ELASTICITY OF DEMAND FOR ELECTRICITY IN KENYA FROM TIME SERIES DATA

MULEA ANN MAWIA

X50/72232/2011

Research Project Submitted to the School of Economics, University of Nairobi in Partial Fulfillment of the Requirements for the Award of the Degree of Master of Arts in Economics

2013

DECLARATION

I declare that this paper is my original work and that it has not been submitted in any university for any degree award.

CANDIDATE: ANN MAWIA MULEA

SIGNATURE ……………………………… DATE………………………………

This paper has been submitted for the award of a degree of Master of Arts in Economics with our approval as University supervisors

DR. KAMAU GATHIAKA

SIGNATURE ……………………………… DATE………………………………

PROF. PETER KIMUYU

SIGNATURE ……………………………… DATE………………………………

DEDICATION

To my late mother, Agnes Mulea for the support that she gave me and teaching me the principles of determination and hard work

ACKNOWLEDGEMENT

First and foremost, I would like to thank God Almighty for the gift of life, good health and sound mind throughout this period of my research.

Secondly, my deep gratitude goes to my supervisors Dr. Kamau Gathiaka and Professor Peter Kimuyu for their guidance and fruitful discussions when writing this paper. Their guidance helped me to remain focused during the period of writing this paper.

Thirdly, I would like to thank African Development Bank and my employer; Ministry of Planning and Devolution for the financial and material support and granting me study leave to pursue my Master of Arts degree in Economics.

Fourthly, I am extremely grateful to my family members particularly my dad Nicholas, sisters Diana and Ruth and my brother-in-law Dennis who supported me emotionally during this period of study. Their encouragement has gone a long way to ensure completion of this paper.

Fifthly, special thanks go to my classmates of Module I 2011 for their assistance during this period of research. Their assistance towards the completion of my research paper was immense.

Last but not least, I am highly indebted to my friends who have shown unwavering support in terms of emotional and academic advice during the entire period of developing this research paper.

Finally, I am also grateful to the staff at Kenya Power, Kenya National Bureau of Statistics and Meteorological Department for availing data for my study. I also thank staff at the School of Economics, University of Nairobi for their support during research

ABSTRACT

The Kenya Vision 2030 identifies electricity as a development enabler. Electricity plays a key role in development. It facilitates technological advancements therefore enhancing gains in productivity. Generally, electricity improves social advancement and attains faster economic growth. However the demand for electricity exceeds the supply. The study investigates the determinants of demand for electricity and their current elasticities using secondary annual time series data from 1971 to 2012. The study employed OLS and the Error Correction Model in data analysis. The results indicated that in the short run industrial production and kerosene prices were key factors that determine demand for electricity. The government therefore should strive to improve efficiency through modernizing industrial technology. The government should also increase production of electricity to match the industrial growth.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

ADF	Augumented Dickey Fuller
ARIMA	Auto Regressive Integrated Moving Average
ECM	Error Correction Model
ERC	Energy Regulatory Commission
GDP	Gross Domestic Product
GWh	GigaWatt hour
IPPs	Independent Power Producers
IV-2SLS	Instrumental Variable Two Stage Least Squares
KenGen	Kenya Electricity Generating Company
KIPPRA	Kenya Institute for Public Policy and Research Analysis
Kg	Kilogramme
KNBS	Kenya National Bureau of Statistics
KP	Kenya Power
Kshs	Kenya Shillings
kWh	Kilowatt hour
LPG	Liquefied Petroleum Gas
MW	MegaWatt
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
REP	Rural Electrification Programme
SBIC	Schwarz-Bayesian Information Criteria
SSA	Sub Saharan Africa
TVCM	Time Varying Cointegrating Model
UAE	United Arab Emirates

CHAPTER ONE

INTRODUCTION

1.1 Background

Kenya uses energy from various sources including electricity, fossil fuels (petroleum/oil, gas and coal) and renewable sources (National Energy Survey, 2011). Energy from the latter source has become increasingly significant over the years. According to National Energy Survey, 2011, the energy sources used in Kenya are renewable sources (69%), electricity (9%) and fossil fuel (22%). Whereas the country has historically depended on hydropower for electricity generation, there has been an increase in investment into alternative renewable sources, especially geothermal and wind with an installed capacity of 212 and 5.45 megawatts, respectively, as at June 2012 (KNBS 2012). The country also relies on oil, a non-renewable source, to produce electricity. The 2000 drought period however recorded very high volumes of imported oil used in electricity generation as it served as the main substitute for hydropower. The country imported a total of 2452.3 tonnes of oil in that year (Economic Survey, 2003). Electricity production from oil sources that year accounted for 50.64% (World Bank 2012).This was in spite of risks involved including price volatility and harmful environmental impact. Following the recent discovery of oil in Turkana, which is located in the northern part of the country, this is expected to have a tremendous impact on the country's energy sector upon commencement of commercial production.

According to the Energy Act of 2006, the energy sector aims to provide affordable energy to all. The sector facilitates the provision of clean, dependable, affordable and secure energy in terms of cost, environment friendly and availability. Energy is utilized in various sectors such as transport, residential, commercial and manufacturing. It is also used for street lighting and power generation. Individuals demand energy for domestic consumption while industries demand energy as an input of production. Renewable sources are used to provide heat, generate electricity and make fuel. They are plenty and are found in every part of the country. Biomass is largely used in rural areas and part of the urban areas. Currently the sector relies entirely on the importation of all petroleum requirements. Wood fuel has been overexploited. It has been harvested to a level of diminishing returns due to its availability and low cost. Other renewable energy resources such as biomass, biogas, solar and wind though abundant, have not been fully exploited due to high costs, lack of appropriate technology and limited research and development (KIPPRA 2007)

Fossil fuels comprise of petroleum and coal resources. Petroleum is used in the transport, industrial and commercial sectors. Kenya imports crude oil from Middle East. Kenya also imports coal but has recently discovered coal deposits in Mui basin, Kitui County. Cement manufacturers use coal to complement heavy fuel oil to generate heat.

Sources for electricity generation are many including hydro, thermal (fuel), geothermal, wind and bagasse. Electricity is used for both production and consumption by economic agents. Industries use it in their production processes. Small firms use it to provide services and households use it for domestic consumption.

The energy sector has an important role in the socio-economic development of a nation. Petroleum and electricity sources are the key drivers of the economy in Kenya. (Kenya Vision 2030) The sub sectors of greatest potential in this regard are electricity, petroleum and renewable energy. This study examines the demand for electricity in Kenya. Electricity is an engine of growth locally and globally. Similarly electricity demand is gaining importance because of its efficiency in production. The government has embarked on measures to increase electricity production even though there is need for demand management so as to eliminate shortages. Demand for electricity has surpassed production over the years mainly due to an increase in the number of consumers as shown in Table 1.1 below.

Table 1.1: Generated Vs Consumed Electricity in Kenya, 2004/05 – 2010/11

Years / **Demand & Consumer Statistics**	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**2010/11**
Electricity Generated (GWh	5,347	5,697	6,169	6,385	6,489	6,692	7,303
Electricity Sold (GWh)	4,379	4,580	5,065	5,322	5,432	5,624	6,123
Number of Consumers	735,144	802,249	924,329	1,060,383	1,267,198	1,463,639	1,753,348

Source: National Energy Survey 2011

Consumption of electricity has been rising with number of consumers as shown in Table 1.1. Some electricity is also lost during transmission and distribution.

Over time Kenya's development and economic growth has continued to rise. Over the last decade the economy has grown from 0.6% in 2000 to 4.6% in 2012 (World Development Indicators 2012). This growth coupled with technological innovations has seen a rise in demand for energy particularly electricity and fossil fuels. The development projects set under Vision 2030 will increase demand for energy. The government is for that reason committed to institutional reforms through a strong regulatory framework, encouraging more private power producers and separating generation from distribution (Kenya Vision 2030). There are challenges of meeting energy needs due to the high expectations in growth to power the economy. It is therefore imperative to design strategies and implement investment plans to ensure sustainable supply of energy to meet the growing demand. The energy sector is considered a key segment to achieving vision 2030.

1.2 Kenya's Electricity Sub-sector: A Situational Analysis

Electricity is one of energy sources widely used in the country. Kenya's electricity is produced from various sources that include hydropower, thermal, geothermal, baggase and wind. Hydro and thermal sources supply over 80% of the country's electricity. Households and firms use electricity for consumption and as a factor of production. Electricity takes part among the most important inputs for industry and production. Per capita electricity consumption is one of the indicators of the level of development in a country. In Kenya, per capita electricity consumption is also used as an indicator of the dependability of electricity services and consumers capability to pay for them (World Energy Outlook 2011)

Electricity is a secondary source of energy produced from primary energy sources specifically renewable energy sources, fossil fuels and nuclear energy. However, in Kenya electricity from nuclear sources is expected to commence in 2022 with a production capacity of 1000MW. Table 1.2 shows production shares of the various sources of electricity in Kenya.

Table 1.2: Sources of Electricity in Kenya

Source	**Percentage of Production**
Hydro	47.8
Thermal	37
Geothermal	12.4
Bagasse (Co-generation)	2.5
Wind	0.3
Total	100

Source: National Energy Policy, 2011

Electricity is crucial to economic growth as it has various uses. Access to electricity is linked to rising or high standards of living. Kenya Vision 2030 identifies electricity as a development enabler in production activities. The provision of inexpensive and reliable supply of electricity is essential in a modern economy (WEO 2011). In terms of access, about 16.1% of the population in Kenya is connected to electricity much of which is urban. Only 5% of rural population has access to electricity (World Development Report, 2009). The Rural Electrification Authority targets to raise rural population access to electricity to 20% by 2015, and to 40% by 2025 (Energy Act 2006). Access to electricity in the rural areas has opened up small businesses such as salons, milling, printing, photocopying, welding/metal fabrication and cyber cafes (Ministry of Energy 2011) thus spurring rural growth.

Globally close to 1.3 billion people lack access to electricity (International Energy Policy 2011). In rural areas less than 10% of the households have electricity connections. Many health, learning and social institutions lack electricity in Sub-Saharan Africa. Increasing population densities in rural areas have put pressure on governments to provide electricity (International Energy Policy 2011). Kenya started the rural electrification project to hasten the speed of rural electrification. *"Umeme Pamoja"* (common electricity connection), an initiative by Kenya Power Company connects power to joint groups of household thereby saving on costs. Low access to electricity is attributed to high costs of connection in rural Kenya (Markandya and Abdulla, 2007)

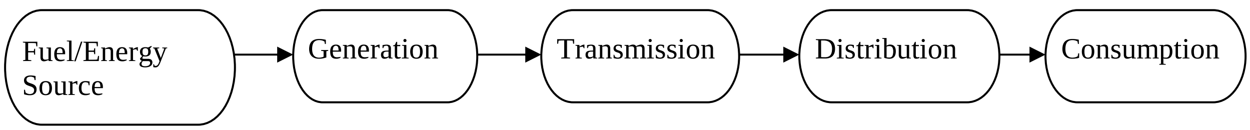
Access to electricity in Kenya is affected by factors such as electricity prices, high connection costs, unavailability of funds to cater for capital and operation expenditures for generation, transmission as well as supply costs of electricity (KIPPRA, 2007). Through the regulation of prices by the Energy Regulatory Commission and the expansion of electricity distribution network in the country more people have been able to access electricity.

Electricity production undergoes various stages before reaching the final consumer. After generation, it is transformed into high voltage power according to the consumer requirements. It is then distributed to end users or consumers through a huge network of power lines and substations.

1.3 Electricity Production in Kenya

Electricity undergoes several chains before it reaches the consumers as depicted in Figure 1.1

Figure 1.1 Electricity Production Chain



Electricity is generated from source (hydro, geothermal, petroleum or wind energy) and a power plant converts the source energy into electrical energy.

The Kenya Electricity Generating Company Limited (KenGen) is the primary electric power production company, generating about 80% of electricity that is used in the country, (National Energy Policy 2011). The company uses hydro, wind, thermal and geothermal, thermal energy to generate electricity. Hydro is the chief source of electricity, with an established capacity of 677.3MW. Hydro-electricity is generated from plants found along the River Tana; Gitaru, Kindaruma, Kiambere, Kamburu and Masinga which have a capacity of more than 400 MW in total. Turkwel Gorge Power Station which is located in Western Kenya has a capacity of 106 MW. In addition there are other small hydro stations - Mesco, Tana, Ndula, Selby Falls, Wanjii, Gogo Falls which were built before Kenya gained independence. They contribute an output of 40 MW.

Geothermal energy produced from natural steam is obtained from volcanic-active regions in the Rift Valley. Plants located in Olkaria contribute about 127 MW to the national grid Thermal energy is produced in power stations located in Nairobi and Mombasa. (National Energy Policy, 2002)

According to the National Energy Policy, 2011, the remaining 20% of electricity is generated by six independent power producers (IPPs) namely, Iberafrica Power (EA) Limited (Thermal plant), Tsavo Power Company Limited (Thermal Plant), OrPower 4 Inc (Geothermal Plant), Mumias Sugar Company Limited (Co-generation), Rabai Power Limited (Thermal Plant) and Imenti Tea Factory Company (Mini Hydro Plant). IPPs entered the domestic market in 1997 to bridge the demand gap. According to the Kenya Economic Survey (2012), Kenya also imports electricity from Tanzania, Uganda and Ethiopia

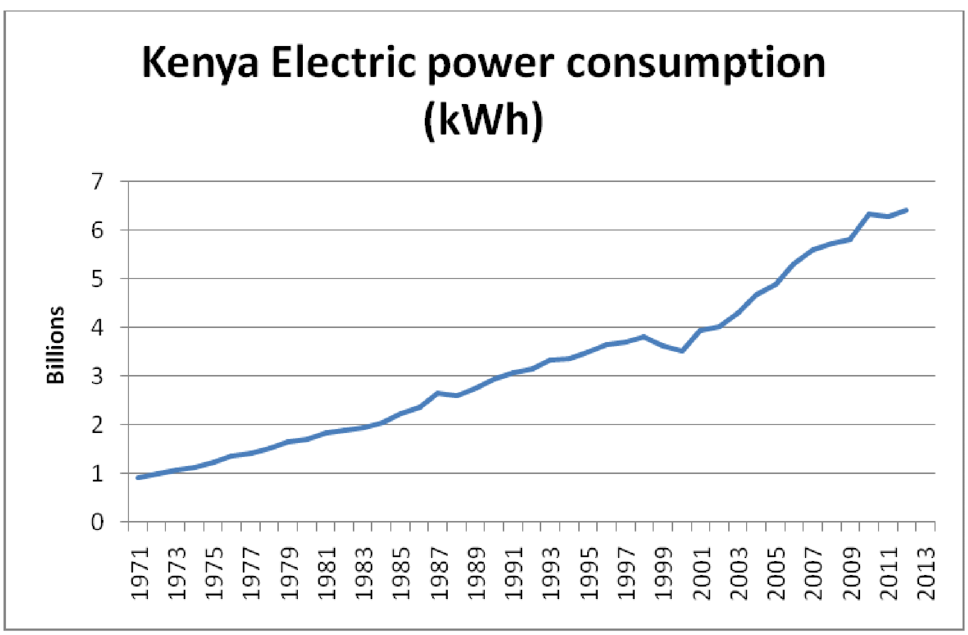
There has been a deficit of electricity supplied despite the efforts made by the government to import power from the neighbouring countries and buy from the IPPs. Uninterrupted and sufficient electric power supply is one of the most crucial stimulants of economic growth for any economy. The electricity subsector in Kenya has been historically characterized by huge shortages and outages. Between the years 1999-2001 there was major power rationing. The study will try to establish whether there are other variables that influence electricity demand in Kenya besides rising number of consumers.

1.4 Electricity Consumption

Over the years the government has recognized the importance of electricity sector in increasing national output. Electricity consumption has revealed an upward movement. (World Development Indicators, 2012) Electricity is used by a number of key sectors like agriculture, manufacturing, trade, transport and communication as well as domestic sector.

The access rate has increased tremendously over the years. The number of customers in 2010/11 financial year was 1,753,348 up from 735,144 in 2004/05 financial year (Kenya Power Annual Report and Financial Statement 2012). This can also be attributed to government's efforts especially through the Rural Electrification Programme to increase electricity connections in the rural areas. Electricity consumption has also been increasing over time as shown in the graph below.

Fig 1.2 Electric Power Consumption in Kenya



Source: **World Development Indicators 2012**

Demand for electricity may be affected by both economic and structural variables. According to economic theory, the economic variables may include the price of electricity, income and prices of substitutes. Population may be a key structural variable that affects demand for electricity. Increase in electricity prices may lead to a fall on the demand for electricity due to the inverse relationship between prices and demand. Prices of substitutes may decrease or increase the amount of electricity demanded. This depends on their prices relative to the price of electricity. High incomes may increase electricity consumption due to raised demand for electrical goods and services. Population growth is likely to exert more pressure on demand for electricity. Industrial production may also increase levels of electricity consumed due to usage of electrical machines.

Elasticities show the proportionate change that occurs in a dependent variable when an independent variable changes. Elasticity of demand for electricity is explained by various factors. Different factors will determine demand for electricity differently.

1.5 Problem Statement

Electricity plays a key role in development. It facilitates technological advancements therefore enhancing gains in productivity. Generally, electricity improves social advancement and helps to accelerate economic growth. Mwakubo, et al 2007, shows that the national access rate in 2007 was 15%, and this was below the average of 32% for developing countries. Insufficient electricity supply is attributed to rising demand. The suburbs of Nairobi have witnessed rapid construction of high rise buildings. An ambitious street lighting program in several of Kenya’s towns has increased the demand for electricity. Industries have also increased their production and consumption of electricity. Industrial production increased from Kshs 42.53 billion in 1971 to 247.98 billion in 2012 (*World Development Indicators 2012*). The slums have also recorded a high number of legal and illegal electricity connections pushing the demand further up. UN-HABITAT report estimates that 60% of Nairobi population lives in slums and that every 1-5 homes have electricity connection. Electricity has limited substitution possibilities in most sectors.

Earlier studies have established the determinants of demand for electricity. This study seeks to establish the income and cross elasticities of electricity demand in Kenya, an aspect that is missing from studies that have been done. Elasticities will provide a dynamic relationship of the responsiveness of the factors determining demand for electricity.

1.6 Research Questions

The study will be guided by the following research questions

a) What is the elasticity of demand for electricity with respect to price?

b) What is the elasticity of demand for electricity with respect to income?

c) What are the cross elasticities of demand for electricity and Kerosene, and electricity and LPG fuels?

1.7 Study Objectives

The general objective of the study is to analyze the responsiveness of electricity demand to its determinants.

The specific objectives will be:

a) To estimate the price elasticity of electricity demand in Kenya.

b) To estimate income elasticity of electricity demand in Kenya

c) To estimate the cross elasticity of demand for electricity demand with non electric energies of kerosene and LPG.

1.8 Significance of the Study

The study will provide a critical analysis of the behavioral relationship between electricity demand response to its determinants. The relationship between elasticity of demand for electricity to changes in its price and its substitutes will provide useful information for demand management, taxation and formulation of sound policies in electricity subsector.

1.9 Scope of the Study

The study focused on the period from 1971 to 2012. The year 1971 was chosen because significant electricity production amounts were reported in the early 1970s following the construction and functioning of the first dam, Kamburu. Electricity production in 1971 increased to 909 million Kilowatt hours (World Development Indicators 2012) from 513 million kilowatt hours in 1970 (Economic Survey 1974). After the oil crisis of 1970s, the importance of energy in production has come to be fully appreciated.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Literature Review

The theoretical literature is based on the general demand theory and demand for energy. This segment will highlight the factors that influence demand for electricity.

2.2 Demand for electricity

This study applies the general theory of demand as well as theory of energy demand. Electricity, just like any other good, has price demand, income demand and cross demand. Electricity is a consumer as well as a producer good. From theory, demand for electricity may be derived demand. Demand can also be classified as short run and long run demand. According to Sheffrin (2003) short run demand refers to existing demand with its immediate reaction to market changes such as price and income adjustments among other factors. Long run demand eventually exists after the market has adjusted to the new conditions. Short run demand is inelastic due to information asymmetry, time factor and capital required to alter consumption patterns. In the short run demand for electricity may be high but in the long run alternatives come up and ease the demand. This may be through modification of the existing ones or introduction on new ones which are more efficient (Narayan et al, 2007).

2.3 Factors of Electricity Demand

Several factors contribute to demand of a commodity (Mankiw 2007). Price has an inverse relationship with demand for a good. An increase in incomes raises demand. Price of substitutes or complementary goods also influences demand. Tastes and preferences also determine the quantity demanded. Advertisements increase demand as consumers are aware of a product or service in the market. Lack of information in the market is a big impediment in efficient market operations. If individual's tastes for a good or service increase, then their quantity demanded increases, and vice versa. Demand can also be influenced by expectations of future prices, prices of related goods and incomes. When future prices are expected to increase, demand today rises. Similarly when incomes are expected to rise, consumption today is likely to increase. Hunt and Ninomiya (2003) expressed demand for energy as a factor of prices, incomes, technical efficiency and tastes.

The factors that influence demand for electricity can be categorized into price, price of other energy sources, geographical location, demographic and environmental factors. Other factors include lifestyles, structural changes and efficiency improvement. All these factors were important when estimating energy demand functions (Hunt and Ninomiya, 2003)

Income is the most significant determinant of electricity consumption. Arthur (2003) defined income demand as the demand of a good at different income levels. Demand for a good is determined by the level of income. When the income levels increase people tend to demand more goods and services. A normal good is described as that whose demand goes up when incomes increase and demand goes down when incomes decrease. The income level which represents economic activity and standards of living is the main factor in determining electricity's demand. Incomes have an impact on the living standards and increasing incomes are the major driving force of electricity consumption. As an individual's income increases their welfare also increases. There is more demand for entertainment, ownership of electrical appliances such as refrigerators, electric kettles, electric cookers, heaters air conditioners among others. Empirical studies confirm that income was a significant and had direct correlation between incomes and electricity consumption. Anderson (2000) , stated that energy was not affordable if incomes did not rise above a certain level.

Electricity price is yet another key determinant of electricity demand. According to Arthur (2003), demand can be also be categorized as price demand, is the demand of a commodity at various prices and demand decreases with high prices. High prices may decrease electricity demand in the short run. In the long run this may result to use of efficient appliances and eventually a substantial reduction of electricity consumed. Consequently, it is expected that there is an indirect link between electricity prices and electricity consumption. Electricity prices have been characterized by huge inconsistencies globally and Kenya is no exception. Despite this, they remain an important factor for electricity demand. The behavior of increased electricity prices and reduced demand is also consistent with the demand theories in economics theory. As the price of a normal good increases, the demand of the good decreases. D'Sa et al (2004) in their study revealed that high price constrains energy consumption. Additionally, Balabanoff (2003) presented electricity as a necessary good with an inelastic demand.

Different lifestyles can also cause a change in the patterns of demand for electricity. There can be an increase or decrease on demand. Some individuals may opt to use different sources of energy other than electricity for example LPG, firewood or kerosene. Others may use environmentally and convenient electrical appliances. With the rapid development, many people have moved to urban areas. Urbanization and higher incomes have led a shift to electricity and gas from kerosene and firewood. Chipman & Dzioiubinksi, (1999) in their study showed that urbanization was an important determinant of quantity and the kind of fuel to be used.

Adjustments in economic structure could bring a significant change in electricity consumption. Factors such as population, size of the household, climatic patterns, age distribution have an effect on electricity consumed. Age group influences electricity in that the old age people remain in their homes during the day thus use more electricity. Younger people go to work. Larger households used more electrical appliances and energy than smaller ones. (UNDP 2000)

According to UNDP 2000 report, other important factors included; price of other fuel substitutes (gas prices, kerosene prices), population and urbanization, climatic conditions, level of industrialization, capital investment and government policies. Population was an essential structural factor which influenced the level of electricity consumption. The higher the population, the greater is the demand for electricity. Pressure on demand for electricity mounted as industrialization in an economy intensified rapidly. Prices of other key substitutes were important in determining demand as they were used as alternative sources of energy. If the price of a substitute increased the demand of the good in question also increased. If the prices of these substitutes (LPG and Kerosene) increased, individuals consumed electricity therefore raising its demand. Climatic conditions also impacted on electricity demanded. Households used more electricity to warm their homes during the cold seasons and air conditioning during the hot periods. However, climatic conditions were rarely incorporated in many studies due to unavailability of data. Capital investment on electricity infrastructure was an important determinant as huge funding to the sector could increase the supply so as to meet the high demand. Government policies could also saw prices regulated and efficiency in operations of the electricity sector so as to meet the demand for electricity in a country.

According to Sheffrin (2003), demand could be autonomous or derived demand. Autonomous demand is direct demand and is final. Demand for consumer goods is autonomous. Demand can also be derived from demand of other goods. Derived demand normally results from usage and prices of complementary goods. These are goods that are used together with the good in question. The prices of the complementary goods go hand in hand. An increase in the price of one of the goods will reduce demand for the complementary good and vice-versa. The cross elasticity of demand for complements is negative. The demand of one good raises the demand of the complementary good. A commodity can also be said to have composite demand when it is required for several different uses. Hartman & Werth (1981) presented energy demand as derived demand and links consumption of energy to development of infrastructure and capital investment.

2.4 EMPIRICAL LITERATURE REVIEW

2.4.1 Empirics of Demand for Electricity

Prices and incomes are principally the two important factors as revealed by numerous studies. Incomes reflect the standards of living. Prices capture the amount individuals are willing to give up for the commodity. A study by Al-Faris (2002) on the Gulf Cooperation Council countries which include Kuwait, Saudi Arabia, Qatar, Oman, Bahrain and the United Arab Emirates (UAE) from 1970 to 1977 concluded that income and price were significant variables. Income and price policies therefore could successfully ease electricity demand.

A study conducted jointly by Chiang-Lee and Chu (2011) used an annual panel dataset covering the period 1978-2004 for 24 OECD countries. The countries included Austria, Australia, Belgium, Greece, Canada, Finland, France, Denmark, Germany, Hungary, Ireland, New Zealand, Switzerland, Italy, Japan, Luxembourg, Norway, South Korea, Portugal, Spain, Turkey, the United Kingdom, Sweden and the United States. The results found that income and prices were key determinants of demand for electricity.

Similar studies were also conducted in Africa. Income and prices were also significant according to studies done by Ekpo, Chuku and Effiong 2011 in Nigeria between 1970 and 2008, Ubani, Umeh and Ugwu (2013) in Nigeria from 1985-2005, Kavezeri (2009) in Namibia from 1993 to 2006.

Income and prices were also found to be important factors in studies conducted in Asia as shown in the studies conducted by Khan and Qayyum (2009) in Pakistan and Labandeira, Labeaga and Lopez-Otero (2011) in Spain. The Alter and Syed (2011) study covering the period 1970-2010 affirmed that electricity was a necessary good in Pakistan. A two-period study by Lin (2003) conducted before (1952-1978) and after economic reforms (1978-2001) in China revealed that GDP was the most important factor. Prices were also significant although China had so many variations therefore the author used fuel prices. A criticism was found in the use of fuel prices as the proxy for electricity price. The author stated that he used this proxy as it reflected 70-75% of supply costs of generating electricity. This may not have captured the total effect of electricity prices thus give misleading results.

Although price and income are the key determinants of electricity demand, many studies have also included other variables such as temperatures, electricity equipment, prices of substitutes, population densities and distance from power stations. Substitutes present cross elasticities of demand. The substitutes for electricity featuring in these studies include LPG, Diesel and Kerosene. Bose and Shukla (1999) used diesel prices in their joint study across 19 states of India. Labandeira, Labeaga and Lopez-Otero (2011) study in Spain, Bekhet and Othman (2011) in Malaysia and a study conducted by Narayan et al (2007) on a group of seven countries used natural gas variable as a substitute to electricity. The Al-Faris (2002) study of Gulf Cooperation Council countries also used LPG prices as a variable to represent substitutes for electricity. Results from these studies showed that electricity in the short run can be substituted by other forms of energy. However in the long-run results indicated that electricity was a necessity due to limited substitution possibilities. Economic units' continued to consume it even when prices increase.

Population growth exerts more pressure on the demand for electricity. There is an increase in the number of individuals who require electricity for cooking, lighting and operating small businesses. This is consistent with the study that was done by Bekhet and Othman (2011) in Malaysia. Urban population was also used to capture structural variables by Holtedahl and Joutz (2004) in their study of electricity consumption in Taiwan. The urban elasticities were found to be positive both in the short run and long run. Lin (2003) study found that population had a direct impact on the quantity of electricity demanded from 1952 to 2001 in China.

An analysis of South East Nigeria by Ubani, Umeh and Ugwu (2013) for the period 1985 to 2005 found that population was a key determinant of demand for electricity. The decision of whether to use urban or total population varied from one country to another depending on the electricity network of a particular country. Population was a significant variable in the study done by Ekpo, Chuku and Effiong (2011) in Nigeria between 1970 and 2008.

The number of electrical equipment used for residential or industrial activities is an important factor of demand for electricity. Equipment raises the consumption of electricity as seen in various studies. A study in Taiwan by Holteldahl and Joutz (2004) used the stock of energy-using equipment. A proxy of urbanization rate was used to capture the equipment. Results for the urbanization rate elasticity were found to be positive and significant.

The number of imported durable electric appliances was used as a suitable proxy for electric appliances stock in Alter and Syed (2011) study in Pakistan. The results revealed that electrical equipment had positive and long run relationship with electricity consumption. Electrical appliances are bought on a regular basis and getting the precise quantities may be a challenge. Choosing a suitable proxy becomes a challenge. Proxies may yield misleading results.

Climatic conditions of a region also affect the demand for electricity. On cold days individuals use more electricity for heating and less electricity on hotter days. This was consistent with the study conducted by Chiang-Lee and Chu using annual panel dataset which covered the period 1978-2004 in 24 OECD countries. The countries included Austria, Australia, Belgium, Greece, Canada, Finland, France, Denmark, Germany, Hungary, Ireland, New Zealand, Switzerland, Italy, Japan, Luxembourg, Norway, South Korea, Portugal, Spain, Turkey, the United Kingdom, Sweden and the United States. The relation between electricity consumed and temperatures revealed a U-Shape relationship with a threshold value of 53˚Farenheit. There was a decline in electricity consumed when temperature increased in low income countries, whilst consumption increased in high income countries. A study by Holtedahl and Joutz (2004) showed more electricity is consumed on days above 80˚ days as people used air conditioners to cool their buildings in Taiwan. Labandeira, Labeaga and Lopez-Otero (2011) found climatic variables (heating degree days, cooling degree days) to be small but significant in Spain.

Some studies used other variables that may have affected electricity consumption. Lin (2003) used efficiency variables to determine demand. Efficiency variable was measured by dividing the value added by electricity consumed in an industry. The results revealed that the variable was negative and consistent with expectations. A high efficiency level reduces the amount of electricity demanded.

An analysis by Ubani, Umeh and Ugwu (2013) used the degree of urbanization, land area, number of households per capita, number of markets, number of banks per capita, number of manufacturing industry per capita, number of households per capita, employment rate per capita and distance to power plant as well as electricity prices, population density and per capita income in Nigeria. All the variables except distance and land area were found to be significant.

Industries also use electricity as a factor of production. Industrial output factor was found to be significant and a major determinant of electricity consumption in Nigeria in the study conducted by Ekpo, Chuku and Effiong (2011). Mwabu et al (2011) studied the demand of energy in manufacturing sector and found that value added in industries influenced the use of energy. The sector is the largest consumer of electricity.

2.4.2 Elasticity of Demand

Elasticity measures how a change in one independent variable influences the dependent variable. Elasticity values that lie from 0 to 1 mean that the demand is inelastic. A value of 1 implies unit elasticity. Values greater than 1 explain that demand is elastic. The sign for price elasticity of electricity should be negative to show the reciprocal nature of price and demand. As price increase, demand is expected to fall. Income elasticity is used to categorize goods. Income and demand for a normal good moves in the same direction and in opposite direction for an inferior good. People consume more of a good with higher income levels. An elasticity value lower than unity implies that the good is a necessary good while a value more than one implies that the good is a luxury good. According to some studies, electricity was a necessary good as consumption did not decline with increase in prices. Kavezeri (2009) study of Namibia, Labandeira, Labeaga & Lopez-Otero (2011) in Spain and Narayan et al (2007) in G7 countries found that electricity was a necessary good.

Various studies depict electricity as a necessity. De Vita et al (2005) reported income and price elasticities for electricity from South America from the 1970s to the early 1990s. The income and price estimates for Brazil were 1.73 and –0.43, and for Columbia 1.88 and –0.18 respectively. Expenditure elasticity for electricity of 1 for middle income countries, and a price elasticity of –0.69 were also reported. Alter and Syed (2011) study in Pakistan show that aggregate income elasticity of 0.251 and the aggregate price elasticity is -0.853. Fan and Hyndman (2008) found that the overall price elasticity in South Australia from July 1997 to June 2008 to be -0.4165 showing an average responsiveness of electricity consumption to changes in prices.

In developing countries, the expectation of price inelasticity and income elasticity was also consistent with Gam and Rejeb (2012) study of Tunisia from 1990-2007. Price elasticity was -0.681 and GDP elasticity was 1.1. Kavezeri (2009) study on Namibia's electricity demand from 1993 to 2006 revealed that electricity prices in Namibia were for many years the lowest in the world. Another study on Namibia electricity demand conducted by De Vita et al. (2006) from 1980 to 2002 estimated the long-run demand income and price elasticities to be 0.589 and -0.298 respectively. The findings pointed out a long-run relationship among the variables. Electricity was found to be necessity as elasticity values were less than one. Electricity demand was found to be income elastic with a long-run elasticity of 1.02. The coefficient for price was negative but not statistically significant.

Studies also compared the short run elasticities to the long run elasticities. They revealed that short run elasticities were less than long run elasticities In the long run economic units exercised their discretion and chose from different possibilities. Kimuyu (1988) study conducted a structural investigation to analyze demand for commercial energy in Kenya. The study developed fuel demand models at two levels. The first level involved behavioral responses in terms of basic variables other than structural, economy, efficiency and conservation variables. Demand for fuel was modeled as a function of fuel price, price of close fuels and per unit income. The second level evaluated the impact of other structural factors on energy demand of alternative sectoral strategies and associated demand to designed structural change. The study used a multiplicative form to estimate elasticities at dissagregated levels of domestic electricity, off-peak electricity and industrial electricity. The demand for electricity was found to be inelastic indicating that electricity was a necessary good or had low substitution possibilities. Price elasticities were found to be greater in the long-run than in the short-run because economic agents exercised their discretion in fuel and equipment choice in the long run. The income elasticities were inelastic in the short run and elastic in the long run because in the latter there were several options of fuels to select from.

A study by Narayan et al (2007) for a group of seven countries (USA, Canada, Germany, France, Italy, Japan and UK) used the firm's production theory to estimate electricity's demand. Price elasticities ranged from -0.03 to -0.08 and -1.38 to -9.32 in the short run and long run respectively. Income elasticities ranged from 0.13 to 0.36 and 1.60 to 2.02 in the short run and long run respectively. Holtedahl & Joutz (2004) in their study showed that the income elasticity values were 0.23 and 1.04 for short run and long run respectively in Taiwan. Price elasticity was found to be -0.15 in the long run. Urbanization elasticities were found to be 1.61 and 3.91 in the short run and long run respectively. A study by Ekpo, Chuku & Effiong (2011) in Nigeria from 1970 to 2008 revealed electricity price elasticity values of -0.44 and -0.23 in the long-run and short-run respectively. They were found to be statistically insignificant due to government regulation of prices. Income elasticity of 0.58 implied that electricity was a normal good that increased with income. Bose & Shukla (1999) found the price elasticity ranging from -0.04 to -0.65. Income elasticity was positive which ranged between 0.49 and 0.81 in India.

High elasticity values show that a good is a luxury good. Individuals can do without it. The study conducted by Khan and Qayyum (2009) as cited by Kavezeri and Ziramba (2012) estimated price and income elasticities for the national level and for households, industry and agriculture sectors in Pakistan. The income elasticity was 4.7 while the price elasticity estimate was -1.64. The high value of the price elasticity implied electricity was a luxury good but the authors justified their findings by saying that Pakistan was majorly rural and not many of the rural area utilized electricity.

2.5 Overview of Literature

From the discussion of theoretical literature it is clear that demand for electricity is determined by various factors. The factors include income, price, price of other energy sources, geographical location, demographic and environmental factors. Studies that have been reviewed show that income levels and electricity prices are indispensable when estimating the demand function for electricity. The studies have also included other variables which have an impact on the demand of electricity such as population and industrial output which had a positive and significant effect on electricity demanded. Studies also incorporate prices of substitutes such as LPG and Kerosene.

Studies reviewed reveal the sign for price elasticity of demand is negative. This implies that the consumption decreases when electricity prices go up in the short run. In the long run however consumption does not decline. Economic agents consume electricity as it is a necessary good that they cannot do without or because it has limited close substitutes. The studies also show that the sign for income elasticity of demand is positive. With an increase in income levels, consumption of electricity rises. Additionally, studies show that the long run elasticity values are higher than short run due to the discretion to choose from different energy types and equipment. Demand for electrical equipment rises as incomes increase.

Scanty evidence exists on determinants of demand for electricity on developing African countries. This study is conducted to focus on Kenya as one of SSA countries. This study is expected to close that gap and estimate the significant factors that determine demand for electricity in Kenya and their elasticities. .

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 Introduction

Electricity demand can be modeled in various forms. A multivariate procedure or an Error Correction Model procedure can be employed to investigate the general long run model and the dynamic model. A bounds test approach can also be applied to investigate the long term relationship where small sample sizes are involved. Markovian models have been used to model residential demand for electricity. A time varying cointegrating model has been used to cater for the changes that affect demand for electricity. These models are explained below.

Multivariate cointegration procedures of Johansen (1988) and Johansen and Juselius (1990) have been used to model electricity demand. Lin (2003) used the Johansen-Juselius multivariate model in modeling demand for electricity in China.

The Error Correction Model was employed to establish the long term relationships between variables. These included Kavezeri (2009) in Namibia, Khan and Qayyum (2009) in Pakistan and Becket and Othman in Malaysia among others. This model can also be applied to establish the long term relationship as well as the immediate relationship of factors determining demand for electricity.

The bounds testing approach proposed by Pesaran et al (2001) has also become increasingly acceptable in modeling energy demand functions because of its strengths over the other approaches. It tests for the existence of long term relationships between variables regardless of the order of integration of regressors. In addition, it allows for simultaneous estimation of the long-run and short-run parameters. Most importantly, it is adaptable to small sample sizes. Owing to its supremacy, Ekpo, Chuku and Effiong (2011), Narayan et al. 2001 and De Vita et al. (2006) adopted it in modeling aggregate electricity demand.

The bounds testing approach to cointegration was used in the study conducted by Kavezeri and Ziramba (2009) in Namibia. This approach does not need the information of order of integration or cointegration ranks. The approach gives an error correction model that has better statistical properties. The short run dynamics in the ECM are not pushed into the residual term. The approach is also advantageous as it is applicable despite of the order of integration. Its limitation however lies in the fact that it cannot be used where there are two or more cointegrating equations.

The Markovian models were used by Rosenberg and Keshav (2011) to model the daily home consumption in Canada. The models used a continuous time process to cater for sequential events. Secondly, the Markov models form the basis of mathematical analysis, particularly stochastic optimization and queuing theory. The finite set of load usage from individuals have also been modeled well in the past using markovian models. The authors collected the daily load measurements. They proceeded to create models for different periods of the day. The models were then tested for accuracy.

A double- log functional form model was used to estimate the demand for electricity in the residential, industrial and commercial sectors in Mexico in a study conducted by Chang and Martinez-Chombo, 2003. A time varying cointegrating model (TVCM) was used. The model took care of changes that affected demand for electricity such as technology, habit persistency and development that occur in an economy over time. The inclusion of TVCM in the cointegrating relationship permits for more than one lags of the error correction term contrary to the ECM based on a fixed coefficient cointegrating model. This means that the TVCM has more than one adjustment paths towards the long run equilibrium. The TVCM also eliminates multicollinearity observed in the usual ECM based on fixed coefficients. However a drawback of TVCM is that it reduces the levels of estimated coefficients significantly than the fixed coefficients model.

A structural time series model was used to model and forecast electricity demand in Turkey. This was in a study conducted by Hunt and Dilaver (2010) for the period 1960-2008. This model broke down time series into a trend component, irregular component and seasonal component. Harvey (1989) described the model as one which the explanatory variable was a function of time and parameter change over time. The model also allowed for introduction of a deterministic or a stochastic trend with the latter being more successful for deciding structural changes in time series due to its flexible nature

Simple estimation models have also been adopted in many studies. OLS model has been used widely. Ghosh, Dar and Abosedra (2009) in Lebanon used three modeling techniques; OLS, ARIMA and exponential smoothing model. The study in seven countries by Narayan et al and Al-faris in GCC countries used OLS models. Mohammed and Bodger (2006) used the multiple linear regression models as their study considered both economic and demographic variables. Kimuyu (1988) uses this model since the study incorporated both economic and structural variables.

Having analyzed the various models, above this study chose the most appropriate in terms of sample size, variables used, aggregate versus disaggregated analysis and the most appropriate approach to a time series analysis

3.2 Modeling demand for electricity

According to Varian, (1992), an individual can consume two goods given a certain level of income. Assuming an individual has a given level of electricity expenditure (E) and other non-electricity expenditures (N) to maximize his utility U, the individual aims to maximize his utility subject to the limited resources available. Mathematically, this can be stated as;

$Max\ U = f(\mathrm{E, N})$ ………………………………………………………...………… 1

Subject to a budget constraint, $Y = P_E E + P_N N$ ………………...…..……….……….....…. 2

$L = f(\mathrm{E,N}) + \lambda(Y - P_E E - P_N N)$………………………………….……..……..……..... 3

$\frac{dL}{dE} = \frac{dU}{dE} - \lambda P_E = 0$ ……………………………………………………….……….……...…... 4

$\frac{dL}{dN} = \frac{dU}{dN} - \lambda P_N = 0$…………………………………..……………………….. 5

$\frac{dU/dE}{dU/dN} = \frac{P_E}{P_N}$ ………………………………………….…………………………....,..... 6

Where is $\frac{dL}{dE}$ = MU_E and $\frac{dL}{dN}$ = MU_N

$$P_E = {}^{MU_N}/_{MU_E P_N} \text{...} 7$$

$$P_N = {}^{MU_E}/_{MU_N P_E} \text{...} 8$$

$$Y = P_E E + MU_N P_E N \text{ ....} 9$$

$$Y - \frac{MU_E N}{MU_N P_E} / P_E = E^* \text{...} 10$$

This is the demand equation for electricity good which is a function of income and prices.

Where: U=Utility

E= Electricity expenditure

N= Non electricity expenditure

Y= Income

P_E=Price of electricity

P_N= Price of non-electricity

MU = Marginal Utility.

Some of the factors believed to influence consumption of electricity include prices, incomes, prices of substitutes and industrial growth. The consumer tariffs include several components; base rate, fuel cost charge rate, foreign exchange rate fluctuation adjustment component, inflation adjustment cost energy revenue commission levy, rural electrification program levy component, value added tax cost (Kenya Power Retail Tariff Application, 2013) Pricing is set according to various consumers: small industrial, households, large consumers among others. High prices are expected to decrease demand. Incomes have an impact on the well being of an individual. High incomes increase electricity consumption. Individuals tend to demand for more entertainment, ownership of electrical appliances such as refrigerators, electric kettles, electric cookers, heaters air conditioners among others, Anderson (2000). Electricity substitutes such as kerosene and LPG are meant to provide a variety of choice, and price competition in the market such that consumers can maximize their utility at the minimum cost. If the prices of the substitutes to electricity are low, demand for electricity is expected to be low. High population exerts more pressure on demand for electricity (UNDP 2000). According to Ekpo, Chuku and Effiong (2011) industrial activities demand a lot of electricity in their production processes. Industries comprise of the manufacturing, mining, and construction among other activities. The study will incorporate the factors above.

A study by Kimuyu (1988) modeled a log-log demand function of each fuel to take the form:

$Ln\,E_{it} = h_o + h_1\,Ln\,UP_t + h_2\,Ln\,A_t + h_3 Ln M_t + h_4 Ln\,T_t + h_5 Ln\,S_t + U_t$……..……11

Where; E_{it} is demand for fuel, UP is urban population, A, M, T, S are shares of GDP from Agriculture, Manufacturing and Repair, Transport, Storage, Refrigeration and Communication and Services sectors. h_o is the usual constant and h_i are the elasticities

Kimuyu also expressed energy demand as a function of its price, income and prices of related fuel as shown in equation below

$E_{it} = f\,(X_{it}, Y_t, Z_{it})$……………………………...…………………………………12

The multiplicative form of the general energy demand function is presented as below;

$E_{it} = b_o * X_{it}^{b1} * Y_t^{b2} * Z_{jt}^{b3} * e_{it}$ ……………………………………………………………13

Where:

bo is the usual constant

bi (i=1,2,3) are the long-run prices, incomes and cross elasticities of demand for electricity and eit is error term

After adjustment process towards a desired level of demand and taking natural logs the equation is summarized by:

$$LnE_{it} = \beta_0 + \beta_1 LnX_{it} + \beta_2 LnY_t + \beta_3 LnZ_{it} + \beta_4 LnE_{it-1} + \mu_{it} \quad \text{..14}$$

Where:

E_{it} = per unit desired demand for energy i in time t

X_{it},= price of energy i

Y_t = per unit income

Z_{jt} =price of a related fuel

E_{it-1} = lagged consumption of energy i

CHAPTER FOUR

METHODOLOGY

4.1 Empirical Model

Adopting Kimuyu (1988) model, this study expressed the demand for electricity as function of its price, income and prices of substitutes, industrial production and population. The model is appropriate as it was applied to Kenya. Borrowing from this model, the study estimated an aggregate model for electricity demand as shown in equation 15.

$$lnEleconspn = \beta_0 + \beta_1 lnEtariff + \beta_2 lnRGDP + \beta_3 lnP_K + \beta_4 lnP_L + \beta_5 lnInd + \beta_6 lnPop + \mu \ldots\ldots\ldots \quad 15$$

Where:

Eleconspn is Electricity Consumed in Kilowatt hours

Etariff is Average tariff of electricity measured in Kshs/Kwh

RGDP is Real Gross Domestic Product

P_K is the Price of Kerosene measured in Kshs

P_L is the Price of LPG measured in Kshs

Popn is the Total Population measured in Millions

Ind is the Industry value added measured in US$

μ is the error term

4.2 Data Sources

The study used national time series data for the period 1971 to 2012. The variables that used were consumption of electricity to represent amount of electricity demanded, real GDP to represent income levels, average tariffs of electricity, average prices of kerosene, population, industrial output and the average prices of LPG. Data was obtained from official government publications including Economic Surveys, Kenya Power reports and tariffs booklets, Meteorological reports and National Energy Surveys. More data was obtained from World Data Bank.

4.3 Definition and Measurement of Variables contained in the model

Variable	Measurement
Electricity Consumption	Measured in KWh. It is the dependent variable. It is the annual demand for electricity.
Income	Incomes were measured by real GDP. This variable measures the purchasing power of the population. As incomes grow, individuals tend to demand more electrical goods and services. Electricity demand is derived demand from these goods and services they consume.
Electricity Tariffs	Measured by price per unit. Electricity prices is a key variable as it reflects the sacrifice in monetary terms that the consumers are willing to pay to acquire a unit of electricity. The prices were calculated as the average tariffs of domestic and commercial electricity prices.
Total	Urban population in Kenya has been increasing over the years as people

Population	migrate to urban areas in search of jobs. Demand for electricity is also expected to rise significantly. This is because there is demand for more electrical goods and services. Access to electricity in the rural areas has opened up small businesses such as salons, milling, printing, photocopying, welding and cyber cafes therefore increasing the demand. Rural electrification programme has also increased access to electricity. Population has a direct link to electricity consumed.
Kerosene Prices	Measures by price per litre. Kerosene is an alternative source of fuel. When prices of kerosene increase, individuals may opt to use electricity if it is cheaper. This will increase demand for electricity particularly the residential demand. Kerosene prices are therefore expected to be inelastic.
LPG Prices	Measured by Kshs per Kg. Gas can also be used as a substitute energy form for electricity. Substitutes most likely influence electricity demand positively.
Industry Output	Measured by output in industry. Manufacturing sector is the third largest use of energy and the largest consumer of electricity. The value added in industries is the net output after summing all outputs and subtracting intermediate values. A high amount of value added in industries implies a high consumption of electricity. The variable captures growth in industrial production.

4.4 Expected Signs of Variables used in the model

Variable	**Measurement**	**Expected Sign**
Income	Kshs	The sign of the income elasticity is expected to be positive
Electricity Price	Kshs/Kwh	As prices increase, demand for electricity will fall The price elasticity is expected to have a negative sign.
Kerosene Prices	Kshs/Litre	The Kerosene elasticity is expected to have a positive sign.
LPG Prices	Kshs/Kg	The LPG elasticity is expected to bear a have a positive sign.
Total Population	Millions	The population elasticity is expected to have a positive sign.
Industry Output	Kshs	The industry output elasticity is expected to have a positive sign.

4.5 Estimation Techniques and Econometric Tests

The model was estimated using the Ordinary Least Squares method. To ensure stationarity of variables, the variables were differenced. The long run equilibrium was captured by a specification of an Error Correction Modelling. The Instrumental Variable 2SLS approach was applied in the ECM to control for endogeneity.

4.5.1 Unit Root

Time series trends tend to exhibit unit root(s) over time. Unit root test are used to test for stationarity of variables. These tests are crucial because non stationary data yields spurious regressions results. The results could reveal an unreliable t-statistic with no economic inference. The value of R^2 may also be too high. (Granger and Newbold 1974). In a stationary series the mean and variance does not vary systematically over time. Differencing was done to eliminate the non stationarity. However, this may lead to loss of some vital long run information or partial solutions. This drawback is addressed through differencing proposed by Dickey and Fuller (1979) - Augumented Dickey Fuller Test. It analyses the existence of systematic and linear relationship between the past and present values of variables.

The study adopted ADF applied in the following form;

$$\Delta Y_t = \beta_1 + \beta_2 T + \delta Y_{t-i} + \sum \Delta Y_{t-i} + \varepsilon_t$$

Where T is trend variables

ε_t t is the error term which is independently and identically identified

The null hypothesis states that $\delta=0$ in each equation, meaning there is unit root in Y_t. If null hypothesis is accepted the presence of unit root is accepted.

4.5.2 Cointegration Analysis

Cointegration means that the non stationary series move simultaneously over time and the difference between them is stable. The cointegrating equation is interpreted as the long run relationship between the variables. It is probable that there is a long run relationship between demand for electricity and the independent variables.

The Johansen test for cointegration which has gained more importance in economic applications was used to test for cointegration. It is the most appropriate for multivariate models. The trace statistic and the eigen values were used to determine if a linear combination of the variables reveals cointegration.

4.5.3 Diagnostic Tests

These tests are used to test the inadequacy or failure of the model. The study used the OLS method of estimation which makes a number of assumptions. The OLS method assumes serial uncorrelation, correct specification of the model, homoscedastic error term and absence of correlation between the error term and the regressors. The study applied several diagnostic tests: The Wu-Hausman and Durbin tests were used to test for endogeneity. Tests to ascertain suitability of the instrumental variable were also carried out.

CHAPTER FIVE

DATA ANALYSIS

5.1 Introduction

This chapter presents the descriptive statistics, graphical analysis, regression results as well as the diagnostic test results. Descriptive statistics from tests of normality will be used to indicate if data is normally distributed. Regression results from both the long run model and the dynamic error correction model are analyzed. Pre-estimation tests to check for presence of unit root and cointegration were used for further data interrogation. Post estimation tests were analyzed to test for the suitability of the model. Discussions of the results are presented at the end of the chapter.

5.2 Descriptive Statistics

Economic data often has clear and defined lower limits but no definite upper limits due to presence of outliers. It is therefore important to check whether data exhibits normality. Skewness and kurtosis are the major tests for normally distributed data. Skewness is the tilt in distribution of a series around the mean. Kurtosis measures the peakedness of the distribution of a series. The Jacque Bera test was used to test for skewness and kurtosis. The sign for skewness shows whether the series is negatively or positively skewed. Normally distributed data should have a skewness value of between -2 and +2. The statistic for kurtosis should be between -3 and +3 for normally distributed series.

Table: 5.1 Descriptive statistics of electricity consumption, electricity tariffs, prices of kerosene, prices of LPG, industrial output and population data

Statistic	Variable							
	Econspn	Etariff	RGDP	Rainfall	P_L	P_K	Ind	Popn
Mean	3194.143	3.8867	839213.9	30968.32	33.9838	21.7399	135905.7	24.9952
Median	3110	1.545	823102.7	30408.3	15.743	9.0365	139356.5	24.9
Maximum	6414	15.97	1605496	45876.1	213.02	88.073	247979	40.5
Minimum	909	0.22	309994.8	20435.4	1.915	0.626	42530.2	11.7
Std. Dev	1618.47	4.2893	347859.3	5536.401	42.0181	25.4832	52879.36	8.82308
Skewness	0.1816	0.0031	0.1756	0.1032	0.0000	0.0022	0.2680	0.6448
Kurtosis	0.1944	0.3010	0.4095	0.5318	0.0001	0.4007	0.4815	0.0062
JB Statistic	3.72	8.42	2.68	3.26	26.06	8.60	1.83	6.93
Probability	0.1558	0.0149	0.2614	0.1960	0.0000	0.0136	0.4014	0.0313

Source: Own computation using STATA

Where: Econspn is Electricity Consumption, Etarriff, Electricity Tariff, RGDP is Real GDP per capita, Rainfall is the annual precipitation, P_L is the LPG Prices, P_K is kerosene prices. Ind is Industrial output and Popn represents Total Population.

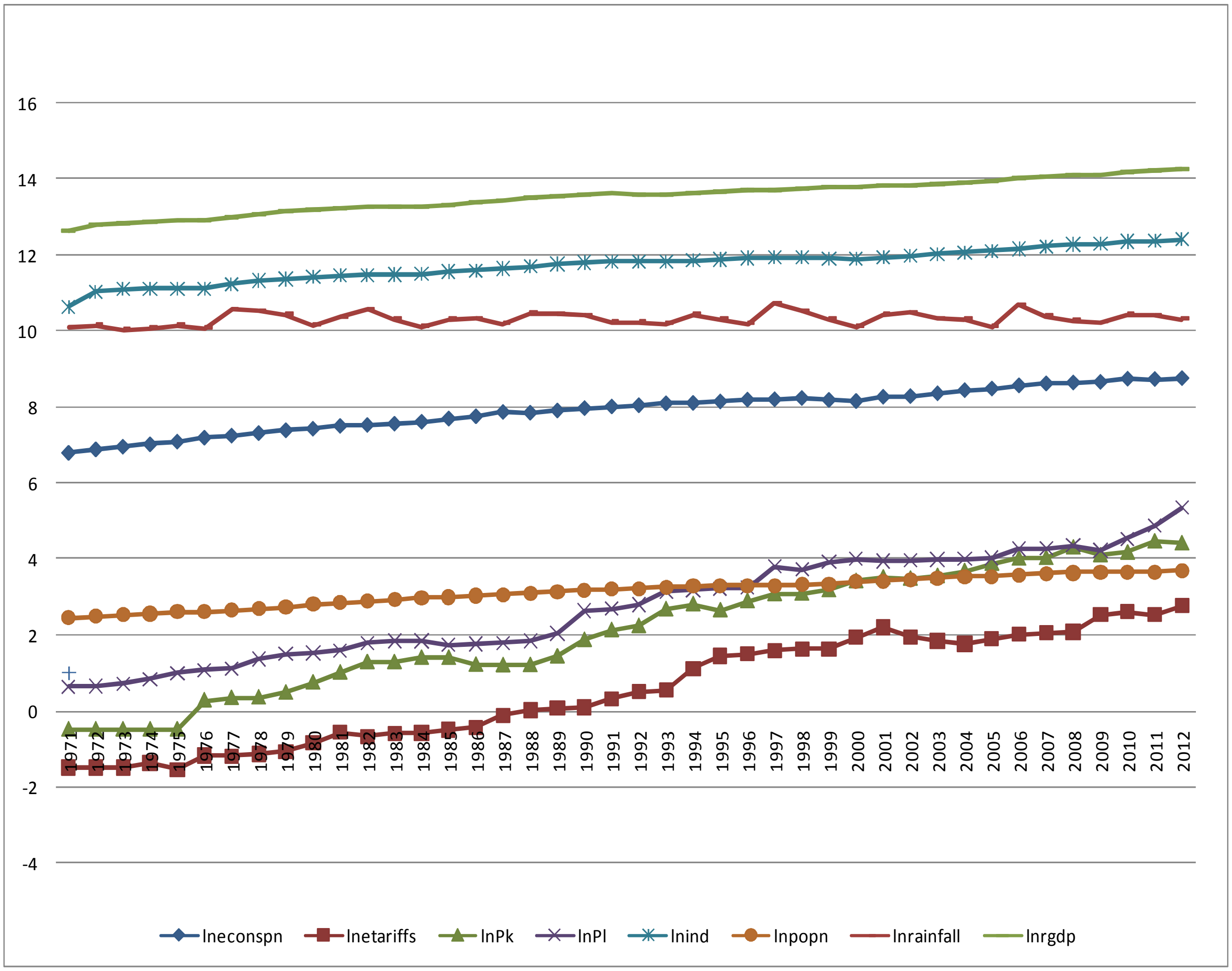
The condition for kurtosis was met. All variables had values near zero for skewness test. The null hypothesis states that if probability is less than 0.05, the series has a normal distribution Several variables (Electricity tariffs, LPG prices, Kerosene prices and Population) have the p-values of less than 0.05 so we reject the null hypothesis of non-normality and accept that the series have a normal distribution The other variables (electricity consumption, real GDP, rainfall and Industrial output) had their median around the mean and therefore the implication is that they are normally distributed.

Distributions of most zero kurtosis are referred to as mesorkurtic. This is the most prominent characteristic of normal distribution. All series above range from 0.0001 and 0.5318. Skewness also ranges between 0 and 0.6448 implying normal distribution.

5.3 Trends in electricity consumption, electricity tariffs, prices of kerosene, prices of LPG, industrial output and population from 1971-2012

A pictorial trend to show the movement of the variables over time is presented in Figure 5.1

Figure 5.1 Trends in electricity consumption, electricity tariffs, prices of kerosene, prices of LPG, industrial output and population from 1971-2012



Source: Own graphing using STATA

The graph shows that electricity consumption had an upward trend almost the entire period except between 1999 and 2000 where there was a severe drought experienced in the country. This led to decreased electricity generation since Kenya primarily relied on hydroelectric sources. Production resumed to normal levels afterwards as oil was used to complement hydropower.

The trend in electricity tariffs has a lot of variations and fluctuations that occur on a monthly basis. The tariffs include several components that are prone to frequent changes.

The tariffs have continued to increase over time. There was a sharp rise in 2001 due to the high production costs of electricity from oil following the severe drought in 2000.

The movement of GDP has been very inconsistent over time. However the was a sharp increase in 1990 because of relatively high economic growth at the time.

The trend of prices for LPG over time has been on the rise. This has been occasioned by factors that influence LPG availability and use.

The shows the trend of industrial production has been increasing over the years. There has been significant increase in the industrial sector following the growth of the economy. The sector comprises of construction, manufacturing and mining.

Population has been on the rise over for most of the years. An increase in population is associated with an increase in supply and consumption of goods and services in an economy

5.4 Time Series Properties of electricity consumption, electricity tariffs, prices of kerosene, prices of LPG, industrial output and population data

Time series data is most often associated with the problem of stationarity. Non stationary data leads to spurious regression and values with no economic meaning. The first step was to test for stationarity using the Augumented Dickey Fuller test. The results are as shown in the tables 5.2 and 5.3

Table 5.2. Stationarity Tests Of Variables Contained In The Model at Their Natural Form

Variables	Trend/No Trend	ADF Test	1%	5%	10%	Comment
Electricity Consumption	No Trend	-2.321	-3.648	-2.958	2.612	Non Stationary
	With Trend	-2.119	-4.242	-3.540	-3.204	Non Stationary
Electricity Tariff	No Trend	-0.207	-3.648	-2.958	2.612	Non Stationary
	With Trend	-2.301	-4.242	-3.540	-3.204	Non Stationary
Real GDP	No Trend	-0.720	-3.655	-2.961	-2.613	Non Stationary
	With Trend	-2.350	-4.251	-3.544	-3.206	Non Stationary
Rainfall	No Trend	-5.445	-3.641	-2.955	-2.611	Stationary
	With Trend	-5.392	-4.233	-3.536	-3.202	Stationary
Kerosene Prices	No Trend	-0.983	-3.648	-2.958	-2.612	Non Stationary
	With Trend	-2..576	-4.242	-3.540	-3.204	Non Stationary
LPG Prices	No Trend	-0.365	-3.648	-2.958	-2.612	Non Stationary
	With Trend	-2.223	-4.242	-3.540	-3.204	Non Stationary
Industrial output	No Trend	-1.008	-3.655	-2.961	-2.613	Non Stationary
	With Trend	-2.270	-4.251	-3.544	-3.206	Non Stationary
Total Population	No Trend	-2.385	-3.648	-2.958	-2.612	Non Stationary
	With Trend	-1.133	-4.242	-3.540	-3.204	Non Stationary

Source: Own computation using STATA

The results showed that the variables are not stationary in their natural form. This is a common problem with time series data. Regression of non-stationary data yields spurious results. There was therefore need to difference the series in order to make them stationary.

Table 5.3: Stationarity Tests of Variables Contained In The Model After Differencing

Variables	Trend/No Trend	ADF Test	1%	5%	10%	Comment
Electricity Consumption	No Trend	-6.023	-3.648	-2.958	-2.612	Stationary
	With Trend	-6.557	-4.242	-3.540	-3.204	Stationary
Electricity Tariff	No Trend	-6.298	-3.648	-2.958	-2.612	Stationary
	With Trend	-6.220	-4.242	-3.540	-3.204	Stationary
Real GDP	No Trend	-3.872	-3.655	-2.961	-2.613	Stationary
	With Trend	-3.832	-4.251	-3.544	-3.206	Stationary
Kerosene Prices	No Trend	-6.120	-3.648	-2.958	-2.612	Stationary
	With Trend	-6.093	-4.242	-3.540	-3.204	Stationary
LPG Prices	No Trend	-5.511	-3.648	-2.958	-2.612	Stationary
	With Trend	-5.504	-4.242	-3.540	-3.204	Stationary
Industrial output	No Trend	-11.599	-3.648	-2.958	-2.612	Stationary
	With Trend	-10.980	-4.251	-3.544	-3.206	Stationary
Total Population	No Trend	-5.569	-3.648	-2.958	-2.612	Stationary
	With Trend	-6.267	-4.242	-3.540	-3.204	Stationary

Source: Own computation using STATA

It is assumed that time series data are stationary after taking their first differences. The tests results above show that the variables satisfy the assumption as all the variables are stationary of order one. The Schwarz-Bayesian Information Criteria (SBIC) was used to establish the optimal lags of the variables. It is preferable to Akaike and Hannan Quinn criteria as it has a larger penalty term to avoid overfitting the model.

The concept of cointegration implies that if there is a long run relationship between two or more non-stationary variables, deviations from the long run path are stationary. To establish if cointegration exists among the variables Johansen Test for cointegration was conducted. Johansen test is the best for multivariate models. This was done by regressing the non-stationary variables in the model. Results for the test are presented in the table 5.4

Table: 5.4: Cointegration Diagnostic Test Results of electricity consumption, electricity tariffs, prices of kerosene, prices of LPG, industrial output and population data

Maximum Rank	Eigen Value	Trace Statistic	5% Critical Value
0	.	139.5902	124.24
1	0.69935	91.5185*	94.15
2	0.56162	58.5320	68.52
3	0.44945	34.6582	47.21
4	0.30160	20.2996	29.68
5	0.22092	10.3137	15.41
6	0.19333	1.7202	3.76
7	0.04209		

Source: Own computation from collected data

Note *Represents the maximum ranks

Johansen test uses the trace statistic and eigen value to determine cointegration. For cointegration the trace statistics should be greater than the critical values. The null hypothesis states that if there is no rank (r=0), there is no cointegration, Johansen (1988). The above results indicate that r=1 and therefore we reject the null hypothesis and conclude that there is cointegration. The trace tests indicate that there is 1 cointegrating equation. The meaning is that a linear combination of all the seven series is cointegrated. An error correction model therefore can be estimated.

For cointegration to exist the eigen values should also be greater than zero. From the test results above all eigen values are greater than zero therefore the series is cointegrated.

5.5 Regression Results

Natural logs of the variables were used to linearize the data. In estimating demand elasticities, the study used a double log function. The long run relationship of the dependent variable (Electricity consumption) and independent variables (Electricity tariffs, real GDP, LPG prices, Industrial Output, Total population) was as presented in Table 5.5 ,m``````````

Table: 5.5 Regression Results of the variables in the Long Run model

Variable	**Coefficient**	**p-value**
Constant	-3.292207	(0.028)
Lnetariff	-0.0010124	(0.970)
lnRGDP	0.4647202	(0.061)
lnP_K	0.0620974	(0.090)
lnP_L	-0.0514115	(0.163)
Lnind	0.2663128	(0.103)
Lnpopn	0.5729933	(0.004)

Source: Own Computation from STATA

From the regression results above the elasticities were represented by the coefficients of the variables as represented in Table 5.6

Table: 5.6 Elasticity Values of the variables in the Long-Run model

Variable	**Elasticity**
Lnetariff	-0.0010124
lnRGDP	0.4647202
lnP_K	0.0620974
lnP_L	-0.0514115
Lnind	0.2663128
Lnpopn	0.5729933

Source: Own Computation from STATA

Kerosene prices were positive and significant at 10% in determining demand for electricity. A 1% increase in the price of kerosene led to 0.062% increase in consumption of electricity. If kerosene prices increase, household will prefer to consume other forms of energy. Kerosene may act as a substitute for the rural population who use kerosene for lighting and cooking. This may also be explained by the low levels of rural connections to electricity, (Markandya and Abdullah 2007).

LPG prices are negatively related to demand for electricity. A 1% increase in price of LPG led to a 0.05% decline of electricity consumption. Consumption of LPG as a substitute to electricity did not yield the expected sign. This could be due to the fact that electricity has limited substitution possibilities and therefore even a price reduction of LPG does not influence the demand for electricity. This is true especially where electricity is used as a factor of production.

Demand for electricity was found to be price inelastic. This is because its elasticity was less than 1 which is 0.001. The sign was negative as the expected relationship of price and demand. An increase in price led to a decline of the electricity consumed. This may be due to the fact that in the long-run consumers may adopt the use of more efficient appliances and machines therefore reducing the level of demand even with a price increase. Electricity tariffs are also is not a key determinant of electricity demanded because it is insignificant. Price regulations do not affect its consumption.

It is also worth noting that the coefficient for the constant is negative implying that holding all other factors constant, demand for electricity is derived demand. Derived demand for electricity is explained by the explanatory variables.

5.6 Error Correction Model

It normally takes some time for economic agents to adjust to information. However the short run relationships are important. There is a potential problem of common trends of spurious correlation. This problem is cured by differencing the variables to make them stationary. However, differencing leads to loss of data in the long-run. To cure this problem a dynamic error correction was formulated and adopted.

The error correction term captures the long run relationship. It reflects the attempt to correct deviations from the long-run equilibrium and its coefficient is interpreted as the speed of adjustment or the amount of disequilibrium transmitted each period to electricity demand.

The lagged dependent variable was also added as one of the explanatory variable in the model to introduce dynamics in the short run model.

5.7 Selection of an Instrumental Variable

Endogeneity of variables can yield biased results. Several of the explanatory variables move together with the explained variable. The real GDP variable also moves directly with other independent variables. This implies that there is correlation among the variables. An instrumental variable for GDP is therefore essential for unbiased results. Suppose an equation $Y = \beta_0 + \beta_1 X + \mu$

Z serving as an instrument for X

There are two conditions which must be fulfilled when using an instrumental variable. (Wooldridge, 2009)

i. $Cov\ X, \mu \neq 0$

This means that the instrument must be exogenous

ii. $Cov\ Z, \mu = 0$

This means that the instrument must be correlated with the endogenous explanatory variable

The bidirectional relationship between the dependent and independent variables can yield biased estimates. The problem of endogeneity yields inconsistent results. Therefore an instrumental variable was used. The two-stage least squares procedure was used in the regression analysis.

The choice of an appropriate instrumental variable is normally subjective. Validity of an instrumental variable is based on common sense and economic theory because there is no unbiased estimator for μ. It is unobservable, (Wooldridge 2009). Annual rainfall/precipitation variable was used as an instrumental variable for GDP as they are highly correlated. High amounts of rainfall are highly related to high levels of GDP. Kenya is also an agricultural dependent country. Rainfall amounts increased to 38878.8millimetres in 1977 from 24214.9millimetres in 1976(Kenya Meteorological Report 2012). In the same period also GDP growth rates grew from 2.15% to 9.4% (World Development Indicators 2012). Rainfall amounts increased from 24784.7 in 2000 to 38878.8 in 2001. GDP growth rate in 2001 stood at 3.78% from 0.6% in 2000..

Considerable literature has also used rainfall as an instrument for income in analyzing the relationship between economic growth and areas such as democratic institutions, civil wars and trade. Miguel, Satyanath and Sergenti (2004) in their study of Sub-Saharan

Africa overcame the causality problem of income shocks and civil wars by using rainfall disparities to explain the result of economic growth on civil wars. Bruckner & Lederman (2012) used rainfall as an instrument for GDP per capita in Sub-Saharan Africa to estimate the response of trade openness to variations in GDP per capita in the country. Bruckner and Ciccone (2011) used rainfall amounts to study how democratic institutions in Africa reacted to economic shocks. The comparison of the results of the dynamic error correction model using the instrumental variable approach and OLS are shown in Table 5.7.

Table: 5.7 Estimated Dynamic Error Correction Model Results Using OLS and Instrumental Variable Methods

Results	OLS coefficients:		IV-2SLS coefficients	
	Coefficient	p-value	Coefficient	p-value
Dependent Variable / Independent Variables	Dlnelecconspn		Dlnelecconspn	
Constant	0.0234426	(0.128)	0.02472	(0.077)
Dlneleconspn(-1)	0.1411819	(0.391)	0.0325008	(0.893)
Dlnetariffs	0.0218706	(0.486)	0.0147672	(0.635)
DlnRGDP(-1)	-0.2063801	(0.292)	0.1247342	(0.836)
Dlnkeroseneprices	0.0553114	(0.055)	0.0616055	(0.027)
Dlnlpgprices	-0.0203969	(0.542)	-0.0390453	(0.380)
Dlnind	0.6554282	(0.001)	0.5410966	(0.036)
Dlnpopn	-0.1740068	(0.525)	-0.2773031	(0.367)
ECT(-1)	-0.5803102	(0.001)	-0.5159814	(0.004)
R^2	51.20%		46.54%	

Source: Own computation from data

The OLS results revealed that population; real GDP and LPG prices were negatively related to consumption of electricity. Electricity tariffs, industrial output, price of kerosene and consumption for the previous period positively influenced demand.

Results using the OLS approach indicated that GDP was inversely related to electricity demand. Economic theory and literature suggest that an increase in the levels of income increase the demand of a particular commodity. On employing the instrumental approach the sign for real GDP improved to show a positive relationship between income levels and demand for electricity. The coefficient improved from -0.2063801 to 0.1247342 with the correct sign. The IV approach is therefore the correct method to estimate the function as it controls for endogeneity in the model. The study adopted the IV results.

Table 5.6 above shows that population and LPG prices were negatively related to consumption of electricity. They are also insignificant. This implies that demand for electricity in the short run is not influenced by populations and price of LPG as a substitute. Electricity tariffs, incomes, industrial output, price of kerosene and consumption for the previous period directly influenced demand.

Industrial output was a significant factor influencing electricity demand in the short run and was significant at all critical levels This implied the industrial sector was a major driver of electricity consumption in Kenya. Kerosene prices were also a significant factor affecting electricity consumption in Kenya and significant at all critical levels.

The coefficient for the error correction term; ECT (-1) indicated that approximately 51.6% of the deviations from the long run equilibrium were corrected. The error correction term had the expected sign and was significant implying that the model was useful to correct the past deviations The R^2 showed that 46.54% of the variations in electricity demanded were explained by the explanatory variables in the model.

Elasticities were measured by the coefficients of the variables as represented in the table 5.8

Table 5.8 Elasticities of Variables used in the model from the IV-2SLS Approach

Variable	**Elasticity**
Dlneleconspn(-1)	0.0325008
Dlnetariffs	0.0147672
DlnRGDP(-1)	0.1247342
Dlnkeroseneprices	0.0616055
Dlnlpgprices	-0.0390453
Dlnind	0.5410966
Dlnpopn	-0.2773031

Source: Own Computation from STATA

Based on the elasticities of the substitutes used in the study, Kerosene and LPG were not suitable substitutes of electricity as they responded weakly to electricity demand. The results also imply electricity has low substitution possibilities.

Electricity demand did not respond strongly to population growth. Demand for electricity responded quite strongly to industrial growth. The government should therefore increase investments in electricity to be in tandem with industrial growth rather than population growth.

Electricity demand responded weakly to tariffs. This implied that demand for electricity is inelastic. This could be a source of government revenue subject to tariffs not discouraging investors.

The levels of incomes and amounts of electricity consumed in the previous period responded weakly to electricity demand. This implied that demand for electricity is inelastic with respect to incomes and previous consumption.

5.8 Diagnostics Test

The endogeneity post estimation test was carried out for the model above to test if the variables were exogenous. The null hypothesis states that if probability is less than 0.05 we reject that variables are exogenous. The Durbin statistic had a probability value of 0.5477. The Wu-Hausman had a probability value of 0.6048. Since both values were greater than 0.05, the null hypothesis that the variables are exogenous was accepted.

Results from the first stage indicated values of 0.4418, 0.2978 and 0.0864 for the R-squared, Adjusted R-squared and Partial R-squared respectively. The R-squared and adjusted R-squared explain the variations in the model from fitting the first stage regression by OLS. The partial R-squared measured the correlation between real GDP and the additional instrument after ignoring the effect of other variables. (Bound, Jaeger& Baker (1995). The F Statistic had a value of 2.93044 with a probability value of 0.0969 implying that the instrument variable was significant at 10% as the p-value was less than 0.1. The F statistic showed the joint significance of the coefficients of the additional instrument. Its significance explained the power to control for the effects of other variables

5.9 Comparison of Long-run elasticities and IV-2SLS regression elasticities

The Industrial output had a positive and significant effect in the short-run to electricity demand. In the long run it had a direct effect though not significant. The parameter was positive with elasticities of 0.541 and 0.266 in the short run and long run respectively. This finding implied that the industrial sector was a major determinant of electricity consumption in Kenya. The studies by Ekpo, Chuku and Effiong (2011) in Nigeria and Mwabu et al (2011) in Kenya showed that the industrial sector is a large consumer of electricity. There is need for the government to streamline policies in the industry sector so as to ensure efficient use of machinery and equipment. This will reduce the consumption of electricity.

Population had a positive elasticity value of 0.573 in the long run and a negative value of 0.277 in the short run. This shows that in the long run increase of population drove the consumption of electricity up. In the short run people resorted to alternative sources of energy. Population parameter was significant in the long-run. This finding was also consistent with those in the study of Ubani, Umeh and Ugwu (2013) in Nigeria that show population was a significant factor in determining electricity demand.

The electricity tariff elasticity in the short run was 0.015 and -0.001 in the long run. This meant that economic agents did not reduce their demand even with a price increase in the short run. This finding was consistent with the result of Kavezeri (2009) study of Namibia. Labandeira, Labeaga & Lopez-Otero (2011) in Spain and Narayan et al (2007) in G7 countries. This was consistent with economic theory of the exceptions in the law of demand that electricity was a necessary good and its demand was not be influenced by its price. However in the long run economic agents adopt the use of more efficient appliances and machines therefore reducing the level of demand even with a price increase. They economic agents can also exercise their discretion in choice of fuel and equipment in the long run.

Income in the short run had elasticity values of 0.125 and 0.464 in the long run. Income was significant in the long run at 10% critical level implying that it was a key determinant of electricity consumption. A 1% increase raised the demand for electricity by 0.125%. Income was not significant in the short run. Income policies therefore did not have any impact on electricity demand in Kenya in the short run. Bekhet and Othman (2011) findings of Malaysia also supported that incomes did not influence electricity demand in the short-run. However in the long-run income levels had a significant impact on electricity demand

LPG as a substitute had values of -0.039 and -0.051 in the short and long-run respectively. Demand theory suggests that substitutes should be positively related to the demand of the good in question. However, from the findings above that electricity is a necessary good in the short run, it also follows that LPG prices did not have any effect on electricity consumed. Electricity has low substitution possibilities especially in production processes. This outcome was consistent with finding of the study conducted by Bekhet and Othman 2011 in Malaysia.

Kerosene prices conformed to prior expectations and theory of demand on substitute goods. They had a positive elasticity of 0.0616 and 0.0621 in the short run and long run respectively. Kerosene prices were a significant factor in the short run and had a significant effect on consumption of electricity at all critical levels. In the long run they were significant at 10% critical level. This implied that kerosene could be substituted for electricity. This is true especially in the residential sector where households can substitute kerosene for electricity for cooking and lighting. Majority of the rural population are also not connected to electricity.

From the analysis above, the industrial output, income, kerosene as a substitute and population had a significant impact of the amount of electricity consumed. Other explanatory variables including electricity tariffs, previous consumption of electricity and LPG prices did not significantly impact on electricity consumption.

CHAPTER SIX

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

6.1 Introduction

This chapter presents a summary of the study, conclusion, policy implications and recommendations. The chapter also gives limitations of the study and areas of further research**.**

The purpose of the study was to establish the factors that affect demand for electricity in Kenya and their current elasticities. Electricity consumption was used as the dependent variable while electricity tariffs, income, kerosene prices, LPG prices, industrial output and population were used as the independent variables. The income variable was instrumented and annual precipitation was used as the instrumental variable.

An error correction model was used to estimate the empirical model. The findings showed that industrial output and kerosene as a substitute were the key determinants of electricity consumption in Kenya. The variables were statistically significant and had the expected signs. Lagged electricity consumption and electricity tariffs, real GDP had positive signs though insignificant. Population and LPG prices had negative signs and were also insignificant factors determining electricity consumption. In the long run however, population and income and kerosene prices were the key determinants of electricity consumption. In terms of responsiveness industrial growth strongly responded to electricity demand.

Post-estimation results explained that the choice of model was accurate. The endogeneity test indicates that the variables used in the model are exogenous. First-stage results also explain that the choice of the instrumental variable was appropriate.

The long-run model estimates found that electricity consumption in Kenya was strongly determined by income, kerosene prices, and population while LPG prices, electricity tariffs and industrial output did not significantly influence electricity demand. This implied that there was little role that substitutes and electricity tariffs played in estimating the demand for electricity in Kenya. However, the ECM results show that kerosene and industrial output were key determinants of electricity demand in the short-run. In terms of responsiveness, kerosene responded weakly while industrial growth responded strongly to electricity consumption. These results were consistent with theory and empirical findings of Ubani, Umeh and Ugwu (2013) in Nigeria and Ekpo, Chuku and Effiong (2011) in Nigeria. Therefore, policies geared towards increasing industrial efficiency, increasing electricity generation to be in line with industrial growth and use of cheap but appropriate substitutes should be given priority as demand management measures in the electricity subsector.

6.2 Policy implications and recommendations

Electricity is a necessity to economic agents. It is of ultimate importance to both production processes and consumption. It is therefore imperative to put in place demand management policies.

First, industrial output in the short run is a main determinant of demand for electricity. Policies geared towards increasing efficiency of production in the industrial sector would automatically ensure that the demand for electricity does not outweigh the supply. Government can subsidize the cost of alternative energies that could substitute electricity in production. These measures will ensure reduced consumption of electricity as well as optimal production. Ultimately this will control the demand for electricity in the industrial sector.

Second, Energy Regulatory Commission should subsidize the prices of substitutes and offer tax incentives of the fuels. This is because the short run and long run elasticity values indicated that electricity did not have close substitutes. Lower prices for substitutes will ensure that more people shift away from the use of electricity.

Third, increase in industrial growth has shown a strong response to electricity demand. Increase in industrial growth implies a high consumption of electricity. There is therefore need for the government to embark on policies to increase electricity generation in tandem with industrial growth.

The public sector should strive to ensure production is commensurate to the demand. The government should ensure that more funds are channeled towards investment in power generation. This will ensure there is sufficient electricity therefore enhanced economic activities.

6.3 Limitation of the study

Only two substitutes, kerosene and LPG were used in the study. This is because data for other substitutes such as charcoal and firewood which are primarily used in the rural areas was not available.

6.4 Areas for further research

The key role played by electricity in the economy requires great attention from all stakeholders. The study could include variables such as political stability and electricity infrastructures which are critical factors influencing electricity production. With the recent discovery of oil in Kenya researches can also be carried out to study the effect of oil discovery in electricity production.

REFERENCES

Al-Faris 2002, 'The Demand For Electricity In The GCC Countries' *Energy Policy* Vol. 30, pp. 117-124

Alter, N & Syed S. H., 2011, 'An Empirical Analysis of Electricity Demand in Pakistan' *International Journal of Energy Economics and Policy* Vol. 1 no. 4 pp.116-139

Ardakanian O., Keshav S., & Rosenberg C., 2011, '*Markovian Models for Home Electricity Consumption*' Working Paper

Arthur S., & Sheffrin S. M., 2003, Economics: *Principles in Action*

Balabanoff, S, 1994, 'The Dynamics of Energy Demand in Latin America', *OPEC Review,* Vol. 18, pp. 467-489

Beckhet, H. A., & Othman N. S., 2011, 'Assessing The Elasticities Of Electricity Consumption For Rural And Urban Areas In Malaysia: A Non Linear Approach' *International Journal Of Economics And Finance* Vol. 3, No.1 pp. 208-217

Bose R. K., Shukla M., 1999, 'Elasticities Of Electricity Demand in India'. *Energy Policy* Vol. 27 pp.137-146.

Bound, J., Jaeger D.A., &. Baker R. M, 1995, 'Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak.' *Journal of the American Statistical Association* Vol. 90, pp 443–450.

Brückner M., Lederman D., '*Trade Causes Growth in Sub-Saharan Africa'* Research Policy Working Paper

Brückner M. & Ciccone, A., 2010. .Rain and the Democratic Window of Opportunity. *Econometrica 79* Vol. 3 pp. 923-947

Buranakunaporn S, & Oczkowski E, 2007, 'A Dynamic Econometric Model of Thailand Manufacturing Energy Demand' *Applied. Economics*, Vol. 39, pp. 2261–2267

Chiang-Lee, C & Chu, Y, 2011 '*Electricity Demand Elasticities and Temperature'* Australian Conference of Economists Working Paper

De Vita, G, Endresen K. & Hunt, L.C., 2006, 'An Empirical Analysis Of Energy Demand In Namibia', *Energy Policy*, Vol. 34, pp.3447–3463

Edward, M, Satyanath. S. & Sergenti, E., 2004. "Economic Shocks and Civil Conflict: An Instrumental Variables Approach." *Journal of Political Economy* 112 Vol.4 pp.725-753.

Eiswerth M. E., Abendroth K.W., Ciliano R.C., Ouerghi A, Ozog M.T., 1998, "Residential Electricity Use And The Potential Impacts Of Energy Efficiency Options In Pakistan." *Energy Policy* Vol.26 pp.307–315

Ekpo, U.N., Chuku, C. A, & Effiong E. L,, 2011, 'The Dynamics of Electricity Demand and Consumption in Nigeria: Application of the Bounds Testing Approach', *Current Research Journal of Economic Theory* Vol. 3, No.2, pp. 43-52

Galindo, L. M, 2007, ‘Short and Long Run Demand For Energy In Mexico: A Co-Integration Approach’ *Energy Policy* Vol. 33, pp. 1179-1185

Gam, I.& Rejeb J. 2012, ‘How Can We assess the Relation Between Equipment Price, Price and Electritiy Demand in Tunisia’ *International Journal of Energy Economics and Policy* Vol. 2, No.3, pp. 159-166

Ghosh, S, Dar, A, & Abosedra, S, 2009, ‘Demand For Electricity in Lebanon’, *International Business and Economics Research Journal* Vol. 8 No.1, pp.11-18

Harvey, A. C., 1989. ‘*Forecasting, Structural Time Series Models and the Kalman Filter’*, Cambridge University Press: Cambridge.

Holtedahl, P& Joutz, F.L, 2004, ‘Residential Electricity Demand in Taiwan’ *Energy Economics,* Vol.26, pp. 201-224.

Hunt L.C., & Dilaver Z., 2010 “*Modeling And Forecasting Turkish Residential Electricity Demand*” Surrey Energy Economics Energy Discussion Paper Series

International Energy Agency, 2011 ‘World Economic Outlook’ France

Jarque, C. M., & Bera, A.K., 1987, ‘A test for normality of observations and regression residuals’, *International Statistical Review*, Vol. 55, pp. 163-172

Johansen, S. 1988, ‘Statistical analysis of cointegrating vectors’, *Journal of Economic Dynamics and Control* Vol.12 pp 231-54

Jung, T. Y., 1993, ‘Ordered Logit Model For Residential Electricity Demand In Korea’, *Energy Economics*, Vol.15, pp. 205–209.

Kavezeri, K. & Ziramba, E., 2009, ‘Long-Run Price and Income Elasticities of Namibian Aggregate Electricity Demand: Results from the Bounds Testing Approach’ *Journal of Emerging Trends in Economics and Management Sciences* Vol. 3 No. 3, pp 203-209

Kenya Meteorological Services, 2012, “*Kenya Meteorological Report*” Government of the Republic of Kenya

Kenya Power, 2012, *Kenya Power Annual Reports and Financial Statements*, Nairobi

Kenya Power, 2013, *Kenya Power Retail Tariff Application Schedule*, Nairobi

Kenya Vision 2030, “*A Globally Competitive and Prosperous Kenya*” Government of the Republic of Kenya, 2007

Khan, M.A. & Qayyum, A., 2009, ‘The demand for electricity in Pakistan’, *OPEC Energy Review*

Kimuyu, P.K., 1988, ‘Demand For Commercial Energy in Kenya; A Structural Investigation, PhD Thesis, University of Nairobi, Nairobi.

KIPPRA, 2007, ‘*Strategies for Securing Energy Supply in Kenya’* Government of the Republic of Kenya

KIPPRA, 2010, *A comprehensive study and analysis on energy consumption patterns in Kenya,* Energy Regulatory Commission Government of the Republic of Kenya

Labandeira, X., Labeaga, J., & Lopez-Otero, X., 2011, "*Estimation of Elasticity Price of Electricity with Incomplete Information Economics of Energy'*, Working Paper 01/2010

Lin, B. 2003, **'***Electricity Demand In The People's Republic Of China: Investment Requirement And Environmental Impact*, Asian Development Discussion Paper No. 37

Mankiw, Gregory 2007. *Principles of Economics*. pp 470.

Markandya, A & Abdullah, S. 2007, Rural Electrification Programmes in Kenya: Policy Conclusion from a Valuation Study

Martinez-Chombo E., & Chang, Y., 2003, "Electricity Demand Analysis Using cointegration and Error-Correction Models with Time Varying Parameters: The Mexican Case" Working Paper

Ministry of Energy, 2012, '*National Energy Policy'*, Third Draft, Government of the Republic of Kenya

Ministry of Energy, 2002, '*National Energy Policy'*, Government of the Republic of Kenya

Ministry of Energy, 2006, *Energy Act 2006*, Government of the Republic of Kenya

Mohamed, Z.& Bodger, P. Forecasting Electricity Consumption In New Zealand Using Economic and Demographic Variables. *Energy* 2005, Vol 30 pp.1833–1843

Mwabu, G, Etyang, M., & Onuonga, S. M., 2011, 'The Demand for Energy in Kenya's Manufacturing Sector' *The Journal of Energy And Development*', Vol. 34, No. 2 pp 265-276

Mwakubo, S., Mutua, J., Ikiara, M. &Aligula, E., 2007, '*Strategies for Securing Energy Supply in Kenya*', Discussion paper No. 74 KIPPRA Nairobi

Narayan, A., Paresh, N., Kumar, N., Smyth, R., & Prasad, A., 2007, 'Electricity Consumption in G7 Countries: A Panel Cointegration Analysis of Residential Demand Elasticities', *Energy Policy* Vol. 35, pp. 4485-4494

Oxford University Press, 2000 "*Human Development Report*" New York United Nations Development Programme

Pesaran, M. H,, Shin, Y., & Smith, R.J., 2001, 'Bounds testing approaches to the analysis of level relationships' *Journal of Applied Econometrics* Vol. 16 pp. 289–326

Republic of Kenya, Economic Survey, Nairobi: Government Printer, 2012

Republic of Kenya, Economic Survey, Nairobi: Government Printer, 2003

Ubani, O. J., Umeh, L., & Ugwu, L., 2013, 'Analysis of the Electricity Consumption in the South – East Geopolitical Region of Nigeria', *Journal of Energy Technologies and Policy* Vol.3, no. 1, pp 20-32

UN-HABITAT, 2006 '*Rapid Urban Sector Profiling for Sustainability*' Nairobi

Wooldridge 2009, *Introductory Econometrics* A Modern Approach 4th Edition

World Bank Indicators, www.data.worldbank.org

Appendix I: Data used

Variable	Eleconspn(Million Kshs)	Etariff (Kshs/Unit)	P_K (Kshs/Litre)	P_L (Kshs/Kgs)	Ind(Million Kshs)	Popn(Million)	RGDP(Million Kshs)	Rainfall (Millimetres)
1971	909	0.23	0.626	1.915	42530.2	11.7	309994.7	20435.4
1972	996	0.23	0.626	1.945	62327.4	12.1	362949.4	25730.9
1973	1067	0.23	0.626	2.06	67242.2	12.5	384351	23053
1974	1137	0.26	0.626	2.34	67778.5	12.9	399977.2	24296.3
1975	1220	0.22	0.626	2.7	68090.8	13.7	403505.8	25741.2
1976	1351	0.32	1.346	2.98	67832.3	13.8	412197.2	24241.9
1977	1426	0.31		3.1	76549.1	14.3	451165.5	38878.8
1978	1526	0.33	1.454	3.974	84643	14.9	482352.3	37887.7
1979	1640	0.35	1.653	4.508	87634.3	15.3	519084.5	34042.3
1980	1707	0.44	2.158	4.632	92306.6	16.7	548111.6	26233.1
1981	1838	0.58	2.802	4.972	95999.5	17.3	568794.8	32380.2
1982	1884	0.52	3.683	6.05	97621.2	18	577363.6	39620.9
1983	1946	0.56	3.683	6.412	98082	18.8	584921.5	30242.8
1984	2051	0.57	4.13	6.399	100171	19.9	595188.2	25149.1
1985	2229	0.62	4.13	5.71	106055	20.1	620784.6	30632.7
1986	2368	0.66	3.444	5.893	110273	20.9	665341.8	30771.5
1987	2645	0.91	3.394	5.984	116105	21.6	704843.8	26704.3
1988	2595	1.04	3.41	6.4	122328	22.4	748566.6	35747.8
1989	2753	1.09	4.278	7.82	129888	23.2	783677	34928.3
1990	2930	1.12	6.598	14.129	135947	24	816529.1	33424.2
1991	3061	1.41	8.544	14.843	139393	24.8	828273.6	28086.7
1992	3159	1.68	9.529	16.643	139320	25	821651.6	27880.3
1993	3323	1.75	14.796	23.388	139600	26	824553.7	26945.7
1994	3356	3.1	16.91	24.454	142259	26.8	846262.4	34341.1
1995	3490	4.29	14.41	25.2	147288	27.5	883550.6	30395.5
1996	3655	4.57	18.27	25.956	152289	27.4	920190	27239.9
1997	3689	4.96	22.08	45	154104	27.1	924560	45876.1
1998	3813	5.17	22.37	42	154467	27.9	954980	37209.6
1999	3625	5.17	24.456	51	150816	28.7	976996	30421.1
2000	3525	7	31.084	55.11	148053	30.2	982855	24784.7
2001	3934	9.12	34.11	52.41	156192	30.9	1020006	34144.3
2002	4013	7.09	33.122	53.32	159857	32.2	1025584	35846.4
2003	4310	6.33	35.488	54.23	169639	33.2	1055659	31007.9
2004	4679	5.92	40.328	55.14	176548	34.2	1109543	30395
2005	4879	6.72	49.094	57.018	184295	35.1	1175080	25052
2006	5305	7.64	56.388	71.794	193444	36.1	1249470	43605.6
2007	5582	7.88	57.248	73.187	207121	37.2	1336849	32836.3
2008	5716	8.03	75.148	79.168	216820	38.3	1357262	29023.7
2009	5813	12.58	61.309	68.983	222890	38.6	1394386	27722.4
2010	6321	13.69	65.668	94.114	234847	38.5	1474771	34247.3
2011	6273.6	12.58	88.073	131.42	241413	39.5	1539306	33172.5
2012	6414.4	15.97	83.922	213.02	247979	40.5	1605496	30293