secondary data in a regression, the results indicated that there exists a significant positive relationship between population growth and massive increase in electronic appliance have caused a dramatic change in domestic electricity consumption.

Shahidan et al, (2013) in examining the relationship among population, energy consumption and economic growth using data from 1991 to 2001 in Malaysia, first carried out a unit root test which indicated a non-stationarity in all levels and using the cointegration model found out that there is a long term relationship existing between population, energy consumption and economic growth. Further carrying out a Granger causality test indicated that population has an impact on energy consumption which also impacts on economic growth.

It is obvious that there exists a vacuum which this study intends to fill. In the Ghanaian context, there has not been any categorical work done to establish the effect rapid growing population and sector energy intensity have on the demand for the limited electricity produced in the country. This study has therefore adopted the bounds testing method to establish the link between the growing population and the long run it has impact on energy demand. The study further uses the decomposition method to examine how energy intensity through key sectors of the economy is impacting on energy demand of the country. Findings from the above methods illuminates the contributions of the various factors to the overall energy consumption.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the methods employed for the study. It is divided into six parts whereas the first part outlines the model specifications. Section two of the chapter presents the determinants of electricity consumption. The third part of the chapter presents the decomposition analysis of electricity consumption. The fourth section of the chapter outlines the estimation strategies of the vector autoregressive model. The final part of the chapter gives a vivid description of the nature of the variables employed in the model and the various sources of the data.

3.2 Model Specification

Demand for electricity is considered derived demand since its use is hinged on the use of input factors which are used in economic production processes. In production theory, economic agents such as households, firms, etc use electricity consumption as an input factor for production of goods and services. Electricity demand therefore depend on the stock of electric appliances, capital equipments, demographic factors, etc. Empirical studies over the years however shows that, income and price of electricity are central in determining electricity consumption. However, the interested explaining variables of this study interest include population growth and energy intensity.

3.2.1 Electricity Demand Function

From basic theory of microeconomics, the demand for a good is represented through a demand function which establishes the relation between various amounts of the good consumed and the determinants of those amounts. Since the emphasis of this study is on establishing the effect of population growth and energy intensity on electricity consumption, the relation between population growth and amount of electricity consumed can be represented in a simple functional form as;

$$EC = f\,(POP, EI, X) \quad \text{………………………………………………………. (3.0)}$$

Where *EC* = Electricity Consumption**,** *POP* = Change in total population, EI= energy intensity and *X* = set of control variables.

3.3. Factor (Decomposition) Analysis

In order to satisfy the second an third objective, by assessing the impact of energy intensity sector growth dynamics on electricity consumption, the study employs the decomposition analysis. Energy consumption is affected by numerous factors. There is a correlation between changes in total energy consumption and the mathematical variations that occur in the contributing factors. But the extent of change in one of the factors, determines the change in volume of total electricity consumption. The decomposition analysis therefore focuses on the decomposition of change in the total electricity consumption and distributes the change among the effects of its determinants. This method has largely been used for this kind of analysis (Ang and Zhang, 2000, as cited in Bhattacharyya, 2011) with the prominent factors usually used being, changes in economic activities (Activity effect), Intensity effect and economic structural changes (Structural effect). The choice of this method is motivated by; Its ability to quantify the relative contributions of the factors predefined to have impact on energy consumption. It is able to track down the origin of variations in energy consumption.

Lastly, it affords the opportunity to measure how effective energy policies and technology are playing out.

The structural changes in production and consumption dictates how capital stock is utilized in the various sectors which causes changes in energy consumption intensity. The decomposition method is used to analyze the changes in energy consumption which are arising from factors such as economic activities (Activity effect), Intensity effect and economic structural changes (Structural effect). It uses data on energy-to GDP (National, Residential), and energy to Value added of various sectors (Services, Industrial) to determine the energy intensities. The total electricity consumption will be given by the sum of electricity use across the three sector economy;

$E = E_R + E_I + E_S$, ……………………………………………… *(3.1)*

where; E = Total electricity consumption, E_R = Residential energy consumption, E_I = Industrial electricity consumption, E_S = Service or commercial electricity consumption.

Electricity intensity of each sector say **i** is then given as; Ei/Y_i, …………………… *(3.2)*

where Y_i is the output of sector *i*. obtained using Y_i/Y………………………… (3.3)

The total output (Y), will then be; $Y = Y_A + Y_I + Y_,$ hence total energy intensity will be given as;

$E/Y = \frac{EA + EI + ES}{Y}$ ……………………………………………………………. *(3.4)*

After which, the following model is derived as;

$E = Q * EI = Q * \sum (E_i Q_i / Q_i Q) = Q \sum EI_i S_i$……………………………. *(3.5)*

where,

EI_i = energy intensity in sector **i** (i.e. ratio of energy consumption in the sector to the driving economic activity of the sector), and

Si = structure of sector i (i.e. share of the activity of sector i relative to the overall activity of the economy),

Q = overall economic activity with *Qi* as the activity of sector **i,**

E = energy consumption and Ei is the energy consumption in sector **i**

In order to estimate the contribution of each factor to the total change in energy consumption, the factor under consideration is analyzed by looking at how it has changed over time whiles holding the other factors constant. Energy consumption in a year (E^t) is given by;

$$E^t = Q^t \sum EI_i^t S_i^t \quad \text{……………………………………………………………(3.6)}$$

From which the contribution of each factor can be derived. The Activity effect (Q effect) is given by;

$$\mathbf{Q_{effect}} = \left(Q^t - Q^0\right) \sum EI_i^0 S_i^0 \quad \text{…………………………………………………………… (3.7)}$$

The contribution of intensity (I_{effect}) to the change in total consumption will be obtained from;

$$\mathbf{I_{effect}} = \left(Q^0\right) \sum \left(EI_i^t - EI_i^0\right) S_i^0 \quad \text{……………………………………………………… (3.8)}$$

Changes to the total energy consumption as a result of structural economic changes (S_{effect}) is estimated from;

$$\mathbf{S_{effect}} = \left(Q^0\right) \sum \left(S_i^t - S_i^0\right) EI_i^0 \quad \text{………………………………………………. (3.9)}$$

The total change in energy consumption is therefore obtained by;

$$\Delta E = Q_{effect} + I_{effect} + S_{effect} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.10)$$

The sum of the three effects from above, under the decomposition analysis is equal to the change in energy consumption occurring between the period considered (2000 – 2015). Depending on the weight of each factor and its operating sign will influence the change in demand.

This study however, wants to identify the degree of changes to the total energy consumption which is attributable to energy intensity.

3.4 Estimation Methodology

In order to establish strong, robust and more reliable model that captures the causal relationship between electricity consumption and population growth, the VAR model is adopted in this studies. According to Sims (1980), the VAR is a valuable tool for investigating the dynamic effect of a shock on a given variable. The vector autoregressive (VAR) model proposed by Sims (1980) is one of the most successful, flexible and easy to use models for analysis of multivariate time series. It is applied to grasp the mutual influence among the multiple time series. VAR models extend the univariate autoregressive (AR) model to dynamic multivariate time series by allowing for more than one evolving variable. All variables in a VAR model are treated symmetrically in a structural sense; each variable has an equation explaining its evolution based on its own lags and the lags of the other model variables (Walter, 2003).

The VAR technique offers two distinct advantages;

The model explicitely allows for endogeneity of variables thereby accommodating the interdependence between electricity consumption and population growth.

Secondly, in contrast to large scale fully specified structural model, the VAR analysis focuses on reduced form relationship and thus only requires a simple model with small number of variables to achieve optimal efficiency.

3.4.1 Unit Root Testing

For the purposes of avoiding the generation of spurious regression which are usually associated with time series data, there exist the need to conduct a unit root test for all the time series variables considered. Given the numerous standard test which can be used for unit root testing, the Augmented Dickey-Fuller (ADF) test and Philip Perron (PP) test is adopted for this study. This is to ensure that, the time series variables in the model are not I (2) stationary and the results of the stationarity test are valid. The presence of I(2) renders the computed results of the model inappropriate. All the variables are considered using the equation below;

$$\Delta Y_t = B_1 + B_2 t + \sigma Y_{t-1} + \alpha \sum_{i=1}^{p} \Delta Y_{t-1} + U_t \text{ ……………………(3.11)}$$

where, Y is the variable of interest, Δ is the difference operator and t the time trend. P is the number of lagged term and U is the white noise residual of zero mean and constant mean and constant variance.

3.4.2 Johansen Cointegration Test

Johansen cointegration test procedure involves the computation of a vector autoregressive (VAR) model which includes difference as well as the levels of the non-stationary variables. Vectors are cointegrated of order (r) in case of their linear association and integrated of (r-d) order (Rao, 1994). Then we declare that 'N' vector is cointegrated: N~ CI (r, d).

The generalized form of equation for Johansen cointegration test is given;

$$\Delta X_t = \tau_1 \Delta X_{t-1} + ... + \tau_{k-1} \Delta X_{t-k} + \pi X_{t-k} + \varepsilon \quad ....(3.12)$$

where ε is the Gaussian random variable, τ and π are matrices of parameters estimated using OLS. The component πX_{t-k} produces different linear combinations of levels of the time series X_t as such the matrix π contains information about the long run properties of the system described by the model. For example, if the rank of matrix π is 0, it suggests that no series of the variables can be expressed as a linear combination of the remaining series. Which suggest that there does not exist a long run relationship among the series of VAR model as a test of cointegration, of rank 0 indicates rejection of integration. However, if the rank of the coefficient matrix is greater is greater than 1, then there exist one or more cointegrating vectors. This indicates that there exists a long run relationship or that the series exhibits significant evidence or behaving as a cointegrated system.

This research has adopted the Johansen (1988, 1990) approach to cointegration as it provides consistent results in multivariate cases. Johansen (1988, 1990) cointegration approach is premised on VAR model. The technique determines the integrating vectors among a series of variables which distinguish it from other techniques used under cointegration analysis. In Johansen cointegration technique, null hypothesis of no cointegration vectors is tested against the alternative hypothesis of cointegrating vectors. Rejection of null hypothesis leads to the confirmation of the presence of long run relationship between the variables.

Hypothesis Formulation;

Null hypothesis: $H_0 : B_i = 0$ (no cointegration)

Alternative hypothesis: $H_i : B_i \neq 0$ (Cointegration among variables)

3.4.3 Vector Error Correction Model (VECM)

The establishment of long run equilibrium relationship between the variables calls for the application of VECM to establish the stability of that long run association. Vector error correction model explains the short run dynamics and speed of adjustment of integrating variables after fluctuations in short run. In error correction model, movement towards long run equilibrium is obtained through previous periods error U_{t-1}. The general VECM is given as:

$$N_t = BZ + V_i + \varepsilon t_i \quad \ldots\ldots(3.13)$$

where Z is the vector of independent variables, V represents the equilibrium error and εt is the white noise error.

Specifying VECM for electricity consumption in Ghana, we have ;

$$\ln EC_t = c_0 + \sum_{i=1}^{p} B_1 \ln EC_{t-1} + \sum_{i=0}^{h_2} B_2 \ln FDI_{t-1} + \sum_{i=0}^{h3} B_3 \ln \ln GDP_{t-1} + \sum_{i=0}^{h_4} B_4 \ln POP_{t-1} + \sum_{i=0}^{h5} B_5 \ln INT_{t-1} + \varepsilon_t \ldots\ldots(3.14)$$

where all the variables are same as previously defined.

Lastly, the short run dynamic effects under the procedure is obtained by estimating an error correction model associated with the long run estimates. This is computed by;

$$\Delta \ln EC_t = \alpha_0 + \sum_{i=1}^{p} \phi_i \Delta \ln EC_{t-1} + \sum_{i=1}^{h} \kappa_i \Delta \ln FDI_{t-1} + \sum_{i=1}^{h} \chi_i \Delta \ln GDP_{t-1} + \sum_{i=1}^{h} \gamma_i \Delta \ln POP_{t-1} + \sum_{i=1}^{h} \tau_i \Delta \ln INT_{t-1} + \delta_i ECM_{-1} + \varepsilon_t \ldots\ldots(3.15)$$

Where κ, γ, χ and ϕ, are the short run dynamic adjustment coefficients of the model. The ECM_{t-1} is the lag of the residual that represents short run disequilibrium adjustment of the estimate of the long run equilibrium error term with δ indicating the speed of adjustment to restoring equilibrium in the dynamic model.

3.5 Data Source

The study employs secondary annual time series data spanning from 1980 to 2015. The variables considered in this study include, electricity consumption, gross domestic product (GDP), foreign direct investment (FDI), and City population. The data on these variables are sourced from the Energy commission, World Bank indicators, and Ghana Statistical Service.

Energy consumption is measured by total electricity consumed in the country per year. GDP is used here as proxy of per capita income and population growth is obtained by calculating the difference in population over a year. Index of industrial production is used to estimate industrial output. Energy intensity is obtained by taking the ratio of energy consumed to a unit of GPD.

CHAPTER FOUR

ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents a thorough analysis and discussion of results of the study. The chapter is divided into six main sections. The first part 4.1, examines the properties of the time series variables of the study. It presents the unit root test results and 4.2 gives accounts of Johansen test for cointegration. Section 4.3 provides the results of the lag selection criteria. The discussion of the results of the causal relationship using the granger causality and estimated long run equation by virtue of the error correction model is presented in sections 4.4 and 4.5 respectively. Section 4.6 presents the results of the decomposition analysis which looks at the impact of electricity intensity on electricity consumption.

4.2 Unit Root Test

A key pre-condition before the application of the VAR test is to determine the stationarity properties of all the variables, so as to ascertain their respective orders of integration. This test is necessary for the avoidance of spurious results due to the presence of I(2) variables. The VAR test is premised on the assumption that the variables considered are all I(1). The presence of I(2) makes a computed F-statistic invalid and therefore does not produce valid results. This study applied the ADF test on each of the variable and further confirming their stationarity using the PP test. The test statistics results for the stationarity of EC, FDI, INT, GDP and POP are reported in Table 4.1

Table 4.1: ADF and PP Unit Root Test at Level without Trend

VARIABLES	ADF WITHOUT TREND		PP WITHOUT TREND		Order
	T-Statistic	P-value	Adjusted Statistic	P-value	
LnEC	-1.2873	0.6244	-1.15250	0.6836	I(0)
lnPOP	-1.00204	0.7410	0.85193	0.9936	I(0)
lnFDI	-0.38544	0.9009	-0.3734	0.9030	I(0)
lnGDP	-2.9473	0.0501	-2.6664	0.0900	I(0)
lnINT	-1.23102	0.6498	-1.1129	0.6997	I(0)
lnEC	-7.0565	0.0000	-7.4039	0.0000	I(1)
lnPOP	-3.8106	0.0066	-5.0904	0.0002	I(1)
lnFDI	-5.1325	0.0002	-3.8580	0.0056	I(1)
lnGDP	-4.1870	0.0027	-7.968	0.0000	I(1)
lnINT	-5.6908	0.0000	-6.11081	0.0000	I(1)

Source: Author Generated Table

The null hypothesis of non-stationarity of a unit root test holds that if the computed ADF test statistic is less than the critical value in absolute terms or the p-value of the variable is more than 5 percent. This hypothesis is however rejected in favour of the alternate hypothesis, if the computed ADF test statistic is greater than the critical values or the p-values less than 5 percent. Results displayed in table 4.1 indicates that the variables failed the stationarity test at level for both the ADF and PP test. These results were therefore rejected and further test carried out to determine stationarity at first difference. The results however confirm that log of all variables under consideration; EC, FDI, INT, GDP and POP are all stationary at first difference. The ADF method was used to test for stationarity and a confirmation test was done using the Philip Perron (PP) method which equally confirmed the stationarity of the variables at first difference. Which therefore means that all three variables considered in this study are integrated of order one making it suitable for the application of VAR.

4.3 Cointegration Test (Johansen Cointegration Test)

In determining the number of cointegrating vectors, the Trace test using the more recent critical values of MacKinnon et al (1990) were computed. The assumption of no deterministic trend and restricted constant was applied. This test is performed basically to ascertain whether there exists long run relationship between the variables under consideration. The variables; EC, FDI, INT, GDP and POP were tested for the existence of cointegration using the Johansen test for cointegration and the results shown in panel A and B of Table 4.2.

Table 4.2 Johansen Cointegration Rank Test

PANEL A				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob
None	0.701485	97.92264	69.81889	0.0001
At most 1*	0.519985	58.02776	47.85613	0.0042
At most 2*	0.416043	33.80784	29.79707	0.0164
At most 3*	0.333684	16.05619	15.49471	0.0411
At most 4	0.077401	2.658498	3.841466	0.1030
PANEL B				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob
None*	0.701485	39.89488	33.87687	0.0085
At most 1	0.519985	24.21992	27.58434	0.1272
At most 2	0.416043	17.75165	21.13162	0.1394
At most 3	0.333684	13.39769	14.26460	0.0682
At most 4	0.077401	2.658498	3.841466	0.1030

***Indicates rejection of the null hypothesis at 5%**

Source: Author computed

The results of the Trace statistic on panel A and maximum eigenvalue of panel B of the Johansen procedure indicates that there exist three cointegrating equations in the trace test and one cointegrating equations in the maximum eigen test indicated by the asterisks (*) and hence cointegration relationship exist between the variables at 5 percent level significance. The null hypothesis (H0) which holds that there is no cointegration among the variables is rejected in favour of the alternative hypothesis of the presence of cointegrating vectors. It thus, can be concluded that a long run relationship exists between the variables.

4.4 Lag Selection Criteria

Table 4.3 reports the lag -order selection statistics. The study adopted lag two as selected by the AIC, LR, FPE, SC, and HQ selection criteria. This is also in conformity with earlier decisions taken based on AIC information.

Table 4.3 Lag Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-73.75652	NA	8.14e-05	4.773122	4.999866	4.849415
1	90.16538	268.2358	1.83e-08	-3.646386	-2.285925	-3.188633
2	148.6169	77.93532*	2.70e-09*	-5.673749*	-3.179570*	-4.834534*
3	173.3548	25.48762	3.75e-09	-5.657869	-2.029972	-4.437192

***Indicates Lag order selected.**

Source: Author computed

LR: Sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

4.5 Granger Causality Test

The results from table 4.1 suggest the existence of long run cointegration relationship between the variables. However, there is the need to establish the direction of causality of the existing long run relationship.

Table 4.4: Granger Causality

	F-STATISTIC	PROB
PANEL A	**Dependent Variable (lnEC)**	
lnGDP	5.49	0.006
lnFDI	7.22	0.0028
lnPOP	6.18	0.0130
lnINT	5.73	0.0080
PANEL B	**Dependent Variable (lnPOP)**	
lnEC)	0.00129	0.998
PANEL C	**Dependent Variable (lnINT)**	
lnEC	1.37	1.2706

Source: Author computed

The results from panel A indicates that, the null hypothesis of the non-existence of granger causality of population growth on electricity consumption is rejected, suggesting that population growth granger causes electricity consumption. It further shows that intensity granger causes electricity consumption. All variables considered in this study jointly granger cause electricity consumption with a significant probability. Panel B and C on the other hand however, fails to reject the null hypothesis, suggesting that electricity consumption does not granger cause population growth and energy intensity. The above results therefore suggest a uni-direction causality between electricity consumption and the interested variables under consideration in Ghana between the periods of 1980 to 2015.

4.6 Vector Error Correction Model

Cointegration and non-spurious regression are the fundamental requirements of error correction model. The results as presented in tables 4.1 for ADF test and Johansen cointegration test provide enough evidence of stationarity at first difference and the existence of long run relationship between variables. It therefore proves that electricity consumption and population growth, together with other control variables are non-spurious and cointegrated, forming a basis for the estimation of error correction model. The presence of cointegration between the variables suggests a long run term relationship among the variables under consideration. The long run relationship between electricity consumption and population growth, together with the other control variables for one cointegrating vector for Ghana in the period 1980-2015 is displayed in Table 4.5 below.

Table 4.5 Long run test results

Dependent Variable: lnEC

VARIABLE	Coefficient	Standard Error	T-statistic
lnGDP	0.073	0.0425	1.718
lnFDI	0.450	0.0857	5.257
lnPOP	0.348	0.058	5.984
lnINT	-0.903	0.4005	2.254

Source: Authors computation

The error correction term indicates the rate at which the disequilibrium between the long run and short run estimates are corrected for. The results of VECM estimate indicates the expected negative and significant error correction term (ECT) (-0.017) and suggesting that on annual basis, disequilibrium between the long run and short run estimates are corrected and brought back to equilibrium.

The long run coefficients of the interested variables of study, energy intensity and population growth) as presented above are significant and therefore have significant impact on the dependent variable, electricity consumption(EC). It therefore suggests that, a 1 percent appreciation in population is likely to increase electricity consumption by 0.348 percent in the long run and this estimate is significant as per the VECM estimation. This supports empirical works done over the years which suggest that population growth has positive impact on electricity consumption. Also energy intensity has a negative coefficient which is also significant. It therefore means that energy intensity for the period considered has caused electricity consumption to fall by 0.903 at any 1 percent increase of energy intensity. This can be attributed to some energy saving measures embarked on by the country over the years.

The findings of this study are consistent with Ackah et al (2014), Zuresh and Peter (2007), Adom et al (2014), Dramani et al (2013), where it is revealed that industry efficiency (energy intensity) negatively affects electricity consumption and population growth positively affects electricity consumption. Adom and Bekoe (2012), however contradicted this position. Their findings indicated no existence of significant long run relationship between population growth and electricity consumption. They further revealed that, industry efficiency has positive impact on electricity consumption. This study did not find any significant short run causality between electricity consumption and population growth, energy intensity, in contrast to the findings of

Zaman K et al (2012), whose analysis established significant long run and short run relationship with electricity consumption.

The short run estimates however does not approve the existence of short run relationship given the probabilities of their coefficients as presented on table 4.7 are not significant.

Table 4.6 Short run coefficients

	Coefficient	Std. Error	t-Statistic	Prob.
lnEC(-1)	-0.011782	0.088810	-0.132664	0.8957
D(lnEC(-1)	-0.250782	0.272552	-0.920125	0.3680
D(lnEC(-2)	0.163263	0.292209	0.558719	0.5823
D(lnGDP(-1)	0.015305	0.011099	1.378928	0.1824
D(lnGDP(-2)	-0.009064	0.011434	-0.792773	0.4368
D(lnFDI(-1)	0.002084	0.049226	0.042333	0.9666
D(lnFDI(-2)	0.050242	0.049375	1.017566	0.3205
D(POP(-1)	-13.68639	19.20745	-0.712556	0.4840
D(POP(-2)	16.72457	18.52749	0.902690	0.3769
D(lnINT(-1)	0.052040	0.272375	0.191061	0.8503
D(lnINT(-2)	-0.220463	0.300928	-0.732610	0.4719
C	-0.018924	0.069410	-0.272640	0.7878

Source: Author computed

4.7. Decomposition Analysis

Generally, this method seeks to estimate the changes in electricity demand arising from a number of factors which for the purpose of this study include; changes occurring in economic activities (Activity effect), the efficiency level of energy use (intensity effect) and changes in the economic structure (structural effect). The study considers three key sectors of the Ghanaian economy and table 4.8 presents the total electricity consumption (TEC) and their driving economic variable (DEV).

Table 4.7. Total Electricity Consumption and Driving Economic variable

SECTOR	2000		2015		DRIVING ECONOMIC VARIABLE.
	DEV	TEC	DEV	TEC	
SERVICE	1604035557	551000325	20068115157	4144000437	Value Added of service sector.
INDUSTRY	1414680629	4306000522	9958328842	1532000129	Value Added of Industry Sector.
RESIDENTIAL	4185740503	1478999893	25482719812	2437000209	Household Consumption of GDP
TOTAL	**7204456689**	**6335999577**	**55509163810**	**8112999612**	

Source; Author Generated Table

From table 4.7, we determine the electricity intensities using equation 3.2, and the structural effect (Q effect), also referred to as the per GDP share by use of equation 3.3, of the various sectors considered in this study. The results of electricity intensity and the per GDP share are presented in table 4.8.

Table 4.8 Electricity Intensity and Per GDP share

SECTOR/YEAR	2000		2015	
	Per GDP share	Intensity	Per GDP share	Intensity
SERVICE	0.2226449	0.343508797	0.361528	0.206497
INDUSTRY	0.19636188	3.043796906	0.179400	0.153841
RESIDENTIAL	0.58099322	0.353342471	0.459072	0.095633

Source; Author generated Table.

In analyzing the change in total electricity demand, the contribution of any one of the factors to the overall change is estimated by examining how that particular factor, that is intensity, economic activity or structural changes, has changed over time whiles holding other factors constant. Therefore, by the use of equations 3.7, 3.8 and 3.9, we obtain the activity, intensity and structural effects respectively. The results are presented in table 4.9.

Table 4.9. Sector Effect of Electricity change

Sector	Activity Effect (Q effect) Kwh	Intensity Effect (I effect) Kwh	Structural Effect (S effect) Kwh	**Total Change Explained**
SERVICE	3694371100	-219772216	343707053	**3818305937**
INDUSTRY	28871069352	-4088368773	-371958064	**24410742515**
RESIDENTIAL	9916436063	-1078702587	-310366625	**8527366851**
TOTAL	**42481876515**	**-5386843576**	**-338617636**	

Source; Author generated Table.

The results from table 4.7 show that all three factors have significant impact on the change in electricity demand. The results suggest that the activity effect, however has a greater impact on the change in electricity demand in the country between the years 2000 and 2015. This implies that a greater percentage of the change in electricity demand emanates from the relative impact of activities.

Using equation (3.10), the total change in electricity consumption can be obtained as; $\Delta E = 42481876515 + (-5386843576) + (-338617636)$

$\Delta E = 36756415303$

The result on electricity consumption above presents a positive change in electricity consumption despite the intensity and structural effects showing negative impacts. This means that electricity consumption as a result of the activity effect is far greater than that caused by both intensity and structural effects. The negative effect of both intensity and structural can be attributed to the fact that there has been a shift from major industrialization in the country over the years to a service oriented economy. The service sector in recent times has been a major contributor the country's GDP and since the energy consumption this sector is relatively minimal as compared to the industrial sector, it has resulted in a fall in electricity consumption in recent years.

Also, there has been some interventions over the years by government and other energy institutions to conserve electricity in the country. In 2007, the ministry of Energy launched the National Compact Fluorescent Exchange Programme targeting to save about 200-220MW of peak electricity demand. The project came with about 6 million CFL's imported to replace incandescent bulbs for household resulting in reduction in 124MW of peak demand. In addition, the Ghana Refrigerating Appliance Rebate Program was introduced and enhanced upon by increasing the rebate from Gh¢200 to Gh¢300 for the purchases of an energy efficient labeled refrigerator and freezer. These interventions can be attributed the reduction in electricity intensity since less energy is now consumed for the supply of goods and services.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS.

5.1 Introduction

This chapter presents the summary and the concluding statements from the study. Furthermore, based on the findings of the study, recommendations are made for policy interventions.

5.2 Summary

The research work has 3 main objectives including, to examine the long run effect of population growth and electricity consumption. Secondly, to investigate the effect of energy intensity on electricity consumption, and lastly to determine how sector growth dynamics influences changes in total electricity use.

The study adopted two methods so as to achieve the aforementioned objectives. The VAR was used to satisfy the first and second objectives of estimating the effect of population growth and energy intensity on electricity consumption. This involved the use of time series data which covers the period 1980 to 2015. The factor decomposition analysis was used to analyze the impact energy intensity and sector contribution to electricity consumption in the country. This method however used data from the year 2000 as the base year and data from the year 2015 as current year.

Analysis of the two methods gave the following results. Firstly, the times series data was stationary at first difference. Based on the evidence from the_Johansen co-integration test, the study reveals the existence of a long run equilibrium relationship between EC, energy intensity and population growth. The granger causality test was also carried out to determine the direction of the relationship between both fundamental variables through VECM. The estimated coefficient of ECT in the electricity consumption equation is statistically significant and has the expected negative sign, which gives credence to the existence of a long run equilibrium between the independent and dependent variables. The estimates further suggest short term relationship coefficients are not significant at the various P-values.

Furthermore, analysis of the decomposition method indicates intensity has a negative effect on the changing electricity consumption over the calculated periods of study. It also revealed that activity effect that is the changing economic activities impacts positively and greatly on the change of total electricity consumption.

5.3 Conclusion

In conclusion, the estimates of the impact of population growth on electricity consumption for Ghana suggests the existence of a long run relationship between the considered variables and EC precisely, the findings suggest that any 1 percent growth of population and energy intensity causes Ghana's electricity consumption to increase by about 0.34 percent and a decrease of 0.90 percent at 5 percent significance in the model. GDP also has a positive and significant impact on electricity consumption. FDI on the other hand has negative contribution with significant contribution in the model. Decomposing electricity consumption using the factor analysis indicated that Electricity intensity has a negative impact on change of EC which supports the estimate of the VAR analysis. The analysis further indicates that, the activity effect, in other words changing economic activities is a greater contributor of electricity consumption in the country with a positive effect.

5.4 Recommendations

Results and analysis of this study suggests valuable policy implications that electricity management should focus on the effective demand side policies to control rising demand. The GSS data on population used for the analysis in this study, suggest a rapidly growing population and given that the estimates from the study indicates a large significant coefficient of electricity consumption, there is the need for the implementation of electricity preservation policies in the country. This will include the use of energy pricing policies to enforce energy conservation especially in the residential sector.

More also, there is the need for rigorous education of people on efficient electrical gadgets imported and used in the country. This is to say; electrical gadgets must meet certain set out efficiency standards before they can be imported and used in the country so as to avoid electrical energy loses and unnecessary high consumption.

Empirical studies like Ackah and Asomani (2015) however reveals that there is the need for diversification of electricity use at various levels. Households must be encouraged to supplement their electricity use with renewable energy. For instance, households can use solar plants to power some of their electrical gadgets whiles heavy gadgets as washing machines and fridges connected to the national grid. This will reduce the existing electricity demand pressure on the national grid. The total change explained by the decomposition analysis indicates that residential electricity consumption constitutes a greater percentage of the total change in electricity in the country. It is therefore necessary key policies targets

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APPENDIX

obs	LNEC	LNFDI	LNGDP	LNINTENSITY	LNPOP
1980	22.24945	16.56278	22.21510	0.034352	2.499120
1981	22.27825	16.60445	22.16368	0.114566	2.499708
1982	22.31103	16.60668	22.11852	0.192509	2.496359
1983	22.34584	14.69098	22.12378	0.222067	2.490982
1984	22.38022	14.50866	22.20766	0.172564	2.489403
1985	22.41259	15.53828	22.22831	0.184287	2.497305
1986	21.94641	15.27413	22.46856	-0.522151	2.507688
1987	22.08179	15.36307	22.34756	-0.265771	2.519878
1988	22.16462	15.42495	22.37151	-0.206886	2.533297
1989	22.20406	16.52356	22.38183	-0.177774	2.546878
1990	22.28781	16.51014	22.49638	-0.208568	2.560235
1991	22.35447	16.81124	22.60981	-0.255343	2.573171
1992	22.42663	16.92903	22.58173	-0.155104	2.586089
1993	22.41211	18.64382	22.50939	-0.097273	2.599321
1994	22.44009	19.26655	22.41788	0.022206	2.613676
1995	22.50612	18.48366	22.58969	-0.083571	2.629448
1996	22.56671	18.60300	22.65984	-0.093133	2.646785
1997	22.65873	18.21979	22.65353	0.005208	2.665173
1998	22.32528	18.93590	22.73563	-0.410344	2.684172
1999	22.62114	19.31145	22.76700	-0.145855	2.702947
2000	22.56184	18.92690	22.32930	0.232534	2.719044
2001	22.60424	18.30774	22.39378	0.210458	2.728748
2002	22.54712	17.89186	22.54237	0.004748	2.738041
2003	22.23222	18.73367	22.75567	-0.523446	2.747077
2004	22.25238	18.75193	22.90722	-0.654842	2.756198
2005	22.39023	18.79204	23.09646	-0.706236	2.765477
2006	22.60447	20.27072	23.73925	-1.134782	2.775103
2007	22.43560	21.04765	23.93245	-1.496845	2.785020
2008	22.54103	21.72203	24.07411	-1.533082	2.795384
2009	22.56165	21.58723	23.98051	-1.418862	2.806148
2010	22.65146	21.65044	24.19445	-1.542992	2.817544
2011	22.80296	21.90118	24.40124	-1.598280	2.829560
2012	22.90900	21.91553	24.45950	-1.550500	2.842269
2013	23.02612	21.89482	24.59040	-1.564280	2.855665
2014	23.08508	21.93622	24.37695	-1.291867	2.869786
2015	22.97862	21.88401	24.35728	-1.378659	2.878609

	2000		2015	
	GDP	TEC	GDP	TEC
SERVICE	1,604,035,557.00	551,000,325.00	20,068,115,156.50	4,144,000,437.00
INDUSTRY	1,414,680,629.00	4,306,000,522.00	9,958,328,841.80	1,532,000,129.00
RESIDENTIAL	4,185,740,503.00	1,478,999,893.00	25,482,719,811.90	2,437,000,209.00
TOTAL	**7,204,456,689.00**	**6,335,999,577.00**	**55,509,163,810.20**	**8,112,999,612.00**