THE IMPACT OF PASS THROUGH COSTS IN ELECTRICITY CONSUMPTION IN KENYA

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DECLARATION

This research paper is my original work and it has not been presented to any other institution for examination.

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DGE	Deemed Generated Energy
EPRA	Energy and Petroleum Regulatory Authority
ERB	Electricity Regulatory Board
ERC	Energy Regulatory Commission
FCC	Fuel Cost Charge
FERFA	Foreign Exchange Rate Fluctuation Adjustment
FIT	Feed in Tariff
GDC	Geothermal Development Company
GW	Gigawatt
GWh	Gigawatt hours
IPP	Independent Power Producer
IEA	International Energy Agency
KES	Kenya Shilling
KPLC	Kenya Power and Lighting Company
KETRACO	Kenya Electricity Transmission Company
KENGEN	Kenya Electricity Generating Company
KW	Kilowatt
KWH	Kilowatt per Hour
LCPDP	Least Cost Power Development Plan
MW	Megawatt
NuPEA	Nuclear Power Energy Agency
REP	Rural Electrification Program

REA	Rural Electrification Authority
REREC	Rural Electrification and Renewable Energy Corporation
WARMA	Water Resources Management Authority Levy

ABSTRACT

Electricity consumption is important for both economic growth and wellbeing of households. As the government implements its growth agenda by increasing investments in energy infrastructure, this has seen increased growth in power supply that is out of proportionate to the increase in power demand. The lag in demand growth has been attributed to rising unit cost of electricity over the five-year period ending June 2018. This study provides empirical evidence on the impact of electricity pass through cost on consumption of power by consumers in Kenya.

The study adopts ARDL regression technique to examine the impact of electricity pass through cost on consumption of power by domestic consumers in Kenya. Data on consumption was obtained from Kenya Power & Lighting Company (KPLC), while the monthly pass through costs obtained from Energy & Petroleum Regulatory Authority (EPRA). The study concludes that WARMA Levy and FCC significantly impact on consumption of electricity by the category of consumers., followed by FERFA and INFA. The impact observed is pronounced on the commercial and industries customer category, where a 1% increase in the pass through costs, is observed to reduce consumption for electricity in the commercial and industries customer category by around 1.4Million KWh in the short run and around 800,000KWh in the long run.

Study recommends review of the pass through costs with reduction of the levies through legislation, abolishing the FCC through 100% adoption of renewable energy power generation and decommissioning of Thermal Power generators. In addition, abolishing the FERFA by adopting local currency based PPAs to avert costs associated with foreign currency based PPAs. Finally, breakdown of the impact of the pass through costs on particular sectors like agriculture and service sectors of the economy. The study recommends further future research on these sub-sectors of the economy.

CHAPTER ONE: INTRODUCTION

1.1 Overview of the global electricity consumption

Globally, electricity is the most widely used form of energy. Consumption in 2018 was 21360TWh (IEA, 2018). According to International Energy Agency (IEA) 2018 report, consumption is high in the developed and industrialized nations, but low in developing nations particularly in Sub-Sahara Africa. Payne (2010) says electricity plays a vital role in production and there is a strong relationship between electricity consumption and economic growth and development. Pao (2009) observe that electricity is a flexible form of energy, and a critical input in socioeconomic growth.

Technological differences between developed and developing nations explain their differences in electricity consumption. In technology driven economies, electrical machines from computerized car assemblies to medical robotics that assist in complex medical operations perform many functions of production (IEA, 2018). Innovative power generation technology has seen more power generated in developed nations, while in developing nations inadequate technology has hindered exploitation of most natural resources include those for electric power generation (Power Africa, 2018).

Low investments in the expansion of the power grid infrastructure is also a factor in low consumption of electrical energy (AFD and World Bank, 2019). According to a United Nation Policy brief on accelerating sustainable development goal number seven, the limitation in grid infrastructure is directly attributable to low electricity access, with an estimated 590 million people in the Sub-Saharan Africa lacking access to electricity. Consequently, the region records low consumption of electricity (United Nation, 2018). The International Energy Association estimates that Sub-Saharan Africa needs to invest US$ 34.2 billion annually to achieve universal access to energy by the 2030.Of these, US$ 32.5 billion should facilitate access to electricity (IEA, 2017a).

A fundamental factor accounting for the difference in access and consumption of electrical energy between developed nations and Sub-Sahara Africa is the high cost of grid connected electrical energy; primarily the pricing of electrical energy per Kilowatt-hour (kWh) and connection costs (World Bank, 2019). Affordable electricity is a key driver of electrical energy consumption and consequently socio-economic growth. Hence, the need to review and analyze the pricing structure of electrical energy with the objective of increasing electrical energy consumption and boosting output.

1.1.1 Electricity demand and consumption in Kenya

In Kenya, electricity plays an important role in economic growth on the modern society given that it can meet a diversity of human energy needs compared to other forms of energy. The modern infrastructure, with sustainable, reliable and affordable generation, transmission and distribution of electricity, is a critical pillar of economic recovery programs in Kenya (Republic of Kenya 2014; 2015).

Accelerated economic development and rising productivity of all sectors are among the overall objectives of the government (Republic of Kenya 2014). Primarily, electricity access in Kenya is limited by initial connection costs, per Kilowatt-hour cost and poor reliability making grid electricity costly.

According to Energy and Petroleum Regulatory Authority (EPRA), retail tariff averaged KES 22.76/kWh in 2018, and KPLC connection costs stood at average of KES 35,000 in the same year. With an average household monthly consumption of 100kWh, annual household expenditure on electricity summed estimated KES 62,312 including connection costs in 2018. According to the World Bank, Kenya's per capita income stood at US$ 3,250 in 2018, implying electricity expenditure takes up entire income from a household with new connection, while taking up to 80 per cent of income for existing connected households.

Nevertheless, demand for electricity in Kenya has been increasing steadily since the year 2013 due to accelerated investments in energy sector by the government. Economic growth and increased entry of private investors in various sectors of the economy has led to increased power demand. Kenya's peak demand increased from 1,468MW in 2013 to 1,802MW period ending June 2018 (Kenya Power 2018). According to Kenya Power 2018, electricity sales with the period rose from 7,244GWh in 2013 to record 8,459GWh in the period ending June 2018. Historical consumption per customer category is as illustrated in table 1.

Table 1: Electrical energy sales by consumer category

Tariff	**Types of consumer**	**Sales in GWh**					
		2012/13	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
DC	Domestic	1,670	1,803	1,866	2,007	2,138	2,335
SC	Small Commercial	998	1,109	1,143	1,153	1,201	1,222
CI	Commercial and Industrial	3,440	3,818	4,030	4,104	4,266	4,225
IT	Off-peak	18	1	15	26	41	33
SL	Street lighting	18	20	35	40	55	66
	REP System[1]	406	454	525	537	549	554
	Export to Uganda	30	37	38	43	20	22
	Export to Tanesco	1	2	2	2	2	2
	TOTAL	**6,581**	**7,244**	**7,655**	**7,912**	**8,272**	**8,459**
	%Increase p.a.	**4%**	**10%**	**6%**	**3%**	**5%**	**2.3%**

[1] REP – Rural Electrification Program. Domestic customers billed under the government's rural electrification program.

Source: Kenya Power, 2018

The number of electrical connections in the country is dependent on growth in demand of electricity with connections increasing more than double from 2,767,983 in 2013 to 6,761,090 in June 2018. Increased connections result from government's realization of the fact that access and consumption of clean and efficient energy is one of the fundamental blocks of a sustained economic growth and development.

However, consumption of electrical energy by domestic consumers (households) lagged behind those of industrial consumers as showcased in the Kenya Power and Lighting Company annual report for 2018 (Kenya Power 2018). In contrast, the domestic consumers' category has the largest number of connections according to KPLC statistics, estimated 90 per cent of total connections. Consumption per consumer category is as illustrated in figure 1.

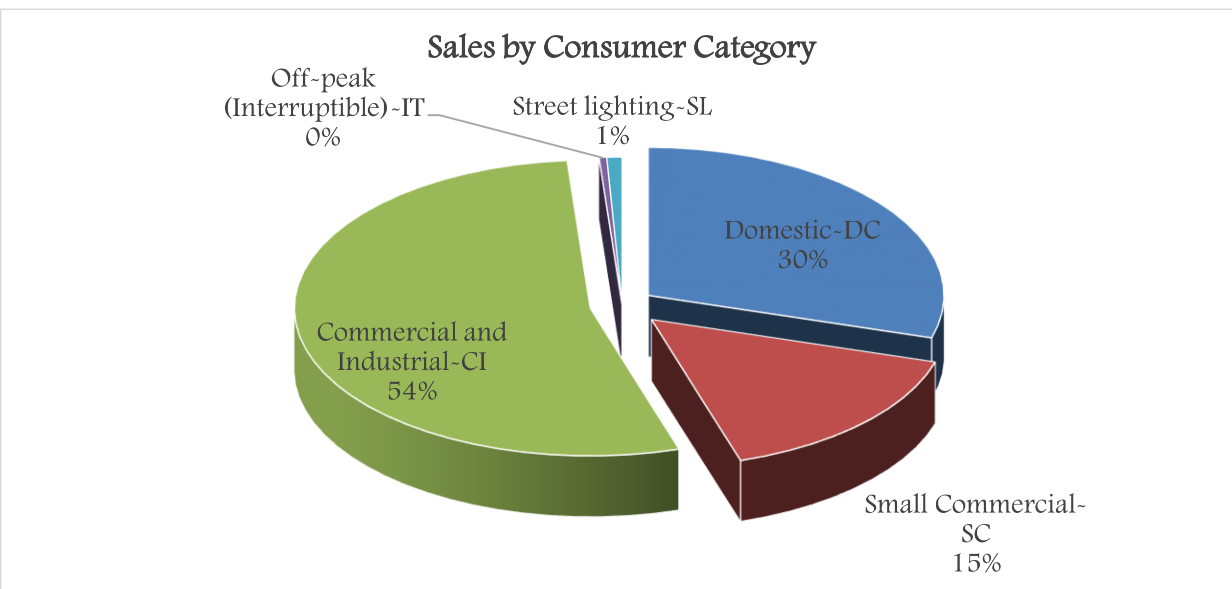


Figure 1: KPLC sales by consumer category 2018

Source: Kenya Power Annual report 2018

1.1.2 Kenya's electricity generation and supply

Historically, Kenya's electricity supply chain has largely been state-owned from generation, transmission to retail and distribution. The current establishment of electricity supply chain traces back to East Africa Power and Lighting Company formed in 1922, after the merger of privately owned Mombasa Electric Power and Lighting Company with Nairobi Power & Lighting Company (Kenya Power 2012). The East Africa Power and Lighting Company renamed to Kenya Power and Lighting Company (KPLC) in 1983, with operations in Generation, Transmission, Retail and Distribution bundled together in one institution (Kenya Power 2012).

Reforms in the power sector resulted in the enactment of the Electric Power Act 1997, which established Kenya's grid code, the Electricity Regulatory Board (ERB) and, demerged KPLC'S generation unit, the Kenya Power Company, into independent Kenya Electricity Generating Company (KenGen, 2012).

Further reforms continued to take place with the adoption and implementation of Sessional Paper No. 4 of 2004, and the subsequent enactment of the Energy Act of 2006. This saw the restructuring of Electricity Regulatory Board (ERB) to Energy Regulatory Commission (ERC). The latter's mandate was expanded to encompass regulation of the entire energy sector including downstream petroleum subsector and renewable energy. The sessional paper number four of 2004 on energy also provided for the creation of the Energy Tribunal, Geothermal Development Company (GDC), Rural Electrification Authority (REA), Kenya Nuclear Electricity Board (KNEB) and Kenya Electricity Transmission Company (KETRACO).

Enactment of Energy Act 2019 by Parliament, and subsequent Presidential Assent in March 2019 saw the latest in the series of sector review. The new law marshalled the transition of Energy Regulatory Commission (ERC) into Energy and Petroleum Regulatory Authority (EPRA).

EPRA's mandate now incorporates the upstream, midstream and downstream operations of the petroleum sector in addition to full regulation of the entire electricity supply chain in the country (Energy Act 2019). The Energy Act 2019 transformed KNEB into Nuclear Power and Energy Agency (NuPEA), to promote and implement a nuclear electricity generation program and implement the training programme for nuclear power in the country.

The Energy Act 2019 reviewed the mandate of Rural Electrification Authority and transformed it to Rural Electrification and Renewable Energy Corporation (REREC), to be the lead agency for development of renewable energy resources other than geothermal and large hydropower, in addition to its current mandate of rural electrification (Energy Act 2019).

As observed in the Energy Act 2019, the institutional framework of the electricity sector in Kenya comprises of the Ministry of Energy, Energy and Petroleum Tribunal, EPRA, KETRACO, KPLC, KenGen, REREC, NuPEA, GDC, independent power producers (IPP) and minigrids (Energy Act 2019).

Continuous sectoral reforms and investment in energy infrastructure has seen increased power generation in the country. According to Kenya Power annual report 2018, in the period 2013-2018, installed capacity in the country has increased from 1,885MW in June 2013 to 2,819MW in December 2019 (LCPDP 2019). KenGen, which is the largest power generator in the country, accounts for 69.2per cent of the industry's effective generation capacity. The Independent Power Producers (IPPs) account for 29.0 per cent in the same period. Isolated grid generation under the Rural Electrification Programme (REP), implemented by REREC account for less than 1 per cent as illustrated in figure 2.

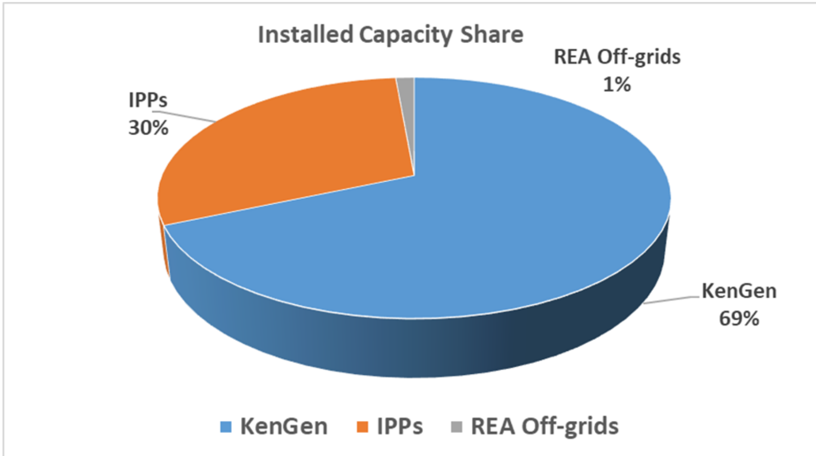


Figure 2: Installed capacity share by power producer

Source; Kenya Power 2018

Kenya's installed electricity capacity as at December 2019 is 2,819 MW as depicted in Table 2.

Table 2: Installed Capacity mix

	Installed MW	**Effective/Contracted MW**	% (effective)	% (Installed)
Hydro	826.23	805.00	29.42%	29.31%
Geothermal	828.44	816.04	29.82%	29.39%
Thermal (MSD)	660.32	640.42	23.40%	23.42%
Thermal (GT)	60.00	56.00	2.05%	2.13%
Wind	335.50	325.50	11.90%	11.90%
Biomass	28.00	23.50	0.86%	0.99%
Solar	50.25	50.25	1.84%	1.78%
Interconnected System	**2,789**	**2,717**	**99.28%**	**98.93%**
Off grid thermal	29	20	0.71%	1.03%
Off grid wind	1	0.00	0.00%	0.02%
Off grid solar	0.71	0.20	0.01%	0.03%
Imports	0	0	0.00%	0.00%
Total Capacity MW	**2,819**	**2,736**	**100.0%**	**100.0%**

Source: Least Cost Power Development Plan 2019.

KETRACO and KPLC oversee power evacuation with management of the county's entire transmission and distribution network system. As of June 2018, the transmission and distribution network's circuit length was 233,700 kilometers for all voltage levels from 49,649 kilometers in 2012/13 (Kenya Power 2018). The growth in transmission and distribution network is attributed to government's increased investments in the energy infrastructure, consequently accelerating efforts to connecting more households with electricity and achieve overall objective of universal connectivity by the year 2022 (Kenya Power 2018).

In power purchasing, Kenya's electrical energy supply is by a procured contractual obligation between the power producer and the off-taker, in this case Kenya Power & Lighting Company. Primarily, Kenya subscribes to two modes of power contractual procurement namely the feed in tariff method and the privately initiated investment project. The feed-in-tariff procurement process oversees power purchasing through the feed-in–tariff (FIT) policy. The policy was introduced in 2008 to boost development of generation of electricity from renewable sources such as small hydro, geothermal, biomass, biogas, wind and solar. The FIT policy recommends tariffs for generation of electricity using renewable technologies considering the costs incurred by project developers in undertaking the project and seeks to ensure a reasonable return to developers (Ministry of Energy, 2018).

Privately initiated investment project method of power procurement is through the Public Private Partnerships (PPP) Act 2013. The PPP Act provides for the involvement of the private sector in the development of infrastructure projects. The involvement of private investors in implementation of projects intended for public good enables the Government to allocate its restricted budgetary resources to other areas such as health and education (Ministry of Energy, 2018). The investors are expected to recover their investment cost and make a return during the life of a project. The

PPP Act provides detailed process of screening and recommending projects' completion within the sphere of the PPP instrument (Ministry of Energy, 2018).

1.1.3 Electricity tariff structure in Kenya

The Energy Act 2019 gives EPRA the task of setting, reviewing and adjusting tariffs and tariff structures, and the terms of electrical supply in the country from both the interconnected system and the off-grid system. According to EPRA, determination of end user tariff is at two levels, generation and retail. The computation of the generation tariff is through consideration of the investment costs and a return on the investment. The investment cost amortized over the entire useful life of the project. The resulting tariffs are either cost reflective or subsidized by the Government (Ministry of Energy, 2018).

In determination of retail tariff, EPRA undertakes demand forecasting for the bulk and retail markets, generation and transmission planning to meet the forecasted demand. Estimating sector revenue requirements based on forecasts of costs likely to be incurred for generation, transmission, distribution and supply of power. In addition, the marginal costs of generation, transmission, distribution and retailing based on approved tariff control period.

In accordance with the Energy Act 2019, EPRA has established tariffs for different customer categories for the tariff control period 2018/2019 as shown in table 3.

Table 3: Approved electricity tariffs by category, 2018

Consumer Category	Load	Energy Limit (kWh/Month)	Charge Rate (KES/kWh)	Demand Charge (KSh/kVA)
DC- Lifeline[2]	240/415V	0-100	10.00	-
DC-Ordinary[3]	240/415V	>100-1500	15.80	-
Small Commercial SC-1[4]	240/415V	0-100	10.00	-
Small Commercial SC-2[5]	240/415V	>100-15000	15.60	-
Commercial and Industrial CI 1	240/415V	No limit	12.00	800
Commercial and Industrial CI 2	11kV	No limit	10.90	520
Commercial and Industrial CI 3	33kV	No limit	10.50	270
Commercial and Industrial CI 4	66kV	No limit	10.30	220
Commercial and Industrial CI 5	132kV	No limit	10.10	220
Street Lighting	240kV	No Limit	7.50	-

Source: EPRA, 2018.

According to EPRA, Kenya's electricity tariff is designed by factoring in type of load, maximum demand, time which load is required, power factor of the load and the amount of energy used. The end user tariff is a blend of types of tariffs according to factors listed above. In context, the basis of domestic consumers and small commercials' tariff is on the principles of two-part tariff methodology, commercial and industrial tariff category is three-part tariffs, while the street lighting category is on flat demand rate tariff.

[2] Applicable to Domestic Consumers for supply provided and metered by the company at 240/415V and whose consumption does not exceed 100kWh per post-paid billing period.

[3] Applicable to Domestic Consumers for supply provided and metered by the company at 240/415V and whose consumption does not exceed 1500kWh units per post-paid billing period

[4] Small commercial category of consumers consuming less than 100kWh in a month.

[5] Small commercial category of consumers consuming more than 100kWh but less than 15000kWh in a month.

Analyzing electricity pricing structure in relation to demand in the domestic consumer category will be the first step in demand management and inform policy recommendations for pricing retail tariff to enhance uptake in domestic consumer category. Power Africa 2018 annual report enlists pricing of electricity as a constraint in boosting uptake of electrical energy in the country, particularly the domestic consumers' category. The extent of realization of Kenya's growth and development objectives hinge on affordability of vital element of production that is electricity (Power Africa, 2018).

1.2 Statement of the problem

As the government continues to implement its growth agenda by increasing investments in energy infrastructure, increased growth in power supply is not proportionate to increased power demand (Kenya Power 2018). As at June 2018, the installed power capacity in the country stood at 2351MW and peak demand for power stood at 1802MW, a surplus of 549MW. Over the same period, energy generated was 10702GWh against energy sold 8459GWh, implying an excess supply of 2243GWh (Kenya Power 2018). As of December 2019, Kenya's installed electricity capacity stood at 2,819 MW, with peak demand of just 1,912 MW.

With surplus power, the government is forced to make Deemed Generated Energy(DGE) payments for power generated but not utilized as part of contractual obligations on Power Purchase Agreements (PPAs) between power producers and the off-taker, Kenya Power and Lighting Company (KPLC), costing billions in taxpayers' money every year. The lag in demand growth has been attributed to rising unit cost of electricity; the average cost per unit of kWh has increased from KES16.70/kWh to KES22.76/kWh over the five-year period ending June 2018.The rising cost of electricity per kWh has changed upwards creating economic burden on consumers. The burden of the price rise on consumers has, however, not been widely studied. This study will therefore provide empirical evidence on the impact of electricity pass through cost on consumption of power by consumers in Kenya. The finding will provide insightful information to policy actors when revising electricity tariffs for consumers. Secondly, there exists deficiency of literature on the effects of electricity pricing pass through costs on electricity consumption by consumers in Kenya. In view of this, this research study will bridge this gap by empirically examining the effect of electricity pricing pass through costs on electricity consumption by consumers in Kenya.

1.3 Research questions

The study will answer the following research questions:

i. What are the effects of pass through costs shifters on cost of electricity in Kenya?
ii. What is the impact of pass through costs on electricity consumptions?
iii. What is the welfare impact of pass through costs of power consumers in Kenya?
iv. What are the policy recommendations in managing pass through costs to mitigate the impact on consumers?

1.4 Objectives of the study

The main objective of this study is to examine the impact of electricity pass through cost on consumption of power by consumers in Kenya.

The specific objectives of study are to:

i. Estimate effect of variable electricity cost shifters on the cost of power in Kenya
ii. Estimate the impact of pass through costs on electricity consumption in Kenya
iii. Analyze the welfare impact of pass through costs on power consumers in Kenya;
iv. Propose policy recommendations to manage pass through costs to mitigate impact on consumers.

1.5 Significance of the study

Establishing the impact of pass through costs on electricity consumption in Kenya will provide policy makers with guidance in the formulation and adjustment of polices relating to electricity pass through costs. Implications of the electricity pass through costs on power consumption may form the foundation of overall tariff review in the country. In addition, the study will also make recommendations that will inform the power purchasing process in the country concerning how to treat deemed generated energy.

Theoretically, the study will offer knowledge on demand for electricity in Kenya, and notably the impact of pass through costs in consumption, by providing literature and basis for establishing research gaps.

1.6 Organization of the study

Organization of the study is in five chapters. Chapter one introduces the study under subsections; background of the study, Kenya's electricity sector, electricity production in Kenya, electricity demand and consumption in Kenya, electricity tariff structure in Kenya, electric power purchasing in Kenya, statement of the problem, objectives, research questions and significance of the study. Chapter two presents the literature review both theoretically and empirically. Chapter three outlines the methodological approach that will be employed in the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical literature review on demand for electricity

Based on the general demand theory and demand for electrical energy, this section highlights the factors that influence demand for electricity, or the relationship between price and consumption of electricity.

Electricity has price demand, income demand and cross demand. It is a consumer as well as a producer good. From consumer theory, demand for electricity may be a derived demand. Demand broadly falls in two categories; short run and long run demand. 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 (Walker, 2014).

Demand of a commodity is determined by numerous elements (Torriti, 2014). Price has an inverse relationship with demand for electricity among household. In contrast, an increase in household incomes raises demand. Expectations of future prices and incomes also attribute to demand behavior. Expectation for future prices to rise, consumption today will rise. Similarly, expectation of future income rise, consumption today is likely to increase.

Aramcharoen and Mativenga (2014) 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 structural changes and efficiency improvement. All these factors were important when estimating energy demand functions (Günay, 2016). Income is the most significant determinant of electricity consumption. Cynamon (2017) defined income demand as the demand of a good at different income levels.

When the income levels increase people tend to demand more goods and services. Description of a normal good is whose demand goes up when incomes increase and demand goes down when income decrease. The income level that represents economic activity and standards of living is the main factor in determining electricity's demand (Cynamon2017). 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.

Electricity price is a key determinant of electricity demand. According to Karanfil and Li (2015) 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, there is a direct link between electricity prices and electricity consumption (Karanfil and Li, 2015).

Electricity prices are 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 theory. As the price of a normal good increases, the demand of the good decreases. Auffhammer and Wolfram (2014) in their study revealed that high price constrains energy consumption. Additionally, Arisoy and Ozturk (2014) presented electricity as a necessary good with an inelastic demand.

According to UNDP (2014) report, other important factors included; price of other fuel substitutes 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.

Capital investment on electricity infrastructure was an important determinant as huge funding to the sector could increase the supply to meet the high demand. Government policies could also saw prices regulated and efficiency in operations of the electricity sector to meet the demand for electricity in a country. Muratori and Rizzoni (2015) presented energy demand as derived demand and links consumption of energy to development of infrastructure and capital investment.

2.2 Empirical literature review of electricity demand

Knaut (2017) surveyed the price elasticity of demand in Germany. It showed that the short-run price volatilities in the day-ahead market could affect consumption. Demand and supply sides were considered simultaneously. Two-Stage least squares procedure is applied so that electricity price is estimated by using a renewable source of energy and then the result sets in the demand equation. The price elasticity at the peak load is about -0.13 (Knaut and Paulus, 2017).

Using a pooled cross-section of 39,000 households from the Family Income and Expenditure Survey in Philippines, Manalo-Macua (2007) estimates an electricity demand function with a three-step methodology. His results lead to a U-shape for both the price and income elasticities per quartile. Price elasticities start with -0.96 for the first quartile, -1.11 for the second, -0.99 for the third and -0.81 for the fourth. The income elasticities are 0.50 for the first quartile, and 0.23, 0.30 and 0.76 for the 2nd, 3rd and 4th quartile, respectively. Finally, to our knowledge, this is the only contribution estimating the welfare losses per quartile. The results show that losses increase in both absolute and relative terms with respect to income levels.

A study by Howarth and Dubey (2017) on the Gulf Cooperation Council countries, which appraised 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.

Salisu and Ayinde (2016) conducted a study and 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 researchers found that income and prices were key determinants of demand for electricity.

Comparable studies conducted in Africa, showed that Income and prices were also significant. According to studies done by Ibrahim and Kirkil (2018) in Nigeria between 2001and 2016, Ohiare (2015) in Nigeria from 1985-2005, Hoffmann and Dall (2018) in Namibia from 1993 to 2006: income and prices are important factors in studies conducted in Asia by Khan and Qayyum (2015) in Pakistan. Alter and Syed (2017) study covering the period 1970-2010 affirmed that electricity was a necessary good in Pakistan with price as the most sensitive factor to demand.

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 per cent 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 (2015) used diesel prices in their joint study across nineteen states of India. Labandeira, Labeaga and Lopez-Otero (2016) study in Spain, Bekhet and Othman (2018) in Malaysia and a study conducted by Narayan *et al.*, (2017) on a group of seven countries used natural gas variable as a substitute to electricity. The Howarth and Dubey (2017) study of Gulf Cooperation Council countries also used LPG prices as a variable to represent substitutes for electricity. Results from these studies showed that other forms of energy could substitute electricity in the short run. 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. This is consistent with the study done by Bekhet and Othman (2018) in Malaysia. Urban population was also used to capture structural variables. In Taiwan, Huang (2015) conducted a study of electricity consumption. The urban elasticities were positive in both the short run and long run. Khanna and

Zheng (2016) study found that population had a direct impact on the quantity of electricity demanded from 2012 to 2015 in China.

Ikejemba and Schuur (2016) did an analysis of South East Nigeria for the period 2005 to 2010 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 Aliyu and Adam (2015) in Nigeria between 2008and 2010.

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 Huang (2015) used the stock of energy-using equipment. A proxy of urbanization rate used to capture the equipment. Results for the urbanization rate elasticity were positive and significant.

The number of imported durable electric appliances was a suitable proxy for electric appliances stock in Hussain *et al.* (2016) study in Pakistan. The results revealed that electrical equipment had positive and long run relationship with electricity consumption. Electrical appliances 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 (2010) using annual panel dataset that 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.

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 Iyke (2015). Omrany and Marsono (2016) 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.

A study by Huang (2015) showed more electricity consumed on days above 80˚ days as people used air conditioners to cool their buildings in Taiwan. Pérez-García and Moral-Carcedo (2016) 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. Khanna and Zheng (2016) used efficiency variables to determine demand. Efficiency variable 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.

2.3 Overview of the reviewed literature

From the discussion of theoretical literature, it is clear that prices of electricity and incomes largely influence demand for electricity. Studies that have been reviewed show that income levels and electricity prices are indispensable when estimating the demand function for electricity. 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. Furthermore, there are even fewer studies on the impacts on the welfare of households with different income levels

The studies have also included other variables that have an impact on the demand of electricity such as population and industrial output, indicating a positive and significant effect on electricity demanded. However, there exists no evidence of studies on causal relationship between electricity demand and electricity pricing variables, the pass through costs. In kenya, the pass through costs make up significant proportion of the unit cost of electricity. This study will focus on Kenya as one of Sub-Sahara Africa countries. This study is expected to close the gap and establish the impact of electricity pass through cost, that form the pricing variables of electricity price in Kenya, on demand and consumption of power in Kenya.

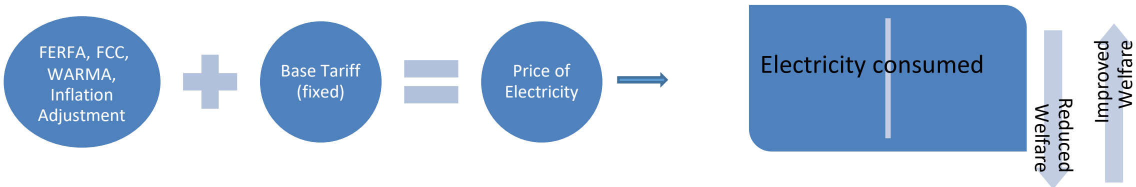
CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction.

This chapter of the study highlights the theoretical and empirical framework that is used to analyze the demand for electricity in Kenya. The theoretical framework describes how the electricity cost-pass through equation derived. By economic theory, the cost function which also defines the price of electricity to the consumer is linked to the units of electricity consumed to estimate the demand function for electricity in Kenya. Conceptually, the cost shifters are expected to influence the price of electricity. The price in turn, is expected to influence the amount of electricity consumed. Welfare in the study is imputed by the per capita amount of electricity consumed.

3.2 Conceptual framework

Figure 3 demonstrates the conceptual framework that links the electricity pass-through cost and the demand for electricity consumed. Inflation adjustment increases the cost of electricity and therefore is associated with a decrease in demand for electricity consumed. The Foreign Exchange Fluctuation Adjustment (FERFA) component on the power bill is a pass-through cost that cushions power sector players from currency volatility of the shilling when incurring costs denominated in foreign currency. Whenever the Kenyan shilling weakens against these currencies, the borrowers usually use more of the local currency to repay these debts and these costs are usually passed on to consumers hence this negatively impact on demand for electricity consumption in Kenya. Water and Resources Management Authority (WARMA) is a levy currently set per kilowatt-hour. WARMA levy is added to consumption charges of electricity and this has a negative effect on demand for electricity since consumers have to bear more cost of electricity. Fuel cost charge (FCC) tends to go up whenever the country turns on thermal electricity generators that use costly heavy fuel oil to produce power. The cost of purchasing the fuel is also passed on to power consumers hence increasing the cost of electricity.



FERFA: Foreign Exchange Fluctuation Adjustment: WARMA- Water and Resources Management Authority: FCC: Fuel cost charge

Figure 3: Conceptual framework of pass-through costs.

Source: Author (2020)

3.3 Theoretical framework

Different approaches can be applied to model the demand for electricity. This study adopts the work of Jouvet and Solier (2013) to model the pass-through costs of electricity to prices of electricity consumed by households. Consider a power producer, i, defined by a given technology in a given country, generating an amount of electricity q, then the electricity produced at time t given by Q_{elect} is defined by:

$$\mathrm{Q}_{elect} = f\left(\mathrm{C}_{t_{iq}}^{\theta} X^{\vartheta}\right) \tag{1}$$

Where C_{iqt} is the cost component faced directly by the producer in generating electricity, θ is a set of cost shifters, X^{ϑ} are other external factors that affect the amount of electricity produced. The factors would either be time variant or time invariant. To price for electricity, a firm would consider both the cost of production and a mark-up. Thus, price P_t in time t may be written as:

$$P_t = f(C_{t\,iq}^{\theta}, M) \tag{2}$$

Where M is mark-up, representing a component of profit levels of producing electricity. The cost component can vary depending on domestic rules and forms of markets of producing electricity in a particular country. In Kenya electricity pricing is usually driven and controlled by the government, thus the cost is usually determined by a set of government-defined parameters. Further, the government does not produce for profits, thus the mark-up component in the price equation (2) would not be observed in Kenyan prices of electricity.

$$P_t = f(C_{t\,iq}^{\theta}) \tag{3}$$

Cost of electricity in Kenya, is culmination of various components. They include: Inflation adjustment component (INFA), Foreign Exchange Fluctuation Adjustment (FERFA), Water and Resources Management Authority (WARMA) fee and Fuel cost charge (FCC). All these components vary with time. However some constant factors are included in the cost component, they include: the Energy Regulatory Commission levy (ERCL), the Rural Electrification Program levy (REPL) and Value Added Tax (VAT). Thus, equation (3) may be re-written as:

$$\mathrm{P}_t = f(\mathrm{INFA}_t\mathrm{FERFA}_t\mathrm{WARMA}_t\mathrm{FCC}_t A) \tag{4}$$

Where the subscript t denotes time periods, and A component is the set of constant cost components. The definitions of INFA_t, FERFA_t, WARMA_t, FCC_t indices are given in table 4. The price of electricity in equation (4) is expected to affect the units of electricity consumed, thus we can have the definition:

$$\mathrm{Q}_t = f(\mathrm{P}_t, \mathrm{K}_t) \tag{5}$$

Where Q_t is the quantity of electricity consumed by respective consumers at time t and K_t are other control factors that would affect consumption of electricity. From the demand function in equation (5), it is expected that an increase in cost of electricity caused by the cost shifters will decrease the amount of electricity demanded through the price equation (3). To understand how consumers' welfare has been affected by change in the price of electricity, equation (5) will be estimated by categorizing consumers in their different segments as shown on table 1. Ideally one would need to estimate the compensation or equivalent variations in conducting welfare analysis, but this is not feasible in this study due to the lack of monthly data for income. Thus, welfare will be imputed by the per capita consumption of electricity by the households.

3.4 Analytical Framework

Equation (4) has previously been estimated by Kimuyu (1988). However, that study does not consider the effect of the price shifters on the demand for electricity in Kenya. During the time of that study, price of electricity was not computed using the INFA, FERFA, WARMA and FCC parameters. This forms the major contribution of this study. By first estimating the pass-through effects of these parameters on price of electricity, we would be able to advice policy-making on which components to adjust in order to reduce price and hence improve household consumption on electricity and by extension, household welfare. Thus, the first component of analysis will be to estimate the price pass-through equation and then later analyze the demand function, where an observation is made on how price of electricity affects the amount of electricity consumed. The price pass-through equation is obtained by transforming equation (4) to the form:

$$P_t = \beta_0 + \beta_1 INFA_t + \beta_2 FERFA_t + \beta_3 WARMA_t + \beta_4 FCC_t + \beta_5 ERCL + \beta_6 REPL + \beta_7 VAT + \mu_t \quad (6)$$

Where $\beta_1, \beta_2, \beta_3, \beta_4 \beta_5, \beta_6, \beta_7$ are the pass-through coefficients and μ_t is the error term. The price estimate from equation (6) is used in equation (5) to estimate the demand function. Thus introducing natural logarithms and using equation (6) on (5) we have:

$$\ln \mathrm{Q}_t = a_0 + a_1 \ln INFA_t + a_2 \ln FERFA_t + a_3 \ln WARMA_t + a_4 \ln FCC_t + a_5 \ln ERCL + a_6 \ln REPL + a_7 \ln VAT + e_t \quad (7)$$

Where α_1 and α_2 are now interpreted as elasticities and e_t is an error term. The dependent variable $\ln \mathrm{Q}_t$ is the natural logarithm of per capita electricity consumption. To conceptually see the effect of changes in price of electricity on household welfare, equation (7) will be estimated for the different electricity market segments. Particularly, Domestic Consumers (DC), Small Commercial (SC), Commercial and Industrial (CI).

To estimate the welfare effects of the cost shifters, equation (7) is re-written as:

$$\ln \mathrm{Pcc}_t = a_0 + a_1 \ln INFA_t + a_{2i} \ln FERFA_t + a_3 \ln WARMA_t + a_4 \ln FCC_t + e_t \quad (8)$$

Where $\ln \mathrm{Pcc}_t$ is the natural logarithm of Per Capita electricity Consumption (PCC). Thus, the effect of cost of electricity follows an estimation of equations (7) and (8). Equation (7) captures the general pass-through effects while equation (8) captures the welfare effect.

3.5 Data type and sources.

The study will employ secondary data on consumption and electricity pass through costs. Data on consumption will be obtained from Kenya Power & Lighting Company (KPLC), while the monthly pass through costs will be obtained from Energy & Petroleum Regulatory Authority (EPRA). The study will analyse monthly data on consumption and pass through costs for the period July 2013 to June 2018.

Table 4 provides definition, measurement and sources of the variables used in the study.

Table 4: Definition and measurement of variables

Variable	Definition and measurement	Source
Q_t	Amount of power consumed in KiloWatt Hours (kWh)	KPLC
INFA	Total inflation adjustment in Kenya cents per unit for the half year period. Monthly units of consumption are subjected to automatic adjustment for inflation	EPRA

FERFA	Foreign exchange rate fluctuations adjustment. Measured as standard deviation of exchange rate Variable measured in KShs/kWh. Units consumed every month are liable to foreign exchange rate fluctuation adjustment.	EPRA
FCC	Cost of fuel passed through to consumers as a result of thermal power dispatch. Variable measured in KShs/kWh.	EPRA
WARMA Levy	Water Resources Management Authority Levy, charged on amount power consumed from hydro power sources. Variable measured in KShs/kWh. Electrical energy consumed every month are liable to Water Resource Management Authority (WRMA) Levy for water used by hydro power plants	EPRA

Source: Author.

3.6 Diagnostics tests

3.6.1 Stationarity and unit root test

Time series analysis calls for test of stationary, as time series data tend to be non-stationary. Non-stationary time series represents statistical challenges as mean, variance and autocorrelation tend to change with time and this undermines tests of statistical significance. For meaningful predictability of future trends, a data series has to have a constant mean and variance over time, essentially it is important for the data to be stationary. To test for stationarity, an Augmented Dickey-Fuller test will be used.

3.6.2 Co-integration Test

Regression of one-time series variable on one or more-time series variables can give spurious results, consequently leading to spurious regression. Co-integration of two (or more) time series variables suggests that there is a long run or equilibrium relationship between them. One way to safeguard is to establish whether co-integration exists. In the event that the series are found to be both integrated in order zero and order one a bound test of cointegration will be used. Otherwise if they are all integrated of order one, a Johansen test of cointegration will be conducted.

3.6.3 Autocorrelation Test

Time series data usually presents a scenario where the error terms for different observations are correlated. In context, the magnitude of the error at one observation has no effect on the magnitude of another observation. If a violation of this assumption occurs, then, the estimated regression model is compromised. A Langragian multiplier test will be used to test for autocorrelation.

CHAPTER FOUR: DATA ANALYSIS

4.1 Introduction

This chapter of the paper presents the empirical results of the analysis that was carried out. The second section (4.2) of the chapter discusses the results of descriptive statistics. The descriptive statistics are generally highlight the nature of the nature used for analysis. Sections three (4.3) onwards discusses the inferential statistics, where an exploration is done in depth to verify the statistical relationship of the variables under study. The inferential statistics begins to verify whether the series used are stationary or non-stationary, particularly checking the nature of the mean and variance of the data series over time. Having data with a constant mean and variance over time is preferred for most analysis, since future projections could easily be inferred by observing past behaviors of the data.

4.2 Descriptive Statistics

The study was conducted from January 2013 to June 2018, forming a time series analysis of 66 observations as shown in table 5. The standard deviation is used to show how far the data values are from the mean.

Table 5 Summary Statistics

Variables	No. of Observation	Mean	Standard Deviation	Minimum	Maximum
DC	66	2.00E+08	2.66E+07	1.58E+08	2.66E+08
SC	66	1.10E+08	1.52E+07	9.17E+07	1.87E+08
CI	66	3.33E+08	3.26E+07	2.61E+08	4.54E+08
FCC	66	3.859545	1.474179	2.31	7.22
FERFA	66	0.906818	0.51339	0	2.35
INFA	66	0.273485	0.104034	0	0.42
WARMA	66	0.03072	0.020493	0	0.06
PRICE	66	5.30572	1.4979	3.18	8.4
PCC	66	171.2389	7.233058	156.1114	179.5786

For the period under study, Commercial and Industries (CI) were the highest consumer of electricity at an average of 3billion KWh per month, followed by Domestic Consumers (DC) at an average of 2billion KWh per month, and finally Small Commercial (SC) at an average of 1billion

KWh per month. In terms of the price shifters, the highest component of the price of electricity was the Fuel cost charge (FCC), followed by Foreign Exchange Fluctuation Adjustment (FERFA), then the Inflation adjustment component (INFA) and finally Water and Resources Management Authority (WARMA) component. The values, FCC and FERFA shows that on average, the price of electricity is usually pushed upwards by external factors. The standard deviation for the price (PRICE) of electricity was low, a reflection that the values of the shifters together with price were averagely close to the mean. The same was also observed on Per Capita Consumption (PCC).

4.3 Pre-estimation test

4.3.1 Lag selection criteria, test for stationarity

To be able to conduct the stationarity tests, lag selection analysis was conducted. The criteria used for selecting the lags was the Schwartz information criterion (SIC). The criteria tends to select more parsimonious models. From this test, it was observed that the appropriate lags for the variables are shown in table 6

Table 6 Lags from Schwartz information criterion

Variable	lag	Variable	lag	Variable	lag
DC	2	FERFA	2	PCC	1
SC	0	INFA	1		
CI	0	WARMA	1		
FCC	2	PRICE	1		

The lags in table 6 were used for all the subsequent analyses. The first set of analysis was checking whether the variables had a unit root. An Augmented Dickey Fuller test was specified with the results are presented in table 7.

Table 7 Stationarity Test

Variables	Test Statistic	1% critical value	5% critical value	10% critical value	Conclusion
DC	-1.792	-3.562	-2.92	-2.595	Non-Stationary
D.DC	-6.579	-3.563	-2.92	-2.595	Stationary
SC	-6.451	-3.559	-2.918	-2.594	Stationary
CI	-7.903	-3.559	-2.918	-2.594	Stationary
FCC	-2.277	-3.562	-2.92	-2.595	Non-Stationary
D.FCC	-4.113	-3.563	-2.92	-2.595	Stationary
FERFA	-2.278	-3.562	-2.92	-2.595	Non-Stationary
D.FERFA	-5.967	-3.563	-2.92	-2.595	Stationary
INFA	-5.492	-3.562	-2.92	-2.595	Stationary

WARMA	-2.06	-3.56	-2.919	-2.594	Non-Stationary
D.WARMA	-6.347	-3.562	-2.92	-2.595	Stationary
PRICE	-5.086	-3.562	-2.92	-2.595	Stationary
PCC	-2.718	-3.56	-2.919	-2.594	Non-Stationary
D.PCC	-4.795	-3.562	-2.92	-2.595	Stationary
Notes: **D.** for each of the variable, implies the first difference					

Among the variables, DC, FCC, WARMA and PCC were non-stationary at level since their test statistics was less than the critical values at all levels of significance. Their first difference was however stationary since all the absolute calculated ADF test statistics was greater than the critical values at the significance levels. The variables being non-stationary on levels but stationary at first difference implied they were all intergrated of order one I(1). Subsequently, it is feasible to test if they are cointegrated. The purpose of testing if they are cointegrated, is to verify the presence of a linear combination among these variables. The other variables under study were all stationary at levels implying they are I(0). Since some of the variables are I(0) while others are I(1), a bound test for cointegration is conducted.

4.3.2 Bound test for cointegration

The results for the bound test for each equation are highlighted on appendix 2. Tables 2A, 2B and 2C shows that the F statistics is larger than the upper bounds at each level of significance. This implies that all these variables are cointegrated. Specifically, DC, SC and CI are cointegrated. For the last variable, per capita consumption, the F statistic is lower than the upper bound at 5% level of significance and below. Thus, a long run (VECM) framework is used to estimate the models of DC, SC and CI while a short run (VAR) framework is used to estimate the model of PCC.

4.4 Pass-through effects of cost shifters on demand for electricity.

4.4.1: Pass-through effects on domestic consumers.

A VECM model was estimated to establish the pass-through effects of the cost shifters on the amount of electricity consumed by domestic consumers. The following model was estimated:

$$\Delta\ln DC_t = \delta + \sum_{i=1}^{k-1} \alpha_{1i}\Delta\ln DC_{t-i} + \sum_{i=1}^{k-1} \alpha_{2i}\Delta\ln FCC_{t-i} + \sum_{i=1}^{k-1} \alpha_{3i}\Delta\ln FERFA_{t-i} + \sum_{i=1}^{k-1} \alpha_{4i}\Delta\ln INFA_{t-i} \sum_{i=1}^{k-1} \alpha_{5i}\Delta\ln WARMA_{t-i} + \boldsymbol{\lambda ECT_{t-1}} + \mu_t \quad (9)$$

The coefficients α^s are the short run coefficients while $\boldsymbol{ECT_{t-1}}$ is the long run term generated by the following equation:

$$ECT_{t-1} = [lnDC_{t-1} - \alpha lnFCC_{t-1} - \beta lnFERFA_{t-1} - \gamma lnINFA_{t-1} - \delta lnWARMA_{t-1}] \quad (10)$$

The short run results are highlighted in table 8 while the long run results are highlighted in table 9. The speed of adjustment $\boldsymbol{\lambda}$ given by the coefficient *L._ce1* on table 8 shows that in the short run, the amount of electricity consumed by domestic consumers does not adjust back to its equilibrium level aftershocks have been experienced on the electricity cost shifters. This is so, because this coefficient -0.0438 is not statistically significant. This implies that, after shocks are experienced, the amount of electricity consumed by the domestic consumers is distorted and does not return to an equilibrium level in the long run.

Table 8 Short-run effects of cost shifters on domestic consumer

VARIABLES	D_ Ln DC	D_ Ln FCC	D_ Ln FERFA	D_ Ln INFA	D_ Ln WARMA
L._ce1	-0.0438	0.118**	0.204	-0.372***	-0.187*
	(0.0596)	(0.0568)	(0.250)	(0.0526)	(0.0954)
LD. Ln DC	-0.652***	-0.347**	0.815	0.291**	0.454**
	(0.142)	(0.135)	(0.594)	(0.125)	(0.227)
LD. Ln FCC	0.0399	0.400***	-0.331	0.192	0.190
	(0.140)	(0.133)	(0.586)	(0.123)	(0.224)
LD. Ln FERFA	-0.0141	0.0326	-0.334**	0.00149	0.0343
	(0.0341)	(0.0325)	(0.143)	(0.0301)	(0.0546)
LD. Ln INFA	0.0276	-0.0123	0.0841	-0.161	-0.332*
	(0.121)	(0.115)	(0.506)	(0.107)	(0.193)
LD. Ln WARMA	-0.106	-0.146	0.161	0.112	0.149
	(0.0950)	(0.0905)	(0.398)	(0.0838)	(0.152)
Constant	0.00312	-0.00450	0.0453	0.0272**	-0.00819
	(0.0140)	(0.0133)	(0.0585)	(0.0123)	(0.0224)
Observations	48	48	48	48	48
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1					

Among the short run models on table 8, the main interest is on the model on the first column. This model shows the short run effects of electricity costs on domestic consumers. No cost shifters are statistically significant. This is an indication that, in the short run, when these cost shifters change, they do not cause a major significant effect on consumption of electricity by domestic consumers. However, in the long run, all the cost shifters have significant effects on electricity consumed by domestic consumers. This is observed on table 9, where all the coefficients are statistically significant at 10% (and lower) level of significance, this is because their p-values were all less than 0.1.

Table 9 Long-run effects of cost shifters on domestic consumer

	Bet Coefficient.	Standard Error	Z	P>Z	[95% Confidence Interval]
Ln FCC	-0.179	0.093	-1.920	0.055	-0.361863 0.0039603
Ln FERFA	-0.165	0.059	-2.790	0.005	-0.2799833 -0.0490268
Ln INFA	1.046	0.173	6.050	0.000	0.7070489 1.385343
Ln WARMA	0.408	0.093	4.390	0.000	0.2258913 0.5909894
Constant	-16.274				

The Johansen normalization restriction imposed coefficients on table 9 are normally interpreted with their signs reversed. Thus, the coefficient of FCC and FERFA are positive, while the coefficients for INFA and WARMA are negative. It is observed that in the long run, an increase in INFA and WARMA, results to decline in the amount of electricity consumed by domestic consumers. The largest negative effect is observed on INFA at a rate of 1.05%, implying that an increase in INFA by 1% causes a 1.05% decline of electricity consumed by domestic consumers. The magnitude of a decline is followed by WARMA, which shows that a 1% increase of WARMA, causes a 0.41% decline in the amount of electricity consumed by domestic consumers. An increase in FCC and FERFA are observed to have an upward pressure on amount of electricity consumed by domestic consumers. For both, the rate is around 0.17%.

4.4.2 Pass-through effects on small commercials

Significant cointegration effect was also established on the variable SC, thus a VECM was also estimated to establish the pass-through effects of the cost shifters on the amount of electricity consumed by small commercials. The following model was estimated:

$$\Delta \ln SC_t = \partial + \sum_{i=1}^{k-1} \beta_{1i} \Delta \ln DC_{t-i} + \sum_{i=1}^{k-1} \beta_{2i} \Delta \ln FCC_{t-i} + \sum_{i=1}^{k-1} \beta_{3i} \Delta \ln FERFA_{t-i} + \sum_{i=1}^{k-1} \beta_{4i} \Delta \ln INFA_{t-i} \sum_{i=1}^{k-1} \beta_{5i} \Delta \ln WARMA_{t-i} + \boldsymbol{\lambda ECT_{t-1}} + \mu_t \quad (11)$$

The terms β^s are the short run coefficients while $\boldsymbol{ECT_{t-1}}$ is the long run term generated by the following equation:

$$ECT_{t-1} = [lnSC_{t-1} - \alpha lnFCC_{t-1} - \beta lnFERFA_{t-1} - \gamma lnINFA_{t-1} - \delta lnWARMA_{t-1}] \quad (12)$$

The short run results are shown on table 10 while the long run results are highlighted on table 11. The speed of adjustment $\boldsymbol{\lambda}$ given by the coefficient *L._ce1* on table 10 (-0.192) is negative and statistically significant at 5% level of significance. This shows that previous period's errors (or deviations from long run equilibrium) are corrected for within the current period at a convergence speed of 19.2%. This implies that, after shocks are experienced in the cost shifters, there would be adjustments in amount of electricity consumed by small commercials such that in the long run, the amount consumed will adjust back to its level of equilibrium at a speed of 19.2%.

Table 10 Short-run effects of cost shifters on small commercial

VARIABLES	D_ Ln SC	D_ Ln FCC	D_ Ln FERFA	D_ Ln INFA	D_ Ln WARMA
L._ce1	-0.192**	-0.0788	-0.0332	0.437***	0.0901
	(0.0854)	(0.0692)	(0.290)	(0.0554)	(0.113)
LD. Ln SC	-0.682***	0.0207	0.0283	-0.241***	-0.157
	(0.127)	(0.103)	(0.432)	(0.0825)	(0.169)

LD. Ln FCC	0.0618	0.363**	-0.0938	0.258**	0.190
	(0.180)	(0.145)	(0.610)	(0.117)	(0.238)
LD. Ln FERFA	0.115***	0.0393	-0.384***	-0.00544	0.0253
	(0.0432)	(0.0350)	(0.147)	(0.0281)	(0.0574)
LD. Ln INFA	-0.0261	-0.0833	0.189	-0.0506	-0.251
	(0.152)	(0.123)	(0.518)	(0.0989)	(0.202)
LD. Ln WARMA	0.237*	-0.0875	-0.0115	0.170**	0.114
	(0.124)	(0.101)	(0.423)	(0.0808)	(0.165)
Constant	0.0226	-0.00148	0.0379	0.0141	-0.00776
	(0.0185)	(0.0150)	(0.0628)	(0.0120)	(0.0245)
Observations	48	48	48	48	48
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1					

The interest model for this study is that in column 1 of table 10, this shows the short run effects of the cost shifters on amount of electricity consumed by small commercials. Among the cost shifters, FERFA and WARMA are the ones that are statistically significant. Their magnitudes are positive. This shows that in the short run, an increase in these cost shifters causes an upward pressure on the amount of electricity consumed by small commercials. In the long run, the effect of an increase in the cost shifters causes different effects on amount of electricity consumed by small commercials as shown in table 11.

Table 11 Long-run effects of cost shifters on small commercial

	Bet Coefficient.	Standard Error	Z	P>Z	[95% Confidence Interval]
Ln FCC	-0.077	0.079	-0.970	0.331	-0.2317925 0.0781132
Ln FERFA	0.098	0.049	2.000	0.045	0.0020164 0.1938622
Ln INFA	-1.299	0.147	-8.810	0.000	-1.588242 -1.010319
Ln WARMA	-0.394	0.079	-4.970	0.000	-0.5488283 -0.2384429
Constant	-21.389				

Since the coefficients are interpreted by reversing the signs, it is observed that a 1% increase in FERFA causes a 0.098% decline of electricity consumed by the small commercials in the long run. An increase in INFA and WARMA are observed to exert an upward pressure on the amount of electricity consumed by small commercials in the long run. Fuel cost (FCC) is observed not to be statistically significant in affecting the amount of electricity consumed by small commercials.

4.4.3 Pass-through effects on commercial and industries

Due to cointegration, a VECM was also estimated to establish the pass-through effects of the cost shifters on the amount of electricity consumed by commercials and industries. The following model was estimated:

$$\Delta \ln CI_t = \vartheta + \sum_{i=1}^{k-1} \gamma_{1i} \Delta \ln CI_{t-i} + \sum_{i=1}^{k-1} \gamma_{2i} \Delta \ln FCC_{t-i} + \sum_{i=1}^{k-1} \gamma_{3i} \Delta \ln FERFA_{t-i} + \sum_{i=1}^{k-1} \gamma_{4i} \Delta \ln INFA_{t-i} \sum_{i=1}^{k-1} \gamma_{5i} \Delta \ln WARMA_{t-i} + \boldsymbol{\lambda ECT_{t-1}} + \mu_t \qquad (13)$$

The terms γ^s are the short run coefficients while $\boldsymbol{ECT_{t-1}}$is the long run term generated by the following equation:

$$ECT_{t-1} = [lnSC_{t-1} - \alpha lnFCC_{t-1} - \beta lnFERFA_{t-1} - \gamma lnINFA_{t-1} - \delta lnWARMA_{t-1}] \qquad (14)$$

The short run results are shown on table 12 while the long run results are highlighted on table 13. The speed of adjustment $\boldsymbol{\lambda}$ given by the coefficient *L._ce1* on table 12 (-1.527) is negative and statistically significant at 5% level of significance. Although the expected magnitude should be less than 1, it generally shows that aftershocks are experienced in the cost shifters, the amount of electricity consumed by commercials and industries, adjust to their levels of equilibrium at very high speed levels.

Table 12 Short-run effects of cost shifters on commercial and industries

VARIABLES	D_ Ln CI	D_ Ln FCC	D_ Ln FERFA	D_ Ln INFA	D_ Ln WARMA
L._ce1	-1.527***	0.0621	2.151**	0.963***	-0.0817
	(0.203)	(0.236)	(0.956)	(0.267)	(0.396)
LD. Ln CI	0.214	-0.211	-1.176*	-0.440**	0.213
	(0.137)	(0.160)	(0.648)	(0.181)	(0.269)
LD. Ln FCC	0.0271	0.414***	0.0771	0.0977	0.153
	(0.118)	(0.138)	(0.556)	(0.156)	(0.231)
LD. Ln FERFA	0.0458	0.0261	-0.415***	0.0199	0.0438
	(0.0292)	(0.0341)	(0.138)	(0.0386)	(0.0572)
LD. Ln INFA	-0.0719	-0.140	0.273	-0.0161	-0.186

	(0.109)	(0.127)	(0.512)	(0.143)	(0.212)
LD. Ln WARMA	-0.0353	-0.0869	-0.0170	0.0414	0.0661
	(0.0789)	(0.0920)	(0.372)	(0.104)	(0.154)
Constant	0.0198	-0.00469	0.00513	0.0197	-0.00647
	(0.0125)	(0.0146)	(0.0589)	(0.0165)	(0.0244)
Observations	48	48	48	48	48
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1					

No short run coefficients are statistically significant for commercial and industries model. This shows that in the short run, a change in the particular cost shifter does not significantly have an effect on the amount of electricity consumed by commercial and industries. In the long run, INFA and WARMA are the ones which have a statistically significant effect on the amount of electricity consumed by commercial and industries. This is observed in table 13, where those two coefficients have a p value of less than 0.05.

Table 13 Long-run effects of cost shifters on commercial and industries

	Bet Coefficient.	Standard Error	Z	P>Z	[95% Confidence Interval]
Ln FCC	0.020	0.022	0.880	0.381	-0.024193 0.063231
Ln FERFA	-0.010	0.014	-0.690	0.491	-0.0369441 0.0177435
Ln INFA	-0.140	0.042	-3.370	0.001	-0.2219561 -0.058586
Ln WARMA	-0.046	0.022	-2.070	0.038	-0.0902166 -0.0025281
Constant	-19.997				

An increase in INFA and WARMA is observed to exert an upward pressure on the amount of electricity consumed by commercials and industries. The coefficients FCC and FERFA are not statistically significant.

4.4.4 Pass through effect on Per capita Consumption

Cointegration analysis showed that PCC and the cost shifters were not cointegrated. Thus, to estimate their relationship, a VAR model (short run) was estimated. The results are highlighted on table 14.

Table 14 pass-through effects of cost shifters on per capita consumption of electricity

	Ln PCC	Ln FCC	Ln FERFA	Ln INFA	Ln WARMA
L. Ln PCC	0.489***	2.481	39.14***	4.598**	8.811*

	(0.142)	(2.672)	(10.18)	(2.180)	(4.522)
L2. Ln PCC	0.0895	0.370	-4.333	3.188	-8.716*
	(0.143)	(2.692)	(10.26)	(2.196)	(4.557)
L. Ln FCC	0.0154**	1.108***	-0.387	0.0905	0.211
	(0.00740)	(0.140)	(0.532)	(0.114)	(0.236)
L2. Ln FCC	-0.0152**	-0.232*	-0.0259	-0.141	-0.120
	(0.00691)	(0.130)	(0.497)	(0.106)	(0.221)
L. Ln FERFA	0.00650***	0.0171	0.195	-0.0279	0.0427
	(0.00207)	(0.0390)	(0.149)	(0.0318)	(0.0660)
L2. Ln FERFA	-0.000702	-0.0501	-0.0879	-0.0491	-0.0485
	(0.00206)	(0.0388)	(0.148)	(0.0316)	(0.0657)
L. Ln INFA	0.00329	-0.00407	-0.0368	0.275***	-0.387*
	(0.00682)	(0.129)	(0.490)	(0.105)	(0.218)
L2. Ln INFA	0.00584	-0.0894	-0.651	-0.0283	0.310
	(0.00610)	(0.115)	(0.439)	(0.0939)	(0.195)
L. Ln WARMA	-0.00120	-0.0727	0.144	-0.0631	1.053***
	(0.00439)	(0.0827)	(0.315)	(0.0675)	(0.140)
L2. Ln WARMA	2.75e-05	0.0145	-0.122	-0.0982	-0.117
	(0.00444)	(0.0838)	(0.319)	(0.0684)	(0.142)
Constant	2.187***	-14.92	-180.4***	-41.66***	-0.929
	(0.737)	(13.90)	(52.95)	(11.34)	(23.52)
Observations	48	48	48	48	48
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1					

The model of interest was the one on column 1 of table, in this model; PCC is specified as the dependent variable. The results show that FCC is the cost shifter that averagely causes a negative effect on per capita consumption of electricity in the country. Specifically, an increase in FCC is associated with a decline in per capita units of electricity consumed in the country. The other cost shifters are observed to have no significant effect on per capita consumption except FERFA. The magnitude of FERFA is positive; this implies that an increase in FERFA causes an upward pressure on per capita consumption of electricity. Specifically, in the short run.

4.4.5 Pass through effects of the costs shifters on cost of electricity

Equation (6) was estimated to find out the effects of each of the cost shifters on cost of electricity. The variables, $ERCL$, $REPL$ and VAT were constants over the period of analysis, thus they were dropped from the pass-through analysis due to collinearity problem. Hence, introducing natural logarithm to equation (6), the following model was estimated:

$$\ln Cost_t = \beta_0 + \beta_1 \ln INFA_t + \beta_2 \ln FERFA_t + \beta_3 \ln WARMA_t + \beta_4 \ln FCC_t + \mu_t \quad (15)$$

Where, $\boldsymbol{P_t}$ is the summation of all the cost shifters, including those that are constant over time. A bound test of cointegration showed that there is no cointegration among these variables. Hence, a short run framework was estimated. The results are shown on table 15 below:

Table 15 Pass through effects of the costs shifters on cost of electricity

	Ln Cost	Ln FCC	Ln FERFA	Ln INFA	Ln WARMA
L. Ln Cost	-0.276	0.262	-4.212***	-0.441	0.452
	(0.365)	(0.342)	(1.413)	(0.304)	(0.604)
L2. Ln Cost	-0.307	-0.547	1.361	-0.339	-0.742
	(0.403)	(0.378)	(1.563)	(0.337)	(0.668)
L. Ln FCC	1.072***	0.971***	3.228***	0.535**	-0.0819
	(0.302)	(0.283)	(1.169)	(0.252)	(0.499)
L2. Ln FCC	0.0356	0.147	-1.231	0.0714	0.389
	(0.330)	(0.309)	(1.278)	(0.275)	(0.546)
L. Ln FERFA	0.124*	-0.0218	1.236***	0.104*	-0.0699
	(0.0742)	(0.0695)	(0.288)	(0.0619)	(0.123)
L2. Ln FERFA	0.110	0.0815	-0.0483	0.0782	0.113
	(0.0847)	(0.0793)	(0.328)	(0.0706)	(0.140)
L. Ln INFA	0.0374	-0.0237	0.425	0.341***	-0.509**
	(0.136)	(0.127)	(0.525)	(0.113)	(0.224)
L2. Ln INFA	-0.122	-0.0249	-0.337	0.0837	0.326*
	(0.114)	(0.107)	(0.443)	(0.0954)	(0.189)
L. Ln WARMA	-0.102	-0.0666	-0.0261	-0.0506	0.984***
	(0.0843)	(0.0790)	(0.327)	(0.0704)	(0.140)
L2. Ln WARMA	0.0322	-0.00303	-0.0347	-0.125*	-0.0803
	(0.0874)	(0.0818)	(0.338)	(0.0729)	(0.145)
Constant	0.872**	0.00976	2.065	-0.748**	-0.464
	(0.354)	(0.332)	(1.373)	(0.296)	(0.587)
Observations	48	48	48	48	48
Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1					

The results of interest are those on column 1 of table 15. The findings show that there is a close to a one to one relationship between cost of electricity and FCC. Specifically, an increase in FCC by

1% leads to a 1% increase in the cost of electricity. The variable FERFA is also statistically significant, showing that a 1% increase in FERFA, causes the cost of electricity to increase by 0.124%. The two variables, FCC and FERFA are observed to be the most significant cost shifters of the cost of electricity in Kenya.

4.5 Post estimation tests

4.5.1 Autocorrelation

The VECM models were estimated with two lags. Thus, a Breusch-Godfrey LM test for autocorrelation with two lags was estimated. The results are highlighted on appendix 3. For each of the models, all the p values of the second lag were greater than 0.05 significance level, an implication that the null hypothesis of no serial correlation could not be rejected at the second lag. Hence, there was no autocorrelation amongst the variables under estimation of all the equations.

4.5.2 Normality Test

The variables under study were tested whether they follow a normal distribution. A Jarque-Bera test was estimated, the results for the test of each model are presented on appendix 4. The null hypothesis is that the variable follows a normal distribution. Table 4A show that for the model of direct consumers, the variables followed a normal distribution. This was because the p-value (0.61209) was greater than 5% level of significance. For small commercials, the p-value (0.08114) was also greater than 5% level of significance. Finally, for commercials and industries, together with per capita consumption, the p-value was less than 5% implying the null hypothesis was rejected.

4.6 Summary of the findings

The study involved 66 observations, from January 2013 to June 2018. The dependent variables under study were Domestic consumers (DC), Small consumers (SC), Commercials with Industries (CI), and Per capita consumption (PCC). Amounts of electricity consumed under these market segments were measured against the various cost shifters. The main shifters were Fuel cost charge

(FCC), Foreign Exchange Fluctuation Adjustment (FERFA), Inflation adjustment component (INFA) and Water and Resources Management Authority (WARMA). Among these variables, DC, FCC, FERFA and PCC were I(0) while the others were I(1). Having both an I(0) and I(1) series, a bound test for cointegration was used to check if the variables had long run relationship. A long run association was observed between DC, SC, and CI together with the respective cost shifters. Thus, a VECM model was used to estimate their relationship. For, PCC, no cointegration was observed, hence a VAR model was used to estimate the relationship between PCC and the cost shifters.

It is observed that the amount of electricity consumed by domestic consumers does not adjust to its long run equilibrium after the cost shifters have incurred a shock. No cost shifter causes a significant effect on amount of electricity consumed by domestic consumers in the short run. However, in the long run, all the cost shifters significantly affect the amount of electricity consumed by the domestic consumers. Specifically, an increase in INFA and WARMA causes a decline of amount of electricity consumed by domestic consumers in the long run. However, FCC and FERFA have an upward pressure on amount of electricity consumed by this segment of the market.

For small commercials, aftershocks are experienced in the cost shifters, there are adjustments in amount of electricity consumed by small commercials such that in the long run the amount of consumption goes back to its level of equilibrium. In the short run, FERFA and WARMA are observed to exert an upward pressure on the amount of electricity consumed by small commercials. However, in the long run, an increase in the amount FERFA, reduces the amount of electricity consumed by small commercials. FERFA and WARMA are seen to exert an upward pressure on amount of electricity consumed in the long run.

The amount of electricity consumed by commercials and industries adjusts to long run equilibrium at a faster rate when shocks are experienced on the cost shifters. In the short run, no cost shifter affects the amount of electricity consumed by commercials and industries. However, in the long run, both INFA and WARMA exert an upward pressure on amount of electricity consumed by commercials and industries. Finally, FCC is the cost shifter that averagely causes a negative effect on per capita consumption of electricity in the country. An increase in FCC is associated with a decline in per capita units of electricity consumed in the country. In terms of the general increase in the cost of electricity in the country, FCC and FERFA are the two variables observed to cause a statistically significant effect on the cost of electricity in the country.

CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Conclusion

The objective of this study was to examine the impact of price of electricity on consumption of power by consumers in Kenya. The study was motivated by the fact that in late 2000s, the government adopted new ways of pricing electricity. Specifically, incorporating the components of FCC, FERFA, WARMA, and INFA on computing the price of electricity. Having these shifters, the study first began by analyzing the pass-through effects of these components in order to identify the most significant shifter on the price of electricity. All of these shifters are observed to be statistically significant, however in terms of magnitude, the larger one is WARMA, followed by FCC, then FERFA and finally INFA. Breaking these components in these form is of importance since it can be easy to advice on specific policy when in need of adjusting the price of electricity.

Consumption of electricity was analyzed in different categories. The first category generalized the whole economy by looking at the average per capita consumption. The second category was the domestic consumers, followed by small commercials and finally commercial and industries. On average, commercial and industries are observed to be the largest consumers of electricity in the country followed by domestic consumers and finally small commercials.

On demand analysis, an increase in the price of electricity is observed to decrease per capita consumption of electricity in the country. Specifically, a 1% increase in the price is observed to reduce per capita consumption by around 0.43% in the short run. The decrease is however observed to be more pronounced on the commercial and industries component. In relative terms, a 1% increase in the price, is observed to reduce demand for electricity in the commercial and industries by around 1.4Million KWh in the short run and around 800,000KWh in the long run.

In terms of welfare, a rise in price of electricity can generally be observed to decrease the welfare of power consumers in the country through a reduction in per capita consumption. The reduction may emanate from domestic consumers who might end up reducing their power usage, for example, by allowing power to be used only for essential services like lighting and discourage other uses like cooking or heating during cold season. On the industry section, an increase in the price may push industries to either cut down on their amounts of production or in the long run shut down altogether. The end effects translate to shortages of commodities or soaring unemployment rates and thus a reduction of welfare for the whole economy.

Finally, as a sensitivity analysis to find out the significant contributor to the rise in the cost of electricity in the country, FCC and FERFA are found to the most significant contributors amongst all the cost shifters. Specifically, a one to one increase in the cost of electricity is observed on FCC.

5.2 Policy recommendations

It is observed that a rise in the price of the electricity generally reduces per capita consumption of electricity and thus hindering the welfare of the whole economy in the country. Thus, the first policy recommendation is for the government to review the price of electricity in the country. Particularly reduce the levies and charges imposed on electricity so as to encourage uptake of electricity by both domestic and commercial consumers of electricity. Since the large contributor to the increase in price has been observed to be WARMA levy, the government could target this component and revise it downwards.

FCC significantly contributes to rise in price as well. The government could fast track adoption of 100% renewable energy power generation, consequently decommissioning the Heavy Fuel Oil based power generators. This will see the FCC abolished from the pricing mechanism. In addition, the FERFA should also be abolished from the pricing mechanism with the adoption of Local Currency based PPAs.

Commercial and Industries consumers have been observed to be more affected by the increase in the price of electricity. For this, two policy recommendations can be made; the first one is that the government can offer these industries some precautionary measures to encourage production. These could be in the form of reduction of excise taxes on products consumed. Though revenue might fall in the short run, an increase in production would be realized in the long run and compensate for the revenue loss. Second recommendation is for industries themselves, the stakeholders could caution themselves from the rise in price of electricity by investing in other sources of power like solar panels, biomass or heavy generators.

This study has mainly looked at the impact of pass through costs on consumption of electricity in the country as a whole. Nonetheless, there can be an interest in a breakdown of the impact of the pass through costs on particular sectors like agriculture and service sectors of the economy. The study recommends further future research on these sub-sectors of the economy. Finally, FCC and FERFA have been seen to be the most significant contributors to the rise in the cost of electricity in the country. Thus, in trying to reduce the cost of electricity, policy makers need to specifically target FCC and FERFA.

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