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DEPARTMENT OF ECONOMICS

AN ANALYSIS OF INDUSTRIAL SECTOR DEMAND FOR ELECTRICITY IN GHANA

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BY

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DECLARATION

I, hereby declare that this research work is part of the requirement towards the award of MSc. Economics Degree and that, to the best of my knowledge, it contains no material previously published by another person nor material which had been accepted for the award of any other degree of the university, except where due acknowledgement had been made in the text.

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DEDICATION

This thesis is dedicated to my parents Alhaji Aziz and Hajia Zainab.

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ABSTRACT

Demand for Electricity in Ghana far exceeds the supply and is perhaps the greatest infrastructure problem confronting the industrial sector which contributes immensely to economic growth. A typical Ghanaian industry experiences power failure or voltage fluctuations about 5 times per week each lasting for about twelve hours without prior warning. The study used partial adjustment model approach to analyze industrial sector demand for electricity in Ghana and the definition for electricity intensity that is electricity consumed in the industrial sector divided by gross domestic product. The study used data from 1971 to 2013 to calculate the model.

From the estimation, industrial value added is positive and significant at 1% significance level. In both the short run and long run there is a positive relationship between industrial value added and industrial electricity demand. The elasticity of petrol price in both the short run and long run is statistically significant in the partial adjustment model. Hence an increase in petrol price will make customers move to the use of electricity. Energy intensity is significant and is positive in both the short run and long run and can be used for policy purposes in the country in both the short run and long run. Policy should aim at increasing the efficiency level of the industries by using good machines and appliances at the work place. Policy can also be directed towards following the standards of Environmental Protection Agency especially using appliances with approved labels.

TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

CHAPTER ONE

INTRODUCTION

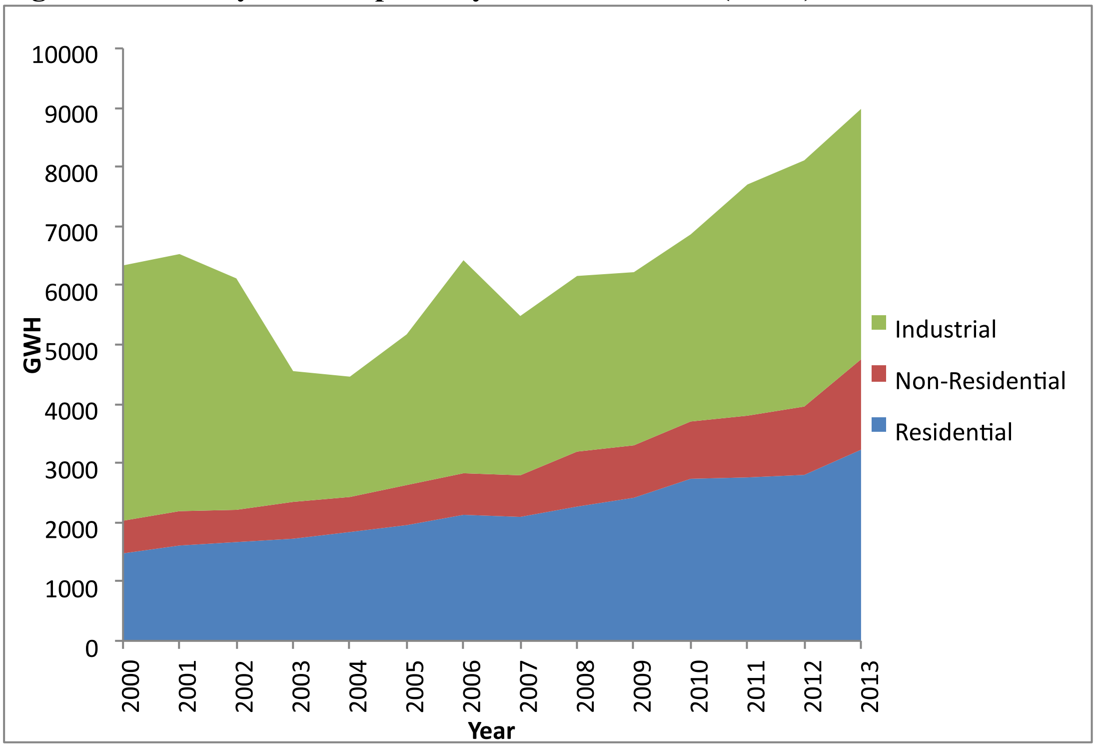
1.1 Background to the Study

A careful analysis of the pattern of demand for power is essential for an appreciation of the process of planning for power in a country (Gleatta, et al, 1979: 106). Electricity consumption in Ghana is estimated to be increasing by 10% per annum due to the demand from the growing population. Current sources of production (hydro and thermal facilities) generate only 66% of the current demand (Essah, 2011).

In Ghana there are three major sectors that demand electricity; residential, industrial and the service sector. The demand for electricity in these sectors has being increasing over the years. It is growing between 6% and 7% annually. Clearly with the Ghanaian economy growing, increasing urban population will consume more electricity. Urbanization in Ghana is expected to increase from around 40% in 2000 to about 55% in 2012 and eventually to 60% by 2020. A little more than a third of the urban population lives in Greater Accra and is expected to reach 40% by 2020 (ISSER, 2005). The Energy Commission (EC) estimates that residential demand may reach anywhere between 7,000 and 13,000GWh by 2020 depending on the rate of economic growth and urbanization. The residential sector is not the only segment expected to grow; commercial and industrial consumption will grow as well from 3,000 to 10,000GWh by 2020 according to the Energy Commission. If VALCO is fully operational, an additional 2,000GWh in electricity consumption should be expected.

In order to meet this increasing demand, new power generation as well as transmission and distribution facilities will have to be built (ISSER, 2005). Figure 1.1 is a chart showing electricity consumption in Ghana from 2000 to 2013.

Fig. 1.1 Electricity Consumption by Customer Class (GWh)



Source of data. Energy Commission of Ghana (2014).

Since the 1990s, residential and commercial demand for electricity has increased rapidly, and is the dominant component of electricity use in Ghana. The other significant consumers of electricity are Volta Aluminum Company (Valco) and the mining companies (Energy Group, 2013). From figure 1.1, it is clear that electricity consumption is increasing in all the sectors of the economy and is following the trend of 1990s. From figure 1.1 it is clear that the major driver for the increase in consumption in the industrial sector may be as a result of the middle income status attained recently by Ghana.

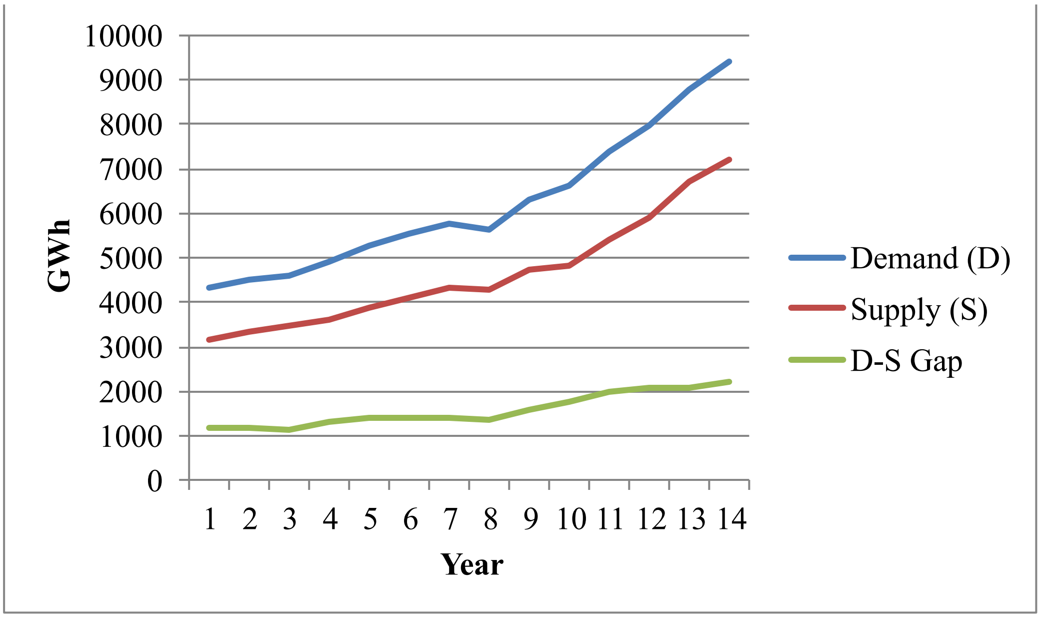
Ghana‟s energy sector has been bedeviled with the inability of power producers to meet demand which led to load shedding popularly known in the local parlance as "dumsor". This load shedding exercise is done without regard to the industries existing in the country.

A major power crisis in 2006–2007 is estimated to have cost the country nearly 1% in gross domestic product (GDP) growth in those years. The immediate cause of the crisis was a shortfall in hydropower production due to lower water levels in Lake
Volta. This shock could not be cushioned by thermal power generation because the Government of Ghana had not invested in additional thermal generation after 2000, nor had the Government facilitated independent power producers‟ (IPPs‟) ability to do so. The situation was aggravated by the resumption of the Valco smelter, which needed large amounts of power, at a time when the level of Lake Volta did not provide an adequate reserve cushion in a dry year (World Bank, 2013).

1.2 Problem Statement

One cannot take the importance of power from economic development and for that matter industrial development. Hence a comprehensive look at the power system in the country is needed to ascertain where we need to look into for alternative sources of power.

Fig. 1.2 Electricity Demand-Supply Gap



Data Source; Energy commission (2014).

Looking at the current situation in Ghana, electricity demand far exceeds supply and is perhaps the greatest infrastructure problem confronting the industrial sector demand for electricity. Figure 1.2 depicts the electricity demand-supply gap in Ghana. A typical Ghanaian Industry experiences power failure or voltage fluctuations about five times per week each lasting for about twelve hours, without the benefit of prior warning. This imposes a huge cost on the industry arising from idled workers, spoiled materials, lost output which leads to lost in revenue, damaged equipment (appliances) and restart costs. The overall impact is to increase business uncertainty and lower returns on investment. For the aggregate economy, this has seriously undermined

Ghana‟s growth potential and the attractiveness of the economy to external investors. Even though electricity consumption is increasing in all the sectors much increase is from the industrial sector. Among measures industries resort to are, reduction in sector employment, reduction in sector‟s real output, increased cost of production of the industry, factor substitution, and private provision of power and choice of business.

While all these elements are presently observed among Ghanaian industries, the most commonly observed ones are reduction in sector employment; reduction in sector‟s real output and increased cost of production. This then calls for a critical appraisal of the causes of the monumental increase in electricity demand in the
industrial sector.

1.3 Research Objectives.

General Objective

To provide an analysis of industrial sector demand for electricity in Ghana.

Specific Objectives

1. To examine factors that causes changes in industrial electricity demand in Ghana.
2. To estimate industrial sector adjustment in electricity consumption from the short-run to the long-run in Ghana.
3. To estimate the impact of industrial electricity intensity on industrial electricity consumption in Ghana.

1.4 Research Questions.

General Question

What are the determinants of industrial sector demand for electricity?

Specific Questions

1. What are the factors that cause changes in industrial electricity demand in Ghana?
2. What is the industrial sector‟s adjustment in electricity consumption from the short run to the long run in Ghana?

3. What is the impact of industrial electricity intensity on industrial electricity consumption in Ghana?

1.5 Relevance of the Research

As an adequate supply of energy is vital for the smooth running of a country, and because of long lead times and capital intensive nature of energy projects, developing countries need to analyze the past trends to forecast the likely paths of energy demand growth.

Again because of the need to forecast for day-to-day operation and management of energy systems, how much electricity needs to be generated next hour or tomorrow? This information forms the basis for unit commitment exercise. Similarly, forecasts for six months to one year are required for business planning purposes, for regulatory approvals, to assess the prospects of the business in the coming year etc.
(Bhattacharyya, 2011).

The studies done so far in analyzing electricity demand in Ghana do not look directly at the industry which is the main focus of this study. With emphasis on the industry, we will be able to know the direct impact of the above variables on it which will go a long way to help government in taking steps to solving the problems of the sector.

Again the study will look at the energy intensity in the country to see the trend that energy consumption is taking in the country so that we can plan on demand management in the country.

This study will help to answer the questions posed above to help in government decision making. The study will also serve as a guide for investors to invest in the country. It will also serve as a literature for further studies into the area because much work is not done on the topic.

1.6 Research Methodology

For the general objective and specific objectives, the study will adopt the partial adjustment model technique to determine the short run and long run effects of the variables on industrial demand for electricity in Ghana. It will also look at the impact of previous electricity consumption on current electricity consumption because electricity consumption depends on previous consumption. With objective 3, the same definition of electricity intensity is used to calculate it (Electricity consumed by the industrial sector divided by gross domestic product).

1.7 Organization of the Study

The rest of the study is organized as follows; Chapter two looks at the literature review, chapter three takes care of the methodology, chapter four looks at data analysis and presentation, chapter five looks at the findings, recommendations and conclusions.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews literature on the work. Section 1. Review literature on the impact of change in industrial value added on industrial electricity demand, section 2. Look at the effect of price of alternative source of energy on industrial demand for electricity, section 2.1 looks at the effect of change in urbanization on industrial demand for electricity 3 is on energy intensity, 3.1 reviews literature on econometric methods of modeling energy demand and section 4 is on econometric methods of analyzing energy demand.

2.1 The impact of change in industrial value added on industrial electricity demand

Several studies have sought to determine the responsiveness of electricity demand to changes in income and other variables like price change, weather, urbanization, changes in appliance, price of alternative source of energy, real GDP on electricity demand and other relevant variables (Khanna and Rao, 2009). The focus of this study is on the impact of industrial value added in industry, price of an alternative source of electricity, impact of changes in urbanization on industrial sectors demand for electricity, and the impact of energy intensity on industrial demand for electricity.

Some of such studies are reviewed below.

Dilaver and Hunt (2010) using data from the period 1960 to 2008 with assumptions on „low", „reference", and „high" case scenarios. All three cases showed that real industrial electricity prices will increase after 2009, industrial value added was expected to increase after 2009 in the reference and high case scenarios but will decrease in the low case scenario in 2009 and start to increase after that. Furthermore, because of efficiency in the Turkish industrial sector, the under laying energy demand trend (UEDT) slope is expected to decrease in all three scenarios with different magnitudes. Turkish Industrial demand for electricity is expected to increase in all three cases.

2.2 Effect of Price of alternative source of energy on industrial Demand for electricity

Price of a substitute, in this study it is taken to be the price of petrol. In this study, the world price of petrol in US dollars per barrel is used. When the price of a substitute goes up all things being equal the demand for electricity will go up and when the price goes down, the demand for the good in this case electricity demand comes down.

There is a positive relationship between electricity demand and the price of petrol.

Karger (2014) did a time series analysis on Turkish Economy using Growth Data between the periods 1970 and 2010. Variables were stationary when first differenced and were moving in the same direction using Engle-Granger approach to co integration. All variables used contained mutual causality relation in the long run. It was found that industrial electricity consumption and economic growth were having a positive relationship. In their study using Engle and Granger approach of co integration to establish a long term relationship between variables that influence electricity demand in the non-metallic mineral products industries of Japan and China, after satisfying for stationarity using ADF and PP tests, it was found that there existed a long term relationship between variables in both Japanese and Chinese non-metallic mineral products industry. All variables were having their expected signs, economic growth and industrial activity will drive up electricity demand in both countries. On the other hand technological progress, increased per-capita productivity and increase in electricity prices will have negative effect on electricity demand (Du and Sun, 2015).

Khan and Ahmed (2009) examined the determinants of demand for electricity in Pakistan at both aggregate and disaggregate levels over the period 1970 to 2006, using Autoregressive Distributed Lag (ARDL) approach to co integration. On testing for co integration, it was seen that there was long run relationship between the variables at the aggregate level in the industrial sector. The estimated parameters were having their expected a priori signs as in the case of Du and Sun (2015). Electricity is considered a normal good as demand for it increased with increase in income in the long run. With price, electricity is considered a luxury at the aggregate level rather than a necessity.

Iqbal (1983) basing his study on the traditional micro-economic theory found that natural gas and electricity in Pakistan were not competitors. With the consumption of both commodities, the elasticities were equivalent in magnitude and significant than when used separately. There was a slow rate of adjustment of fuel-consuming devices in the residential sector of Pakistan. Yavuzdemir and Gogkoz (2015) used three different forecast methods (time series, regression and fuzzy logic) techniques to estimate gross annual electricity demand of Turkey. Basing their findings on AREP figures (absolute relative errors); time series analysis gave better results than regression and fuzzy logic models.

Dramani and Tewari (2014) did a time series analysis of Residential Sector Demand for Electricity in Ghana. After first differencing, both the ADF and KPSS exhibited stationarity. There was long term relationship among variables and all the explanatory variables were having their expected signs in the long-run. Electricity consumption was seen as an indicator of improved wellbeing of the people of Ghana.

Khan and Ahmed (2008) in their study after testing for unit root using the t-ADF test found that all the variables were stationary with the exception of per-capita consumption of petroleum. The trace test was then done and they found that there was no long-run relationship between per capita electricity consumption, per capita real income and domestic price level. Causality test was then done among variables; the results showed that electricity demand was determined by the lag of all the variables (electricity demand, real income growth and domestic price changes) in the short-run. The lag of electricity demand, lag of real income per capita have positive impact on electricity consumption but price change had negative impact in the short-run.

In the short-run it was found that electricity demand was not responsive to price, income, customers and stock of appliance, hence electricity was considered a necessity. Prices of electricity had an inverse effect on electricity demand. With respect to the long-run, all the variables were having their expected elasticity signs except customer‟s variables in the residential, industrial and agricultural sectors (Alter and Shabib, 2011). In their study, all variables were having their a priori signs after first differencing and using the Autoregressive Distributed Lag Approach of co integration to do the estimation of the regression (Nasir, et al, 2008).

2.2.1 Effect of changes in urbanization on industrial demand for electricity

Urbanization is the movement of people from the rural areas to the cities or towns. Theoretically, the more urban a country is the more people are employed in the industrial sector. So it is expected that urbanization all things being equal will increase industrial demand for electricity because more people will be employed in the industrial sector and as more people are employed they will demand more electricity to work with. Urbanization has a positive relationship with industrial sectors demand for electricity. Urban population growth rate is used in this study.

Using Unit roots test (PP and ADF tests) to test for stationarity and vector autoregressive regressions(VAR) for modeling of electricity demand in South Africa, Inglesi (2009) found that the variables were stationary after first differencing and examining of long term relationship realized that; in the short-run, electricity demand was influenced by GDP and population growth. However in the long-run electricity demand was influenced by disposable income and electricity prices with each variable having its expected sign. After testing for stationarity and long-term relationship using Johansen co integration, they found that all variables were stationary and had longterm relationship in the long-run; they then applied the VECM for short-run dynamic stability and realized that variables were stable and significant at 5% significance level.

Shahbaz et al. (2015) found that urbanization is positively related to energy demand which further confirms the theory of Kuznets in developing countries. Energy consumption in industrial areas in urban Malaysia is high.

2.3 Energy Intensity

There are so many methods used to measure how energy affects the economy but the most widely used one is Energy Intensity which measures the energy requirement per unit of a driving economic activity. Normally it is given by the ratio of the amount of energy consumed to the economic activity (GDP or value added).

Even though it is widely used as a measure of the performance of the economy, it is subject to so many conceptual and measurement problems. The base is an area of utmost concern because it affects the numerator and the denominator. Again, the problems related to GDP as a measure of output also affects the ratio. Underground economy may lead to an underestimation of GDP which is common in developing countries.

Inefficiency and conversion to a common denominator are all problems of measuring intensity. Among problems of energy consumed are uses of traditional energies, aggregation of energies to a common unit, differences in energy consuming sectors etc.

De La Rue du Can et al. (2011) using economic output approach to calculate energy intensity found that, petroleum manufacturing was the leading energy consumer in California followed by oil and gas in the periods 1997 and 2008. Furthermore using electricity and fuel intensities in the same study to calculate final energy intensity for each sector found that oil and gas has the highest energy intensity in 2000 followed by nonmetallic minerals and oil refineries sectors.

In their study electricity intensity in South Africa was higher than OECD countries in 1990s. Again South Africa showed a 117% increase in electricity intensity which was different from the average of the OECD countries of only 10.09%. It was in Spain, Greece, Portugal and Italy as well as Korea and Iceland that there was increase in electricity intensities. Both output and electricity consumption increased in these countries but the increase in output was a little less than in electricity consumption leading to that increase in intensities. There was an inverse relationship between electricity consumption and growth in the 1990s (Inglesi and Blignaut, 2011).

2.4 Partial Adjustment Model Analysis of Energy Demand

Using annual time series data, Amarawickrama and Hunt (2007) estimated the electricity demand for Sri Lanka using different econometric estimation techniques. The results were not the same in terms of specifications and results. There existed differences in the estimated effect of energy demand trend between the techniques;

ranging from being positive to zero to negative. This showed the importance of using causal econometric relationship rather than using a range of techniques without clear statistical rationale.

The special features of electricity demand make it different from the demand of other goods. Demand for it is a function of demand for end use service, such as cooking, heating, washing and air conditioning, and the demand for associated fuel using equipment. Demand for a service depends on the cost of the service and the operating cost. Given this, there is the need to differentiate between short run and long run changes of electricity demand. In the short run the change is not as evident as in the long run because of change in appliance and change in utilization rate.

As a result of this different methods have been used to capture the distinction between the short run and long run behavior of electricity demand, but the most widely used method is the partial adjustment model.

Ashraf and Sabih (1992) using partial adjustment model after testing for autocorrelation found that the short run price and long run price elasticity were very close in Pakistan"s industrial sector. Variables were not having their expected signs and were insignificant which might be as a result of accurate index to deflate price for the industrial sector.

Econometrically, energy demand relies on the microeconomic approach to energy demand and the effects of variables like price, urbanization, income and other variables on energy demand. Any energy demand analysis takes into consideration the basic three principles of energy demand because of the derived nature of energy demand. They are equipment buying decision, fuel and equipment choice and capacity utilization decision. The above is embedded in the econometric method with different levels of usefulness as a result of varying modeling techniques.

We use the reduced form models and the structural models. The model begins with an identity that equates energy demand to capital equipment and rate of use. It is given in equation (2.1)

$$A = f_1(P_i, P_j, P_a, Y, X) \quad \text{(2.1)}$$

$$R_i = f_i(P_i, Y, Z) \quad \text{(2.2)}$$

pi is price of fuel i, p_j is price of competitive fuel, $p\alpha$ is price of appliance, Y is income, X and Z other variables. The appliance stock depends on fuel price, substitute fuel price, income and other variables. The rate of utilization depends on own-price of fuel, income and other variables.

As a result of unavailability of information, a reduced form model is used to estimate the fuel demand. In the reduced form the above model can be written as;

$$Q_i = k(P_i, P_j, P_a, Y, X, Z) \quad \text{(2.3)}$$

The above model assumes an instantaneous change in the appliance stock. The model does not differentiate between the short run and long run adjustment.

As a result of the lack of distinction between the short run and long run adjustment process, most studies employ the partial stock adjustment models with the assumption that the stock of appliances cannot adjust rapidly because of time lags in the process of retirement and new capacity addition.

In the partial adjustment model, a distinction is made between actual and desired demand. The desired consumption is dependent on current price and other variables. This is given by the equation (2.4).

$$Q_t - Q_{t-1} = g(Q_t^* - Q_{t-1}),\ 0 < g < 1 \quad \text{……………………………… (2.4)}$$

Due to price change, the consumer moves partly from his initial consumption to the desired consumption. The closer g is to unity, the faster the speed of adjustment.

When we substitute desired consumption into equation (2.4) and rearrange terms, we get equation (2.5) below.

$$Q_t = a^{'}g + b^{'}gP_t + C^{'}gZ_t + (1-g)Q_{t-1} + ge_t^{'} \quad \text{…….. ………………...(2.5)}$$

Equation (2.5) can be rewritten as

$$Q_t = a + bP_t + cZ_t + dQ_{t-1} + e_t \quad \text{……………………………………….. (2.5)}$$

The observable variables are Q and its lagged term. The coefficient is the speed of adjustment used to determine the short and long run coefficients.

Equation (2.5) usually takes the following form (2.6) because of direct interpretation in elasticities.

$$\log E_t = a + b\log(P_t) + c\log(Y_t) + u_t \quad \text{………………………………… (2.6)}$$

E is determined by the error term, price of energy, and per capita real output.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter discusses the methods employed by this study in answering the questions posed above. The methodology gives details of the study framework with emphasis model specification, source and type of data and estimation strategies. Section 1 looks at model specification, section 2 is on source and type of data. Section 3 is on estimation strategies, section 4 is on diagnosis and stability test.

3.1 Model Specification

This study examines the industrial electricity demand using a combination of methodologies. The first estimation uses partial adjustment model and the second one uses the definition of energy intensity to calculate energy intensity in Ghana. After which a model is then run using energy intensity as the dependent variable and electricity consumption as the independent variable to answer question five.

Partial Adjustment Models are used to differentiate between short run and long run adjustments in electricity demand. It also assumes that desired demand is dependent on current price and other variables.

$$E_t^* = a_1 + a_2 P_t + a_3 Z_t + e_t' \qquad \text{3.1}$$

In any given period, an adjustment process is needed due to lack of knowledge, technical constraints and other factors. The adjustment process is given as

$$E_t - E_{t-1} = g(E_t^* - E_{t-1}) \qquad \text{3.2}$$

$0 < g < 1$

The closer g (the speed of adjustment) is to unity, the faster the adjustment process. Substituting equation 3.1 into equation 3.2, we get equation 3.3

$$E_t = a_1^{'} g + a_2^{'} g P_t + a_3^{'} g Z_t + (1-g)E_{t-1} + g e_t^{'} \ldots\ldots\ldots 3.3$$

Rearranging and substituting terms equation 3.3 is now given in equation 3.4

$$E_t = a_1 + a_2 P_t + a_3 Z_t + dE_{t-1} + e_t \ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

The only observable terms in this model are E and its lagged term.

Industrial electricity demand model

$$E_t = \beta_0 + \beta_1 I_t + \beta_2 P_t + \beta_3 U_t + \beta_4 EI_t + dE_{t-1} + \lambda_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

Where

E_t Is the demand for electricity by the industrial sector.

I_t Is industrial value added which is percentage of GDP measuring revenue for industries.

P_t Is price for a substitute which measures the price of petrol.

U_t Stands for urbanization; measuring the effect of changes in urbanization on industrial demand for electricity.

E_{t-1} Is the lag of the dependent variable which is the demand for electricity by the industrial sector.

EI_t Is energy intensity in Ghana.

λ_t Is the error term and

Short run elasticities are given by $\beta_1, \beta_2, \beta_3, \beta_4$ and long run elasticities are given by $\frac{\beta_1}{1-d}, \frac{\beta_2}{1-d}, \frac{\beta_3}{1-d}, \frac{\beta_4}{1-d}$. Partial adjustment models are preferred over static single equation models because of their simplicity and their ability to capture differences between short run and long run responses.

Now we specify the model in log-log form because of the direct results it gives with respect to elasticities.

$$\log E_t = \beta_0 + \beta_1 \log I_t + \beta_2 \log P_t + \beta_3 \log U_t + \beta_4 \log EI_t + d \log E_{t-1} \quad \text{(3.6)}$$

Industrial value added which comes from the industrial sector is used as output for the industrial sector. Industrial value added measures the level of industrial activity. There is a positive relationship between industrial value added and industrial demand for electricity.

3.1.1 Variable Description and a priori expectation

3.1.1.1 Dependent variable

Industrial sector demand

Industrial sector demand for electricity refers to electricity demanded by the industrial sector in Ghana within the study period. Industrial value added, price of a substitute, urbanization, energy intensity, lag of the dependent variable are the independent variables of the study.

3.1.1.2 Independent variables

Industrial value added

Industrial value added is taken in the study to mean the change in industrial activity that is the addition to industrial production which will increase industrial revenue. Hence increases in industrial activity will all things being equal increase industrial sector demand for electricity meaning there is a positive relationship between industrial value added and industrial demand for electricity.

Price of substitute

Price of a substitute, in this study it is taken to be the price of petrol. In this study, the world price of petrol in US dollars per barrel is used. When the price of a substitute goes up all things being equal the demand for electricity will go up and when the price comes down, the demand for the good in this case electricity demand comes down.

There is a positive relationship between electricity demand and the price of petrol.

Urbanization

Urbanization is the movement of people from the rural areas to the cities or towns. Theoretically, the more urban a country is the more people are employed in the industrial sector. So it is expected that urbanization all things being equal will increase industrial demand for electricity because more people will be employed in the industrial sector and as more people are employed they will demand more electricity to work with. Urbanization has a positive relationship with industrial sectors demand for electricity. Urban population growth rate is used in this study.

Energy intensity

There are so many methods used to measure how energy affects the economy but the most widely used one is Energy Intensity which measures the energy requirement per unit of a driving economic activity. Normally it is given by the ratio of the amount of energy consumed to the economic activity (GDP or value added). Even though it is widely used as a measure of the performance of the economy, it is subject to so many conceptual and measurement problems. The base is an area of utmost concern because it affects the numerator and the denominator. Again, the problems related to GDP as a measure of output also affects the ratio. Underground economy may lead to an underestimation of GDP which is common in developing countries. Inefficiency and conversion to a common denominator are all problems of measuring intensity. Among problems of energy consumed are uses of traditional energies, aggregation of energies to a common unit, differences in energy consuming sectors etc.

3.2 Source and type of data

The study uses secondary data to answer the questions. The sources of the data are made up of published reports on reliable energy data sources such as World Development Indicators, Energy Commission of Ghana (National Energy Statistics), BP Statistical Service. Industrial electricity consumption is in Giggawatt per hour (GWh), Gross Domestic Product is in real terms constant 2005 US dollars, Industrial value added is percentage of gross domestic product, Urbanization is percentage of annual population growth and price of petrol is in US dollars.

3.3 Estimation Strategies

3.3.1 Stationary test

The use of time series data for analysis requires the test for stationarity of the variables. It is necessary for econometric model specification A number of alternative tests are available for testing whether a series is stationary or not, the Augmented Dickey-Fuller (*ADF*) as well as the Phillips Perron (PP) test. This study adopted the Augmented Dickey-Fuller-GLS (DF-GLS) framework for stationarity in testing the endogenous and exogenous variables. The objective of this unit root test is to check whether, the variables of interest are not integrated of order one- I(1) before proceeding to estimate the coefficients of the variables. It is necessary since modelling with non-stationary variables can result in spurious relationships which is a common problem associated with time series data, whereas a combination of nonstationary variables can, in certain circumstances, result in co-integration and hence an inappropriate relationship among variables.

3.3.2 Estimation technique

There are so many techniques available for estimating the partial adjustment model but the most widely and accepted one is the ordinary least squares method. The ordinary least squares method is used over the others because of its advantages when dealing with time series data. The ordinary least squares give as the best fit of the estimated sample regression of the data with the following properties; exogenous regressors, no perfect multicollinearity, and optimal in the class of unbiased estimators when the errors are homoscedastic and serially uncorrelated.

3.4 Diagnostic and Stability test

The diagnostic tests are done to examine the reliability of the results of the study. In order to check for the estimated partial adjustment model, the significance of the variables and other diagnostic tests such as serial correlation, functional form, normality; heteroscedasticity and structural stability of the model are considered. Following Pesaran and Pesaran (1997), the stability of the regression coefficients are evaluated by stability tests and they can show whether or not the regression equation is stable over time. This stability test is appropriate in time series data, especially when we are uncertain about when structural change might have taken place.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION

4.0 Introduction

This chapter presents the data analysis and estimated results of the estimated models in chapter three. This begins by testing for the stationarity of the variables, followed by the test for the presence of co-integration or otherwise among the variables; the log of industrial electricity consumption, log of industrial value added, log of world price of petrol, log of urbanization, log of lag of industrial electricity consumption and log of energy intensity. The short run and long run relationship estimated results and discussion are presented and finally, the stability test and diagnostic test results are presented.

4.1 Results of Stationarity Test

Table 4.1 Augmented Dickey-Fuller test

VARIABLE	LEVEL		FIRST DIFFERENCE	
	CONSTANT	CONSTANT AND TREND	CONSTANT	CONSTANT AND TREND
LogE	-2.491980	-3.316408*	-6.239558***	-6.153613***
LogP	-2.213490	-2.509845	-6.179707***	-6.186233***
LogIV	-1.324527	-1.979294	-4.535866***	-4.504543***
LogU	-1.074047	-0.712997	-5.594270***	-5.568891***
LogE_1	-2.459801	-3.349048*	-6.157631***	-6.068040***
LogE1	-0.509596	-3.188126	-6.485575***	-6.484059***

Note; * and *** denote 1% and 10% significance level respectively.

Non-stationarity of the variables has some statistical and economic implication worth noting. The presence of unit root in the data has the tendency of producing spurious relationship when ordinary least square is applied for estimation statistically.

Economically, the presence of unit root in the data implies that there is likely to be a lasting effect when there is a shock.

From table 4.1, the null hypothesis is rejected when the ADF test statistic is less than the critical values. The unit root tests at the levels show that, apart from logE and logE_1 that the null hypothesis is rejected; the null hypothesis is not rejected in all the other variables (logP, logU, logIV, logEI). This implies that logP, logU, logIV, logEI are non-stationary at the levels whiles logE and logE_1 are stationary at the levels at the 10% significance level.

For all the variables to achieve stationarity, logarithms of the first difference were tested. From the results above, the null hypothesis is rejected indicating the absence of unit root in all the variables at the 1% critical value hence stationarity at first difference. Since logEI, logIV, logP and logU are all stationary at first difference, it can be concluded that the variables are integrated of order one or I (1).

4.2 Results of the Partial adjustment Model

Table 4.2 Short run and Long run Results on Partial Adjustment Model

Variable	Coefficient	Std. error	T-statistic	Prob.	Long run Values	T-statistics
C	5.764653	0.633914	9.093752	0.0000*		
LogP	0.185815	0.042022	4.421868	0.0001*	0.2282	5.4305
LogIV	0.373892	0.079651	4.694138	0.0000*	0.4592	5.7652
LogU	-0.06444	0.108333	-0.59498	0.5556	-0.0791	-0.7302
LogE(-1)	0.185748	0.096908	1.916747	0.0632***		
LogEI	0.565667	0.069211	8.173062	0.0000*	0.6947	10.0374

Note; * and*** denote 1% and 10% significance level respectively.

Table 4.2 shows the results of the partial adjustment model, the short run and long run results of the model. From table 4.2, price of petrol, industrial value added, energy intensity are all significant at 1% significance level and the lag of the dependent variable is significant at 10% significance level with their expected a priori signs. It is only urbanization that is not significant in the above table without its a priori economic sign.

The coefficient of the price of petrol is positive. This result shows that a 1% increase in price of petrol will cause industrial electricity demand to increase by 18.58 in the short run and it will be in the steady state in the long run at 22.82. This implies that petrol is considered as a substitute good in both the short run and in the long run.
From table 4.2 the t-values for both short run and long run are not significant.

Again, the coefficient for industrial value added is positive and is statistically significant at 1% significance level. This means that, a 1% increase in industrial value added will lead to a 37.39 increase in industrial electricity demand. This could happen for the reason that, as industrial value added increases, it leads to increase in industrial revenue and increase in industrial activities because of expansion, the industry is in a good position to afford high cost and expand their line of operation thereby increasing electricity consumption.

As a priori, the coefficient of the speed of adjustment is supposed to be positive and statistically significant for the variables to converge to equilibrium. From table 4.2, the speed of adjustment term is statistically significant at 10% significance level and the sign of its coefficient is also positive. The coefficient for the speed of adjustment is 0.1857 implying that, in the long run, equilibrium is restored at 18.57. In other words, industrial electricity demand is able to restore to its long run equilibrium at the rate of 18.57.

Finally, the coefficient of energy intensity suggests that an increase in energy intensity by 1% will lead to increase in industrial electricity demand by 56.57. This is true because energy intensity talks about energy efficiency so as the efficiency level improves more energy is available for the industrial sector.

4.3 Results for diagnosis and stability tests

Table 4.3 Diagnostic Test

Test Statistics	LM-Version	P-Value	F- Version	P-Value
Serial Correlation	3.3080	[.069]	2.4777	[.138]
Functional Form	1.7575	[.185]	1.2155	[.289]
Normality	.46038	[.794]		
Heteroscedasticity	.0040947	[.949]	.0037232	[.952]

Table 4.3 shows that there is no serial correlation because its p-value is insignificant using the F-version therefore the null hypothesis is rejected for serial correlation and we accept the alternate hypothesis that there is no serial correlation. More so, there is correct functional specification and from the LM-version the model is normally distributed, furthermore, there is no heteroscedasity since the p-values are insignificant in both the LM-version and the F-version.

CHAPTER FIVE

SUMMARY, POLICY RECOMMENDATION AND CONCLUSION

5.0 Introduction

This chapter is the final chapter of the study. Section 1. Is made up of the summary of the empirical findings of the study, section 2.conclusion and section 3. Policy recommendation for implementation in the energy sector of Ghana.

5.1 Summary of Empirical Findings

The study employed time series data ranging from 1971 to 2013 to analyze the industrial sector demand for electricity in Ghana. The study applied various techniques in the estimation including partial adjustment model and energy intensity definition. The study tested for the stationarity of the variables using the Augmented Dickey Fuller test where all the variables where found to be stationary at first difference but industrial electricity demand was found to be stationary at the levels and the other variables were non-stationary at the levels. The partial adjustment model technique was then applied to test for industrial electricity demand in Ghana. The model was tested for its stability and reliability using several test techniques as in chapter four. The results show that the model is reliable and stable and can be used for policy implementation.

The estimated coefficient for industrial value added is positive and is statistically significant at 1% significance level hence meeting its theoretical economic sign. Its short run value is 0.3739 and the long run value is 0.4592 as expected.

The estimated petrol price elasticity of industrial electricity demand in both the short run and long run is positive and statistically significant in the partial adjustment model.

The estimated petrol price is positive and meets its a priori sign implying that petrol and electricity are substitutes.

Furthermore the value of energy intensity is positive and is statistically significant at 1% significance level. The values of the short run and long run estimates are respectively 0.5657 and 0.6947.

Finally, the lag of the dependent variable (industrial electricity consumption) is positive and is statistically significant at 10% significance level.

5.2 Policy Implication and Recommendations

The results from the estimation show that industrial value added is statistically significant in both the short run and long run hence can be considered for short term and long term decision making. Given the positive relationship between industrial value added and industrial electricity demand, the policy implication is that promotion of industrial activity will in turn increase industrial value added which will increase the consumption of electricity by the industrial sector. Policy makers should therefore consider making policies which will increase the efficiency of electricity usage. This can be done by; following EPA (Environmental Protection Agency) guidelines on electricity usage, subsidizing electric equipment, discouraging the use of old electric gadgets among other policies. This will reduce electricity consumption in the industrial sector.

Also, the results show that petrol and electricity are substitutes, the coefficient of price of petrol is statistically significant and so it can be used for policy making. The policy implication is that any upward adjustment in price of petrol will lead to people shifting to electricity demand, which is shift from petrol to electricity. This situation provides sufficient room to reduce petrol prices so that there will be a shift from electricity to petrol since they are substitutes.

Furthermore, energy intensity is statistically significant and policy makers should take it into consideration when energy management practices are to be considered in the industrial sector. Policy should be directed towards reducing energy intensity. This can be done through education on how to use machines, machines with the right standards and labels should be used at the work place.

Finally as is evident in the value of previous industrial electricity consumption, much work needs to be done about how much electricity is consumed yesterday, today because it affects industrial electricity consumption in the future.

5.3 Conclusion

The study used partial adjustment model to estimate industrial sector demand for electricity in Ghana. The results show that price of petrol is a substitute to electricity; industrial value added is significant and is to be considered in making policies, energy intensity is also significant and hence the EPA policies that are to ensure energy efficiency are to be adhered to, to help in the energy situation of the country.

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APPENDICE **Appendix 1: Summary of data used in the estimation of the industrial electricity demand Model**

Year	logE	lopP	logIV	logU	logE_1	logEI
1971	3.577951	0.350248	1.317727	0.529768		-13.994
1972	3.670545	0.394452	1.297942	0.557105	3.577951	-13.7554
1973	3.697578	0.517196	1.305872	0.560038	3.670545	-13.5167
1974	3.729286	1.063709	1.299492	0.533913	3.697578	-13.278
1975	3.717338	1.061829	1.369214	0.487483	3.729286	-13.0393
1976	3.720242	1.10721	1.330912	0.42616	3.717338	-12.8006
1977	3.782544	1.143639	1.234883	0.376173	3.720242	-12.562
1978	3.773128	1.146748	1.110063	0.367041	3.782544	-12.3233
1979	3.779669	1.499824	1.113347	0.415804	3.773128	-12.0846
1980	3.79767	1.566202	1.09013	0.488339	3.779669	-11.8459
1981	3.798047	1.555457	0.979482	0.556231	3.79767	-11.6072
1982	3.788576	1.518119	0.810713	0.601621	3.798047	-11.3686
1983	3.655292	1.470557	0.885291	0.623293	3.788576	-11.1299
1984	3.333175	1.459091	1.047426	0.661223	3.655292	-10.8912
1985	3.618713	1.440279	1.255065	0.72817	3.333175	-10.6525
1986	3.783925	1.159266	1.236625	0.707067	3.618713	-10.4138
1987	3.747217	1.265761	1.21358	0.690191	3.783925	-10.1752
1988	3.782283	1.173769	1.220125	0.679012	3.747217	-9.93648
1989	3.81595	1.260787	1.227322	0.674584	3.782283	-9.6978
1990	3.677999	1.375298	1.226731	0.676081	3.81595	-9.45912
1991	3.706506	1.30103	1.230002	0.678873	3.677999	-9.22044
1992	3.737843	1.286007	1.241714	0.678308	3.706506	-8.98176
1993	3.761993	1.229682	1.444037	0.672764	3.737843	-8.74308
1994	3.743508	1.199206	1.441821	0.661969	3.761993	-8.5044
1995	3.749144	1.23096	1.427206	0.646794	3.743508	-8.26572
1996	3.765984	1.31534	1.424202	0.630659	3.749144	-8.02704

1997	3.689522	1.280806	1.458357	0.616541	3.765984	-7.78836
1998	3.554301	1.104487	1.450656	0.609686	3.689522	-7.54968
1999	3.604477	1.254548	1.452732	0.61019	3.554301	-7.311
2000	3.634074	1.454845	1.453124	0.610607	3.604477	-7.07232
2001	3.637189	1.388101	1.449287	0.59941	3.634074	-6.83364
2002	3.59151	1.398287	1.45021	0.604508	3.637189	-6.59496
2003	3.343606	1.459845	1.44338	0.607825	3.59151	-6.35628
2004	3.307282	1.582858	1.432295	0.608777	3.343606	-6.1176
2005	3.405176	1.736556	1.438725	0.606607	3.307282	-5.87892
2006	3.555457	1.813848	1.318052	0.605229	3.405176	-5.64024
2007	3.429268	1.859679	1.316956	0.602932	3.555457	-5.40156
2008	3.471732	1.987934	1.310152	0.596951	3.429268	-5.16288
2009	3.465383	1.790074	1.278736	0.585811	3.471732	-4.9242
2010	3.499137	1.900367	1.281393	0.572526	3.465383	-4.68552
2011	3.591065	2.046339	1.407505	0.557133	3.499137	-4.44684
2012	3.618362	2.047937	1.456943	0.541554	3.591065	-4.20816
2013	3.625724	2.03607	1.455871	0.527658	3.618362	-3.96948

Appendix 2: Summary of data used in the estimation of energy intensity model

Year	Electric C	GDP	EI
1971	3784	4523846484	8.365E-07
1972	4683.22	4411308786	1.062E-06
1973	4984	4538556665	1.098E-06
1974	5361.5	4849562039	1.106E-06
1975	5216	4246682511	1.228E-06
1976	5251	4096766829	1.282E-06
1977	6061	4189931719	1.447E-06
1978	5931	4545067634	1.305E-06
1979	6021	4430761850	1.359E-06
1980	6275.81	4451661567	1.410E-06
1981	6281.27	4295716859	1.462E-06
1982	6145.77	3998296446	1.537E-06
1983	4521.6	3815824683	1.185E-06
1984	2153.65	4145800765	5.195E-07
1985	4156.36	4356889102	9.540E-07
1986	6080.3	4583410740	1.327E-06
1987	5587.49	4803180643	1.163E-06
1988	6057.35	5073511803	1.194E-06
1989	6545.61	5331544145	1.228E-06
1990	4764.301	5509021559	8.648E-07
1991	5087.513	5799998499	8.772E-07
1992	5468.183	6025004753	9.076E-07
1993	5780.861	6317217484	9.151E-07
1994	5539.979	6525685661	8.489E-07
1995	5612.34	6794049194	8.261E-07
1996	5834.23	7106742655	8.209E-07
1997	4892.4	7404967010	6.607E-07
1998	3583.45	7753029398	4.622E-07

1999	4022.32	8094162423	4.969E-07
2000	4306	8393646433	5.130E-07
2001	4337	8729392290	4.968E-07
2002	3904	9122214943	4.280E-07
2003	2206	9596570120	2.299E-07
2004	2029	10133978047	2.002E-07
2005	2542	10731883141	2.369E-07
2006	3593	11418723662	3.147E-07
2007	2687	12156343018	2.210E-07
2008	2963	13181184012	2.248E-07
2009	2920	13707278823	2.130E-07
2010	3156	14804825657	2.132E-07
2011	3900	17026596445	2.291E-07
2012	4153	18523201271	2.242E-07
2013	4224	19844237673	2.129E-07

Appendix 3: Summary of results of the model

Dependent Variable: LOGE

Method: Least Squares

Date: 01/12/16 Time: 14:56

Sample (adjusted): 2 43

Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.764653	0.633914	9.093752	0.0000
LOGP	0.185815	0.042022	4.421868	0.0001
LOGIV	0.373892	0.079651	4.694138	0.0000
LOGU	-0.064449	0.108333	-0.594918	0.5556
LOGE(-1)	0.185748	0.096908	1.916747	0.0632
LOGEI	0.565667	0.069211	8.173062	0.0000

R-squared	0.847976	Mean dependent var	3.646605
Adjusted R-squared	0.826861	S.D. dependent var	0.139664
S.E. of regression	0.058114	Akaike info criterion	-2.721252

Sum squared resid	0.121581	Schwarz criterion	-2.473013
Log likelihood	63.14628	F-statistic	40.16088
Durbin-Watson stat	1.068180	Prob(F-statistic)	0.000000

E=Energy consumption, P=price of petrol, IV=industrial value added, U=urbanization, EI= energy consumption intensity