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Electricity Accessibility And Electricity Consumption In Kenya.

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Abstract.
The discourse relating to energy and economic growth have received much consideration from scholars all across the globe. However, much of the of focus as reviewed revolves around the role of energy on the economic growth. Electricity which is one of the key sources of clean energy has been a focal point of study in developing and less developed countries which continues to grapple with high levels of energy poverty and fossils fuels that are environmentally hazardous. Interventions geared towards increasing electricity accessibility has been implemented in addressing the issue. Kenya being a developing economy, have performed well under this metric with electricity access rates of 76.4% which is above the region's average rate of 52.77%. However, the paradox remains that despite increased electricity access rates, consumption rates have not grown in tandem with access rates. The study sought to establish the relationship between electricity accessibility and electricity consumption. Secondly, the study focused on determining the effect of tariffs on electricity consumption.
The study was anchored on the theory of demand and adopted an Auto Regressive Distributed Lag Model while utilizing secondary time series data set from 1990 to 2022. Both pre-estimation and post-estimation tests were utilized to ensure validity and robustness of the regression results. The study findings were that electricity accessibility was found to be insignificant. This to mean that there existed no relationships between electricity accessibility and electricity consumption in Kenya. Secondly, the study established that there existed a negative relationship between tariffs and electricity consumption, where a unit positive change in tariff causes a decline in electricity consumption by 0.84276. The finding was in concurrence with the demand theory. The study recommended that the government through the Ministry Energy and Petroleum should align their concerted efforts to go hand in hand in addressing the challenges in electricity consumption. Additionally, more focus should be given on harmonization and rationalization of the existing tariff system which comprises various numerous levies to lower the cost of electricity. The study identified energy efficiency as a frontier of future studies in determining whether the low consumption observed is as a result of increased energy efficiency by consumers.

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I. Introduction

Background of the study.

Energy sufficiency and reliability is a critical driver of the economy both as a determinant of economic growth and as an indicator of quality of life. Economies across the globe has continued to channel substantial amount of resources in developing the energy infrastructure. The development of the energy infrastructure is meant to assist in addressing the developmental needs of any country, especially the developing and the less developed economies. Energy poverty, which refers to inadequacy and inaccessibility of reliable modern energy sources, has continued to undermine the progress envisioned in various developmental blueprints that has so far been formulated and adopted. In addition, energy poverty has hindered the realization of the previously MDGs and risks of some current SDGs. The report on SDGs, (GSDR) 2023 notes that some of the goals are stagnant and facing multiples crisis despite the planned timeframe of year 2030. More specifically, sustainable development goal number seven and thirteen. SDG seven aims at ensuring accessibility to clean energy which is reliable and affordable, while SDG thirteen which is inter - related, aims at combating climate change and its impact as highlighted by FUND (2015). One of the key threats to climate change mitigation is use of unfriendly sources of energy which have high concentration of carbon gases. The use of fossils fuels is highly linked with poverty levels especially in less developed and developing countries.

The prominence of energy in the development agenda can be delineated to the era of industrial revolution in Europe. Availability of energy sources in terms of vast coal deposits was a growth enhancing factor for the much-needed energy to power the industrial plants. This has continued to date where energy is a vital component for growth especially in the mass production which has massive potential for employment creation. Consequently, availability and accessibility of reliable modern energy has pivotal role to play in poverty alleviation, wealth creation and welfare improvements.

The concern on the nature of the energy sources arises due to the environmental effects and climate change patterns. Consequently, adoption of clean energy has taken center stage as negative effects of climate change continues to erode the progress made in realization of the SDGs due to persistent draughts, floods and increased global warming.

The clamor for development is now anchored on sustainable development which is alive to the significance of the environment. Therefore, reduction of fossil fuels with high levels of carbon emissions is a major policy intervention in poverty-stricken countries. This is so particular because of the high poverty levels which makes accessibility and affordability of clean energy become a challenge. Consequently, governments, development partners and other stakeholders have intensified efforts aimed at addressing the existing and glaring gaps in accessing clean energy.

Electricity consumption.

Electricity consumption refers to the amount of electricity being used by customers over a period of time, mainly per year. The major consumers of electricity are industries, public utilities such as street lighting, agricultural sector, households, manufacturing and commercial sectors. Electricity consumption is a major catalyst for growth and welfare upgrade. A look at the electricity consumption pattern in Kenya shows a rather sluggish growth rate

Data from the world development indicators report (2022) shows that electricity consumption grew from 130.8689 Kilowatt per capita in 1993 to 207.0782 kilowatt per capita in 2021. This represents a 58.2331 % increase in electricity consumption.

It's good to note that the challenge of slower growth rate in consumption rates is not a supply side issue since electricity generation have more than doubled. The problem of low electricity consumption rates poses the question whether it is a case of demand led problem or is it as a result of improved efficiency use of the resource?

Figure 1.2 below shows the electricity consumption trend from 1993 to 2021 as obtained from the WDI report (2022).

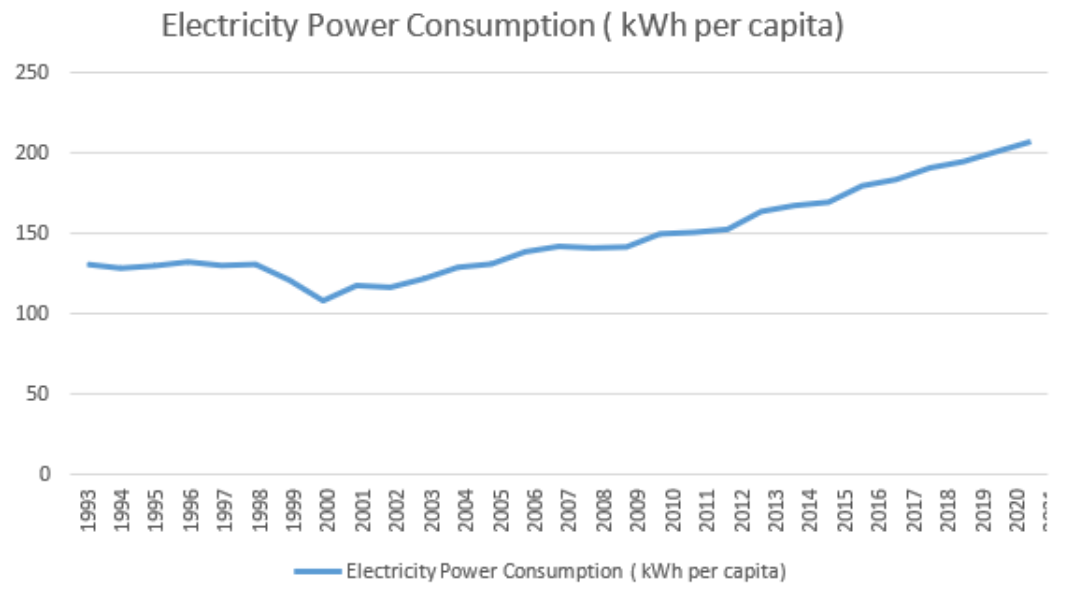

Figure 1.1: Kenya's Electricity Power Consumption in kWh per capita from 1993 - 2021. Source; World development Indicators report 2022.

Low electricity consumption rate is a major drawback to the realization of the benefits associated with improved electricity accessibility. Tangible benefits of improved access rates can only be realized with increased consumption rates since the utility of a product is derived from its consumption and not from its availability.

The problem of low consumption is a key concern to all stakeholders especially the government and the utility company itself which is KPLC. Kenya power shareholders disclosures report (2021) shows that the average monthly electricity consumption for a rural household is paltry six kWh valued at shs100.45. The report observes that such consumption levels are inadequate to lift the sales of the utility firm in tandem with the sharp increase in connections to the national grind. This is because low consumption rates translate to lower sales hence threatening the company continuity as a going concern due to liquidity problems. As a result, the financial position of the company is adversely affected.

IEA (2022) noted that most of the electricity providers especially in the SSA remains at risk since they are unable to meet their operating costs with the revenues generated from their customers. Moreover, low electricity consumption rates render investments and interventions made towards improving electricity access rates across the country, futile. This is because the efforts made will not yield the intended economic benefits resulting to poor distribution of the scarce resources. The intended transformation especially in the rural and peri urban areas will not be achieved and will remain underdeveloped limiting both human and economic development. Low electricity consumption rates correlate with lower economic growth rates, poor welfare levels, and low income among others.

Yadoo (2022) observes that there exists significant relationship between electricity consumed and HDI in that, countries with low electricity consumption levels experiences the least human development index. The unexpected relationship between electricity access rates and electricity consumption levels calls for an empirical study to explain the phenomena. This study therefore posed the question whether consumption of electricity accrued from electrification is commensurate to the electricity access rates achieved. Furthermore, there is need to test statistically how the existing tariff system has affected electricity consumption in Kenya. Existing tariff have a profound influence on electricity consumption as it can encourage or discourage electricity consumption. The findings of this study will assist to validate or otherwise the need to continue committing resources to attain electricity universal access rates in Kenya.

Electricity Accessibility.

SDG seven aims at ensuring universal access and utilization of affordable, reliable, sustainable and clean energy. The SSA region is the most affected where statistics show that out of 675 million people globally who don't have access to clean energy, 80 % are in Africa as per the International Energy Agency report (2022). Moreover, the situation is worse in rural and peri-urban areas where majority rely on carbon fuels such as kerosene and firewood to meet their energy demands. Such fossils fuels which have high carbon emissions yield negative effects on the households. The adverse effects experienced are air pollution, poor lighting, and deteriorating environmental, health and economic wellbeing.

Electricity is one source of clean energy which governments has put a lot of efforts to increase its accessibility. Globally, China is the largest consumer of electricity consuming 30% of the global supply, followed by USA at 16%. In Africa, the access rate has greatly improved with 150 million people expected to have accessed electricity by 2030 and 480 million people by 2050 as per the International Energy Agency report (2022).

Yadoo (2012), highlights that access to electricity yields both direct and indirect benefits which serves as a catalyst to economic growth, poverty alleviation and general human development. The direct benefits are mostly economical in nature and are reflected in increased income levels, increased employment opportunities, optimized expenditure patterns, improved saving rates and wealth generation and accumulation. The indirect benefits are primarily social and cultural aspects of living which includes education, heath, women empowerment, lifestyles modernization, among others. The associated benefits were supported by the empirical findings of Walsh (2011), where the study outcome indicated that, households with electricity had a higher income compared to households with no access to electricity. Similarly, literacy levels in households connected to the electricity were higher by 16.5% compared to those not connected.

IEA (2022) reports that electricity access rate in Africa stands at an average of 52.77%. Mauritius, Cape Verde and Gabon have the highest electricity access rates at 99.6%, 95.52% and 91.8% respectively. Chad, Burundi and South Sudan have the least electricity access rate at 11.27%, 10.23% and 7.74% respectively. In Kenya, various programs and policy interventions has been implemented over the years by successive government regimes in their efforts to achieve universal access rates. Examples of such interventions which has been rolled are the Last Mile Connectivity, Umeme Jamii, Rural Electrification Program, Global Partnerships of Output Based Aid (GPOBA) and Electrification program for all the public primary schools. These programs have seen remarkable progress in electricity access rates in Kenya.

Data from the WDI (2022) shows that the electricity access rates in Kenya have increased from a marginal access rate of 10.9% in 1993 to 76.4% in 2021.The attained access rate is far above the regions average electricity access rate which is at 52.77%. Similarly, electricity access rates by the rural population have registered a huge improvement having grown from 4.129% in 1993 to 68.1725 % in 2021. Access rates by the urban populace have also grown from 42.5% to 97.54% under the same period. The trends in electricity access rates by both the rural and urban population from 1993-2021 are presented graphically in figure 1.1 below;

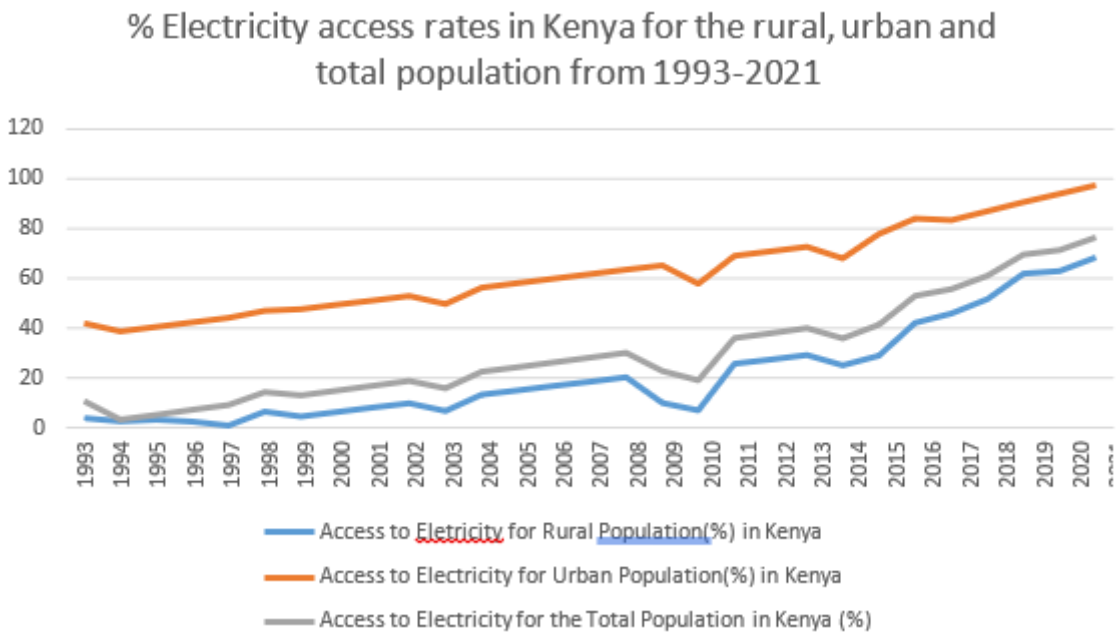

Figure 1.2: Kenya's Electricity Access Rates in Percentage for the rural, urban and total population from 1993-2021
Source; World Development Indicators Report, 2022.

Kenya aims at attaining electricity access to all by 2030 as enshrined the vision 2030 blueprint. Kenya government enacted a legal framework in 2014 to guide the attainment of universal access of electricity. The legal framework facilitated the development of Kenya National Electrification Strategy (KNES) which revised the target year for universal access to 2022. However, the target was not achieved within the proposed timeline hence reverting to the prior timeframe of 2030.

The KNES identified several challenges that hampers the attainment of universal access to electricity. The challenges highlighted were, high connection charges, inadequate motivation to attract private investors, weak implementing capacity, demand for high compensations for rights of ways and way leaves. The strategy aimed at coordinating and collaborating all the synergies from all the sector players towards attainment of the vision 2030 goal on universal access to electricity as well the SDG number Seven (SDG 7).

A notable observation is that despite the huge efforts in ensuring universal access to electricity, it's consumption hasn't been growing in proportion to the increased connection rates. The expectation is that as supply side increases due to investments in electricity generation projects, the demand side also increases at least by the same proportion arising from having more consumers enlisted in the electricity network. The paradox arises that, Kenya's access rates have grown from 10.9% in 1993 to 76.5425% in 2021. In terms of percentage change, it can be said that electricity access rates have grown at a rate of 600.2247 % while electricity consumption has not recorded such a massive change. The unparalleled change between electricity access rates and electricity consumption rates invites an investigative empirical study to establish the nexus between these main variables, which this study sought to achieve.

Electricity Tariffs in Kenya.

As postulated by the demand theory, willingness and ability is what constitutes demand. The consumption of electricity is hampered by it's unaffordability. In Kenya, expensive electricity has been a concern to all the major sector players since it's a detriment to welfare improvement. Different tariff system has been implemented over time in Kenya. However, a historical review of the tariff system shows a continuous increase in the price of electricity from an average of Kshs.1.5 kWh in 1993 to an average of KShs. 26 kWh in 2023 as reviewed by Klug et al. (2022).

Electricity tariffs in Kenya are provided by EPRA which is legally mandated to review the prices monthly. The price of the electricity is determined by costs incurred in generation, transmission and distribution of power. Additionally, other costs such as FEC, FERFA, WARMA levy, and inflation adjustments, a three Kenya cents/kWh EPRA Levy, a five per cent levy for the Rural Electrification, and a 16 per cent VAT also forms part of the pricing model as reported in Energy and Petroleum Regulatory Authority (2023).

The gradual increase in prices of electricity can be attributed to different factors namely; increase in inflation levels, increased levies, high cost of production, increase in global fuel prices, volatility of the domestic

currency, incorporation of independent power producers and climatic change conditions leading to draught and famine which affects power generation.

Various policy intervention aimed at managing the price of electricity have been instituted. Among the interventions made are Renewable Energy Feed-in Tariffs (REFIT), geothermal energy production, rural electrification, incorporating private investors and introduction of subsidy. However, the actions taken have not been fruitful with some being unsustainable, and other being driven by global factors such as increased fuel prices which are out of control of the sector players. Corruption has also been major challenge where investments made geared towards production of cheap electricity which is also green energy end up not realizing the intended benefits.

According to Fobi et al. (2018), increased price of electricity not only hinders consumption of electricity, but also increases the consumption expenditure of the consumers thereby decreasing their disposable income. Moreover, Tanaka et al (2022) highlights that, as a key driver of economy, high cost of energy and by extension electricity, will increase the overall cost of living. Increased cost of electricity will also prompt adoption of fossils fuels as an alternative which will not only increase carbon emissions, but also will bring health related complications affecting the quality of human capital available for spurring economic growth as noted by Schleich et al (2023). As an important determinant of cost living and as a vital component of welfare improvement, there exists a need to explore how electricity tariffs affect the consumption of the electricity in Kenya.

Problem Statement.

An efficient electricity supply offers an array of economic, environmental, education and health benefits therefore becoming a critical factor in sustainable development. Kenya quest to attain universal access rate is well on course. At 76.54% access rate, it is crystal clear that with sustained efforts, both SDG seven and SDG thirteen on clean, modern and reliable energy for all and climate change mitigation, respectively will be achieved by 2030.

Despite the remarkable progress on the accessibility font, consumption of the availed electricity remains aloof hindering the realization of the intended transformation especially in rural and per- urban areas. Equally, the progress envisioned will not be attained as observed by Rosenberg (2018). Authors' computation shows a big difference in terms of incremental changes between the two variables. While electricity access rates were found to have grown with massive 600.2247% for the period 1993-2021, electricity consumption was found to have increased by only 58.2331% within the same period. In other words, electricity access has grown ten-fold compared to the consumption levels. Such huge difference invites further empirical research to investigate the uneven growth in both accessibility and consumption, considering that consumption of a commodity, in this case electricity is curtailed if it's inaccessible and vice versa. Equally, prohibitive tariffs hinder consumption of electricity curtailing the realization of the related benefits.

Extensive review of literature on electricity access rate and electricity consumption have shown that existing publications have researched on the link between access rate and economic growth. Additionally, Volkert and Klagge, (2022), Yawa (2023), Ototo and Nzai (2021), Sardokie and Adom (2018) have focused on rural electrification programs and the transformation of the rural areas. Kwaka, Adu and Osei (2018) focused on causal factors that determine electricity consumption levels. This study focused on establishing the nexus between electricity access rates and electricity consumption levels in Kenya.

Research questions.

The research questions are;

i. What is the effect of electricity access rates on electricity consumption in Kenya?
ii. What is the effect of tariffs on electricity consumption in Kenya?

Research objectives.

The general objective of this study was to establish the relationship between electricity access rates and electricity consumption levels in Kenya.

The specific objectives are;

i. To determine the effect of electricity access rates and electricity consumption levels in Kenya.
ii. To determine the effect of tariffs on electricity consumption in Kenya.

Significance of the Study.

The study is of help to several groups of people. First, the study is helpful to the Ministry of Energy and Petroleum, KenGen, KPLC, REA, Kenya Electricity Transmission Agency and Energy and Regulatory Commission. All these institutions play instrumental roles from generation, distribution, selling and regulation of the electricity. The study can of great assistance to these institutions in having a collective and integrated approach in addressing the low consumption rates observed despite the high access rates realized. Energy and Petroleum

Regulatory Authority that is charged with establishing the tariffs applicable in a given time, will find this study helpful as well. By considering how tariff affects electricity consumption, the commission will be better informed when announcing new tariffs.

Additionally, this study will be useful to the central and devolved governments in exploring possible reasons behind the low consumption of electricity and advice on interventions to increase the consumption levels. The study provides feedback which is useful in planning process for the universal access attainment. The study also generates new knowledge and policy debates on the need to carry proper needs assessment before implementation of SDGs and relevant government projects.

Lastly, this study is helpful to the government in assessing which policy interventions to put in place to realize a friendly tariff system which will be growth- enhancing in terms of electricity consumption.

Scope of the study.

The study explored the effect of electricity access rates on electricity consumption rates in Kenya. The study covered the period 1993 – 2022. The study's period was informed by availability of data.

II. Literature Review

Introduction.

The chapter presents the economic theories used to anchor the study and the reviewed literature with respect to this study. The empirical literature review captured the existing studies done on electricity accessibility and electricity consumption. The last section provided a literature overview which will capture the gap this proposed study intends to fill.

Theoretical literature.

Theory of Demand.

The demand theory captures the relationship that exists between consumer demand and the price of the good. The model postulates that the demand of any commodity in the market is influenced by it's price. However, other factors at play in market system can as well determine the demand of a particular good. These factors include; number of consumers, price of related commodities, level of disposable income, consumer expectations and preferences. Demand of any commodity is guided by two key principles of willingness and ability of the consumer to make a purchase. Both ability and willingness are fundamental factors in order to determine demand, since either ability or willingness alone cannot constitute demand.

An extension of demand theory is the concept of derived demand. Derived demand refers to demand that arise because of consumption of another commodity. In this context, the consumption of electricity is based on the benefits derived and not consumed for its own sake. Just like any other commodity, the amount of electricity demanded is affected by its price. Additionally, the price of the electricity which ultimately determines its cost have a large multiplier effect on the overall cost of living in the economy as observed by Aytac and Guran (2011). The proposed study will utilize the theory of demand in understanding why despite accessibility and availability of electricity, the consumptions patterns and levels remain relatively low and unproportionate in Kenya.

Empirical literature.

Slim and Ben (2000) considered the significance of electricity consumption in economic progress. The study was a panel analysis for 19 African economies from 1990-2009. The authors adopted a dynamic OLS to achieve their study objectives. The findings of the study were that the variables correlated positively.

Berndt, E. R., & Samaniego, R. (2004) sought to establish if improved electricity access rates equate to improved consumption in electricity in Mexico. The authors utilized a time series dataset covering the period 1962- 2000 with two stage least square regression method to find out of the distinction between the two. The study found that the distinction between improved access rates and increased consumption rates was empirically significant and that improved electricity access rates will yield the expected outcome only when accompanied by increased household incomes levels.

Chen, Kuo and Chen (2007) employed a panel data method using a timeseries dataset for ten Asian developing countries in determining the causality between electricity consumption and GDP from 1971-2001. A short run causality was established running from economic growth to electricity consumption.

Kirubi, Jacobson, Kammen, & Mills (2009) explored how rural electrification programs impacts on the rural economies. The study which focused on rural areas in Kenya, specifically Mpeketoni in Lamu used primary data collected for a duration of three months in 2006. A positive effect of rural electrification on productivity and incomes was established.

Odhiambo (2010) included labor force as the intervening variable while exploring the nexus between electricity consumption and economic growth in Kenya for the period 1996-2006. The author used cointegration analysis alongside error correction models in establishing a tri-variate causality model. A unidirectional causality

from electricity consumption to economic growth was established. In addition, the study found that the two variables granger cause labor force participation in Kenya.

Sami (2011) used a time series dataset from 1960 to 2007 to analyze the relationship between consumption of electricity, exports and GDP in Japan. The study adopted a VECM model and the findings were that exports exhibited a long run positive effect while GDP only had a short run positive effect on electricity consumption.

Karumba (2012) carried out a multi variate analysis using a VECM model between 1970 to 2008. The research focused on determining the causality between energy consumption and output in Kenya's manufacturing sector. The author found that there exists a unidirectional causal relationship running from manufacturing sector to electricity consumption.

Khandker, Barnes and Samad (2012) work on socioeconomic outcomes of electricity access in Indian households, used a cross-sectional data set for 2005 sourced data from IHDS. The study used a two-staged least square method. The study found that households with access to electricity have superior education results in future since boys and girls spend more time studying as compared to households with no electricity.

Pata and Terzi (2012) work was on the nexus between electricity accessibility and economic growth in Turkey during 1970-2010. The study employed error correction model with Johansen cointegration tests. The authors found a positive short run relationship where a unit change electricity accessibility influenced a 28.97 percentage change in economic growth

Kumar (2014) explored income level and electricity consumption, specifically evaluating the impact of income gap and GDP on the growth rate on electricity consumption in India. A time series dataset from 1990-2012 was used while both fixed effects and random effects models were adopted. Income gap was found to have a significant positive relationship with electricity consumption.

Ackah (2015) considered how demand for electricity is affected by both endogenous and exogenous factors in Ghana. The authors employed a structural time series model. Among the endogenous factors considered was education and consumer price index. The findings were that that education reduces the consumption of electricity due to improved efficiency that comes along with increased literacy levels while consumer price index exhibited negative relationship with electricity consumption.

Guyu (2017) assessed the relationship between electricity access and education in Kenya while using two stage least square framework with spatial econometric techniques. The study used cross sectional data set with counties as units of analysis. The finding was that electricity impacted education positively four-fold.

Sarkodie (2017) on the other hand, focused on estimating future electricity consumption patterns in Ghana by 2030. The author used an ARIMA model with timeseries data spanning 1980 to 2013. Electricity consumption was projected to grow by 1.04 billion kwh in 2030

Twerefou and Abeney (2020) focused on households' utilization efficiency of electricity in Ghana using a 2016/2017 cross sectional data set obtained from Ghana living standard survey (GLSS). The study also looked at factors influencing electricity efficiency in Ghana. The study findings were that power blackouts adversely affected electricity efficiency in Ghana. Use of appliances and physical location, whether urban or rural were observed as consumption enhancing factors.

Eyuboglu, and Uzar (2022) contradicted the findings of Pata and Terzi (2012) on bi-directional causality. An ARDL model was utilized covering the period 1968-2008 and a uni-directional causality was established.

Daniel et al. (2023) assessed household electricity inefficiency and poverty in Ghana using a cross-sectional data from a household survey. The study employed a Probit model and the findings were that a positive change in electricity efficiency reduced poverty levels by 9.4 percentage points.

Yawa (2023) explored the relationship that existed between electricity accessibility and electricity consumption in Ghana. Among the control variable included was population which was found to have a significant positive effect on electricity consumption. A time series data set from 1990- 2020 alongside a VECM model was employed. The study findings were that electricity accessibility was a causal factor in determining electricity consumption in Ghana.

Overview of the Literature.

Empirical literature has shown that that substantive research has been done both locally here in Kenya and in other parts of the word. The studies Yawa (2023), Twerefou and Abeney (2020), Kumar (2014) and Sami (2011) have concentrated on electricity consumption- economic growth causality. A slight departure is that a few studies such as Pata and Terzi (2012) and Berndt and Samaniego, (2004) have looked at the nexus between electricity accessibility and economic growth. The studies differ in terms of methodology adopted ranging from OLS, Error Correction modes, VAR, ARDL and 2 stage least method while utilizing either panel, cross sectional, or time series data. The findings differ with much concurrence on the existing positive relationship between the variables. Similarly, for the work done on electricity consumption and economic growth, a positive relationship has also been established. However, contra findings have been found on the same. The studies emphasis that

electricity consumption is the transformative factor in harnessing social and economic benefits and not mere accessibility to electricity. As established from the literature reviewed, no studies specifically in Kenya has sought to link electricity accessibility and electricity consumption. Yawa (2023) is closely related to this study which was carried out in Ghana. However, the study is asymmetrical in two perspectives. First, the study differs geographically where the study done was for Ghana, and this study focuses on Kenya. Secondly, Yawa (2023) work utilized a VECM model which captured both the long run and the short run relationships, while the current study modelled short run relationships only through the use of an ARDL model. Consequently, the empirical work purposed to fill this gap by establishing the causality between electricity accessibility and electricity consumption and exploring the effects of tariffs on electricity consumption.

III. Methodology

Introduction.

The chapter discusses how the objectives will be achieved. A theoretical and empirical model specification that was used in analyzing the data is provided. Additionally, the chapter highlights the definition and measurement of the variables, estimation procedures, diagnostic tests, and data sources.

Research design.

An explanatory research design as proposed by Cooper & Schindler (2008) was utilized. This was informed by the objective of the project which goes beyond observing the relationship between the variables.

Theoretical framework.

As discussed in the theoretical literature review, the study was anchored on demand theory which postulates that the demand for a good or service is influenced by it's price alongside other factors such as, number of consumers, price of related commodities, level of disposable income and consumer expectations and preferences. Electricity accessibility-consumption link, have to factor in the considerations that consumption of electricity, which is derived demand is dependent on how much the consumers are willing and able to demand. This study therefore, assisted the study to incorporate other demand determining factors as control variables to achieve the research objectives.

Model Specification.

The study's first objective was to find out the relationship that exists between electricity accessibility and electricity consumption. The second objective is to determine how tariffs affect consumption of electricity. The study borrowed from Kraft and Kraft (1978) which focused on the role of electricity in spurring growth. However, as evident in previous discussion, accessibility without a matching consumption won't yield the expected results. This was collaborated by Dang and La (2019) work in Vietnam where consumption matched the increased electricity accessibility rates from 1990 to 2019. The study therefore regressed electricity consumption on the access rates and electricity tariffs while incorporating other determining factors as justified by the existing theory.

The study had proposed to adopt a VECM in achieving the study objectives. A VECM model, which is a restricted version of vector auto regressive model (VAR) had been proposed based on the assumption that the two variables have cointegration relationship as suggested by the empirical literature reviewed. However, the cointegration test as established by the Bound test indicated no cointegration relationships. Consequently, an ARDL model was used as guided by cointegration test. The bound test for cointegration was adopted after the ADF test for stationarity showed that variables are integrated of different orders.

The general format of an ARDL model is as given below;

$$Yt = \sigma + \sum_{i=1}^{p} \varphi i \, Yt-1 + \sum_{i=1}^{q} \beta i \, Yt-1 + \varepsilon t \qquad (3.1)$$

Where;

$Yt-1$ = Vector of variable, either I (0) or I (1)

εt =K X 1 Vector residual

σ = Constant

p and p are optimal number of lags

φi and βi = coefficient of ith endogenous term

The study adopted and adapted Yawa (2013) methodological framework which explored effects of electricity access rates on electricity consumption in Ghana.

The adapted functional form of the model used as adopted from Yawa (2013) is given in equation

3.2 below;

$ECt = f\ (EAt, ETt\ POPt, GDPt, CPIt)$ (3.2)

where;

ECt is electricity consumption, EAt is the electricity accessibility, ETt is electricity tariffs, $GDPt$ is gross domestic product, $POPt$ is total population and CPI is the consumer price index. GDP, Population, and CPI, have been incorporated as control variables as guided by the reviewed literature.

Equation 3.2 can be expressed as a liner function for regression purposes as given below;

$ECt = \alpha0+\alpha1EAt + \alpha2\ ETt + \alpha3GDPt + \alpha4POPt + \alpha5CPIt+\varepsilon\ldots$(3.3)

The ARDL model which only captures the short run specifications was hence adopted. It's important to note that the dependent variable in an ARDL model is a function of its lagged values, the current and lagged values of other independent variables. Incorporating the variables of interest as well the control variables,

$$\Delta ECt = \beta0 + \sum_{i=1}^{p} \beta1i\ \Delta ECt-1 + \sum_{i=0}^{q} \beta2i\Delta EAt-1 + \sum_{i=1}^{q} \beta3i\ \Delta ETt-1 + \sum_{i=1}^{q} \beta4i\ \Delta POPt-1 + \sum_{i=1}^{q} \beta5i\ \Delta GDPt-1 + \sum_{i=1}^{q} \beta6i\ \Delta CPIt-1 + \varepsilon t \quad (3.4)$$

Equation 3.4 will be used to achieve the two objectives.

Definition and measurements of variables.

Dependent variable.

Electricity consumption (EC) entails to the amount of electricity being used by customers over a period of time, mainly per year. It is measured in kilowatt per hour (kWh). Data will be sourced from Kenya Power and Lighting Company produced annually.

Independent Variables.

Electricity access (EA); refers to the proportion of population who are already connected to the power grind and have electricity in their homes. It's measured as a percentage of the population who are connected to electricity. Data will be sourced from World development Indicators report (2023).

Electricity Tariff (ET); refers to the rate at which consumers are charged for the amount of electricity consumed in a given period of time. It's measured in kilowatts per hour (kWh). Data will be sourced from KPLC records for the study period.

Consumer Price index (CPI); reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. CPI Has been used to cater for inflation due limited data. Data will be sourced from WDI report (2023).

Gross Domestic Product (GDP); Refers to the total value of goods and services produced in a Kenya. GDP will be used as a proxy measure of income. Data will be obtained from WDI report (2023). Income is expected to confirm with the theory of demand and have a positive effect on electricity consumption.

Population (POP); Refers to the count of all residents regardless of legal status or citizenship in Kenya and is determined by the total population of all residents. Data will be obtained from WDI and collaborated with census reports from KNBS.

Diagnostic tests.

The study employed several diagnostics tests as a safeguard in ensuring accuracy, reliability, and correctness of the results to be obtained. The type of diagnostic tests had been selected based on the type of data to be used, as well as the model. The pre- estimation tests conducted were.

Unit root test of stationarity.

There is need to test for unit root since it's a common occurrence when dealing with time series trends. As a result, ADF test was applied and the results verified by the Philip Perrons test as an extra measure of caution.

Cointegration test.

Cointegration test measures if the variables exhibit long run relationships. Existence of cointegration relationships is a key determinant for the model to be adopted. In cases where the variables are found to be of different order, bound test for cointegration is adopted.

Optimal lag length.

It's paramount to ascertain the number of lags to consider. This is because past events tend to have an effect in the current period hence the need of determining the number of lags. Various test criteria available were utilized. These included AIC, BIC, SIC, HIC and FPE. The information criteria with the smallest value was used.

Normality.

Normality of residuals is a vital consideration to have in ensuring residuals are normally distributed. The study utilized Shapiro-Wilk test for normality.

Auto correlation.

This test will be done to establish whether there exist inter- associations between explanatory variables. When variables are intercorrelated, they can cause skewness in a regression model. The study utilized Bresuch Godfrey LM test .

Heteroscedasticity.

Homoscedasticity is important in ensuring that the residuals have constant variance in all levels. Presence of heteroscedasticity interferes with the accuracy of the estimates obtained since the standard errors and the p-values will be biased. The study utilized White test to test for heteroscedacity.

Data Type and Sources.

The study utilized secondary data for 31 years from 1990 to 2022 in Kenya. Data was sourced from WDI report 2023 and Kenya Power and Lighting Company. The WDI reports are produced annually by the World bank providing the most comprehensive database of development indicators across the globe, hence its reliability. As the primary seller of electricity in Kenya, KPLC is the most reliable source of data on electricity consumption and tariffs.

IV. Empirical Findings

Introduction.

The chapter presents the descriptive statistics, diagnostic tests, regressions results, and discussion.

Descriptive statistics.

The descriptive statistics are used to highlight the major characteristics of the variables. These characteristics included the number of observations, mean, standard deviation, minimum and the maximum. The results are presented below in Table 4.1

Table 4. 1: Descriptive Statistics

Variable	Obs.	Mean	Std. Deviation	Minimum	Maximum
Year	33	2006	9.66954	1990	2022
Electricity consumption	33	148.1302	29.64609	108.1629	215.7835
Electricity Access	33	.2835639	.2093393	.034734	.765425
Tariffs	33	5.114706	3.373954	1.25	10
Consumer Price Index	33	93.16164	71.70527	8.66902	246.2953
Gross Domestic Product	33	5.5693	2.2135	3.1625	10.4
Population	33	38.1	10.2	23.16	54.03

The total number of observations used for the study is 33 for each variable. Electricity consumption, which is our dependent variable possess a mean of 148.1302kWh per capita. This to mean that on average, electricity users consume 148.1302 kWh per capita annually. The minimum consumption recorded is 108.1629kWh while the maximum level of electricity consumption observed for the period under consideration is 215.7835kWh. Electricity consumption deviates from the mean with 29.64609kWh. Electricity access scored a mean average of 0. 2835639 and a deviation of 0.2093393 which translates to 28.36639% and 20.93393 % respectively. The minimum rate of electricity access observed was 0. 034734, translating to 3.43734 % while the maximum rate was found to be 0.765425 which is 76.5425%. Electricity tariffs showed a mean average of 5.114706 with a deviation of 5.114706. The minimum tariff structure was 1.25 while the maximum was 10.

CPI which acted as the relative measure of inflation across the study period showed an average of 93.16164 and a deviation of 71.70527. The minimum recorded for CPI was 8.66902 while the maximum was 246.2953. Gross domestic product had a mean average of US$5.5693 million and a deviation from the mean of US$ 2.2135. The minimum level of Gross domestic product recorded was US$ 3.1625 and the maximum was US$ 10.4. Population variable had a mean of 38.1 million and a deviation from the mean of 10.2 million. 23.16 million and 54.03 million were recorded as the minimum and the maximum value respectively.

Diagnostic Tests.

Unit root test for stationarity.

Timeseries dataset mostly suffers from the stationarity issues. The unit root test of stationarity as guided by Augmented Duckey Fuller test was carried out. Phillip Perron test was also utilized as an extra safeguard measure to ascertain the findings of the ADF test, since the tests ought to yield similar results. The test statistics obtained were compared to the critical value obtained at 5% level of significance. The results as presented in table 4.2 below show that some variables were stationery and others non-stationery. The variables were subjected to log transformation as a way of improving the accuracy of the results obtained. More specifically, electricity consumption, electricity access, consumer price index and population were found to be stationery at level. However, both tariffs and gross domestic product were found to be non-stationery.

Table 4.2: Unit Root Test Results for the Variables

Variable	ADF Test unit root test		Phillip Perron Unit root test		Comment
	Test Statistic	*Critical value at 5%*	*Test Statistic*	*Critical value at 5%*	
Ln EC	-2.196	-1.950	-2.405	-1.950	***I (0)***
Ln EA	-2.005	-1.950	-2.051	-1.950	***I (0)***
Ln TA	1.183	-1.950	3.978	-1.950	***Non-Stationery at Level***
Ln CPI	-2.647	-1.950	-3.623	-1.950	***I (0)***
Ln GDP	-0.173	-1.950	-0.549	-1.950	***Non-stationery at Level***
Ln POP	-3.823	-1.950	-4.674	-1.950	***I (0)***

Inclusion of non-stationary variables in the model woud yield spurious results and affects the accuracy and realibility of the results obtained. Consequently, there was need to eliminate the presence of unit roots which was done through differencing where a new differenced variable was generated. The differenced variables became stationery upon testing and verifying using ADF and PP tests as shown in Table 4.3 below.

Table 4. 3: Unit Root Tests Results After First Difference

Variable	ADF Test unit root test		Phillip Perron Unit root test		Comment
	Test Statistic	*Critical value at 5%*	*Test Statistic*	*Critical value at 5%*	
dlnGDP	4.459	-3.580	2.429	-1.950	*I (1)*
dlnTariff,	2.558	-1.950	-0.463	-1.950	*I (1)*

Cointegration Test.

A cointegration test was carried out to establish if there exists long run relationships between the variables. The study adopted ARDL bound test for cointegration which was developed to deal with series which are of mixed order. The ARDL bound test is also appropriate to use when there is a smaller number of observations like in this study hence overcoming one of the challenges of the study. The Bound test is conclusive upon comparison of the f statistic to both the upper limit and the lower limit. The f statistic obtained was established to be below the lower limit hence providing proof that there exists no cointegration relationships as shown in Table 4.4 below.

Table 4. 4: Peasaran/Shin/Smith (2001) ARDL Bounds Test (F-Statistic)

Peasaran/Shin/Smith ARDL Bound Test							F = 1.559 t = -2.674	
	L.L	U. L	L.L	U. L	L.L	U. L	L.L	U. L
	2.26	3.35	2.62	3.79	2.96	4.18	3.14	4.68

NB; LL -Lower limit & UL - Upper limit H0: no levels relationship

The cointegration test is very important as it determines the choice of model to adopt. Since cointegration relations were not established, the study will focus on establishing short-run effects only using ARDL Model. Long-run effects would have been established if there existed cointegration by use of error correction term.

Optimal Lag Test.

Optimal lag test is needed to confirm the number of lags to be used in the model since an ARDL model considers the effect of both the current and lagged variables. There exist different methods of determining the optimal lag length. Each method produces different number of lags after carrying out iterations and the method with the least number of lags determines the optimal lags to be used. The results of the different methods are presented in Table 4.5 below.

Table 4. 5: Results for Optimal Lag Length Selection Order Criteria.

lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	-418.993				1.9e+06	31.481	31.5666	31.769
1	-194.122	449.74	36	0.000	1.70906	17.4905	18.0899	19.5063
2	-144.569	99.106	36	0.000	.980693	16.4866*	17.5998	20.2301
3	-72.2806	144.58	36	0.000	.30791	13.7986	15.4255	19.2699
4	1905.26	3955.1*	36	0.000	. 6.3e-61*	-130.02	-127.879*	-122.82*

AIC produced the least number of lags, which is two in number hence guiding the number of lags to be used.

ARDL Model Regression Results.

Pre-estimation tests conducted informed the adoption of an ARDL model. The ARDL model focused only on the short-term coefficients since there were no long-run relationships as established by the cointegration tests. The regression results are shown in table 4. 6 below, with the natural log of Electricity Consumption used as the dependent variable as guided in equation 3.4

It's paramount to note that an ARDL model establishes the relationship of dependent variable alongside the lagged variables of itself and other independent variables since all variables are endogenous.

Table 4. 6: ARDL Regression Results

Variable	Coefficient	Standard error	t-value	P-value
Constant				
lnEC | L1.	0.7246368***	.1618609	4.48	0.0000
lnEA	.0044137	.0335435	0.13	0.897
dLnGDP	.4170403	.3423409	1.22	0.237
dlnTariff	-0.84276***	0.25851	-3.26	0.024
lnPOP (L1)	50.07683**	20.20173	2.48	0.022
(L2)	-21.68823**	9.592423	-2.26	0.035
lnCPI	-.1260719	.0991021	-1.27	0.217
Constant	**-6.342075**	**6.423486**	**-0.99**	**0.335**
R-Squared		**0.9751**		
Adjusted R-Squared		**0.9656**		

NB *** Significance at 1%, ** Significance at 5%, *Significance at 10%

The first lag of our key variable of interest, which is electricity access was found to be significant at both at 5 % and 1 % significance level. A unit change in electricity consumption in the yester period causes a 0.7246 increase in electricity consumption in the present year, ceteris paribus. The increase in electricity consumption can be explained by the desire by households and electricity consumers to maintain and upgrade their lifestyle compared to the previous period. Therefore, an incremental positive change in the previous year causes to a continued growth in the present. The findings is a convergence to the findings of Yawa (2023) who found a significant relationship of electricity consumption between the current time and the past period.

The natural log on electricity access (EA) was found to be statistically insignificant at all levels. With a p -value of 0.89, the variable is insignificant. The finding is in agreement with the demand theory that accessibility to a good or service cannot constitute demand or consumption. Additionally, the research findings conformed to the findings of Berndt and Samaniego (2004), where electricity access was found to be insignificant on its consumption. Equally, the study findings were in convergence with the findings of Twerefou and Abeney (2020), Kumar (2014) and Sami (2011) who established there existed no electricity access- consumption nexus. However, the results negated the conclusions made by Yawa (2023) where a positive significant relationship was established by the author. Consumers can be proximate to where the good or service is but other factors such as affordability hinder consumption.

The natural log of Gross Domestic Product was also found to be statistically insignificant with a p-value of 0.237. The hypothesis is that an incremental change in GDP translates to increased economic activity due to factors such as urbanization and industrialization, leading to an increased consumption of electricity. However, the findings were contrary to the hypothesis and contradicted the findings obtained by Kumar (2014), with respect to GDP. This could be explained by the fact that the higher GDP could be driven by the growth of a non-intensive electricity consumption sector such as agriculture. Kenyan economy being agriculture based explains the insignificant relationship between the two.

The natural logarithm of Tariff was found to be statistically significant. A unit increase in tariffs causes a corresponding negative change of 0.8427 in electricity consumption, ceteris paribus. The negative relationship is in tandem with the fundamentals of demand theory, where the price of a commodity has an inverse relationship with its demand. An increase in tariff will reduce consumption of electricity due to affordability element. Moreover, as noted by Schleich et al (2023) and Tanaka et al (2022), whose findings collaborated the outcome of this study, increase in tariff will prompt consumers to abandon electricity which is clean energy and result in fossil fuels which are cheaper though environmentally hazardous, hence cutting down on electricity consumption and globally leading increase in carbon emission as a result of increased fossil fuel use.

The first and second lag of population are significant at one percent and five percent significance level respectively, which was in concurrence with the findings of Yawa (2023). However, in the first lag, the change is positive while in the second lag, the change is negative. Holding all other factors constant, a unit increment in population causes a corresponding increase in electricity consumption by 50.07683. On the contrary, a positive unit change in population in the second lag, causes a decline in electricity consumption by -21.68823 ceteris paribus. The positive change in electricity consumption can be justified by the fact that increase in population translates to having more consumers of electricity hence the increased consumption. The negative relationship on

the hand can be explained by the fact that the populace may lack the ability to pay for electricity. Secondly, the structure of the population matters where majority of the population maybe dependents hence the electricity consumed will decline despite the increase in population. Adoption of energy-saving technologies and appliances may also reduce the amount of electricity consumed despite a rise in population.

Lastly, consumer price index was found to be statistically insignificant in explaining electricity consumption patterns in Kenya. The findings contradicted the work of Ackah (2015) which found a negative relationship between the two variables. The author argues that as value of money diminishes due to inflation as measured by CPI, consumers rationally will downsize their aggregate consumption including electricity consumption. This current study however argues that, CPI which shows the relative changes in prices of a basket of goods for a period of time, may not explain the electricity consumption patterns due to inelasticity of electricity consumption. This is because, consumption of electricity will rarely have a huge margin of change to increase or decrease in inflations.

The R -Squared obtained is 0.9751, which means that the variables explain the model by 97.51% and hence the model can be said to have high explanatory power.

Post Estimation Diagnostic tests.

Post estimatiom diagnostics test were carried out to ensure the accurancy of the the results. The tests carried out were to test for normality of residuals, homoscedasciticty and for serial correlation. Shapiro Wilk test for normality was used and confirmed that the residuals exhbited normal distribuition. Additionally , White test for heteroscedacity confirmed that model was homoscedstic. Bresuch Godfrey LM test also veried that the model was free from serial correlation. In all those instances the null hypthesis was not rejected since the p value was greater than 0.05 as shown in table 4.7 below.

Table 4. 7: ARDL Model Results for Diagnostic Tests.

Test	**P-value**
Shapiro Wilk Test for Normality	0.74198
White test for Heteroscedasticity Test	0.4140
Breusch-Godfrey LM Test for Serial Correlation	0.5249

Equally, Cusum test for model stability was utilized to verify and confirm the stability of the model. As shown in Fig 4.1 below, it was observed that the test statitic was within the bounds hence model proved to be stable

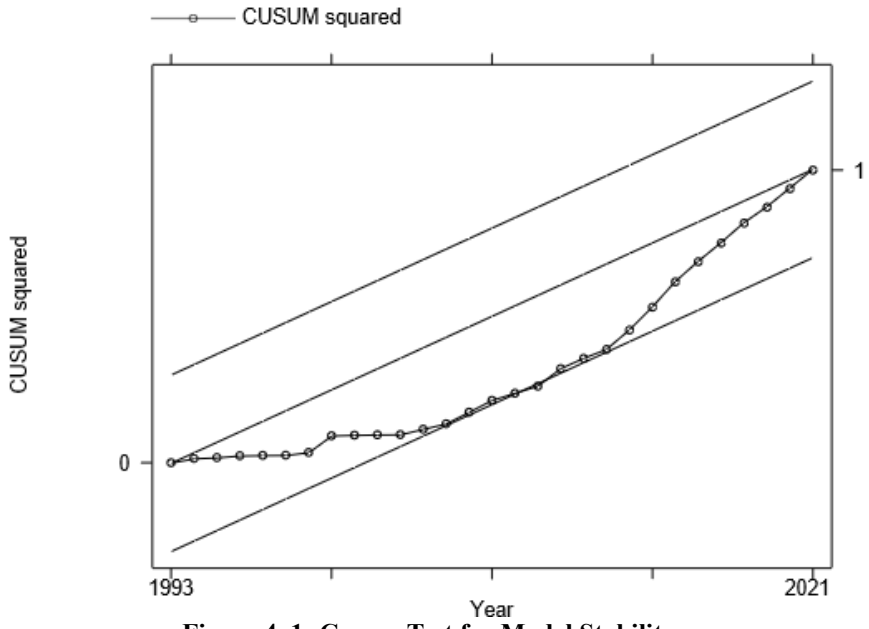

Figure 4. 1: Cusum Test for Model Stability

V. Summary, Conclusions, And Recommendations.

Introduction.

The chapter highlights the summary, conclusions, recommendations, contribution to knowledge and areas for future studies

Summary of the findings.

Despite the significance of electricity as a source of clean energy and in addressing energy poverty especially in developing and less developed economies, the findings on electricity access and electricity consumption have yielded divergent views. The clamor in attainment of sustainable development goals seven and goal thirteen motivated this study in assessing the relationship between the two.

The aim was to find out why electricity consumption has not been growing despite growth in access rates and coverage. Debate on whether electricity access rates influence consumption rates attracts various explanations. Some of the works done such as Twerefou and Abeney (2020), Kumar (2014) and Sami (2011) have argued that electricity access has no relationship with electricity consumption. The explanations fronted is that accessibility doesn't in any way amount to consumption and therefore expecting electricity consumption to grow proportionally to the growth in electricity access rates is a wrong policy advocacy.

On the other hand, other studies such as Yawa (2023) presents a contra view that one cannot consume that which is unavailable. The studies argue that the first step in improving consumption rates of any commodity is making it available to the consumers and hence increased electricity access rates should be encouraged and more interventions towards attainment of universal access rates should be implemented. Additionally, there was need to explore the how Tariffs influences electricity consumption in Kenya where the tariff system has been said to be prohibitive to the consumers. As noted by Fobi et al. (2018), a high electricity tariff system is a hindrance to electricity consumption and disadvantages consumers by reducing their net disposable income because of settling huge bills. Therefore, the study sought to determine the effect of electricity access on electricity consumption in Kenya, and the second objective of the study was to find out the effect of tariffs on electricity consumption in Kenya.

The two objectives were achieved using an ARDL model after pre-estimation test permitted the adoption of the model. As a result of adopting the ARDL model, only the short run coefficients were estimated since there were no cointegration relationships. The findings with respect to objective one was that electricity accessibility was found to be insignificant. This to mean that there existed no relationships between electricity accessibility and electricity consumption in Kenya. The findings collaborated with the work of Berndt and Samaniego (2004), which obtained similar results. However, there was a departure in the research outcome with respect to the work of Yawa (2023), which obtained a significant positive relationship.

The findings on the second objective were that there existed a negative relationship between tariffs and electricity consumption where a unit positive change in tariff causes a decline in electricity consumption by 0.84276. The result was in concurrence with the demand theory which anchors this study where an inverse relationship exists between quantity demanded and the price. These findings collaborated with the findings of Schleich et al (2023) and Tanaka et al (2022).

Among the control variables, only the first lag of electricity consumption and population were found to be significant with positive and negative effects respectively. The need to maintain a previous lifestyle can be said to be the explanation why the electricity consumption of previous period positively affects the consumption of electricity in the current period. Secondly, the negative effect of population on electricity consumption can be attributed to the demographic of the population. In cases where the majority of the populace are dependents, an increase in population will not cause an increase in electricity consumption.

Electricity access, gross domestic product, and consumer price index were found to be statistically insignificant in explaining electricity consumption.

Conclusions.

The conclusion drawn was that an increase in electricity access rates doesn't affect electricity consumption In Kenya. However, an increase in electricity tariffs negatively affects electricity consumption in Kenya.

Policy Implication.

In line with the study findings, the study recommends that as government, through the Ministry of Energy and Petroleum where Kenya National Electrification Strategy (KNES) is domiciled seeks to attain universal access of electricity in Kenya by the year 2030, more concerted efforts should go hand in hand in addressing the challenges in electricity consumption. More focus should be given on harmonization and rationalization of the existing tariff system which comprises various numerous levies. EPRA which reviews and set energy prices should undertake a comprehensive review of the tariff system and offer appropriate directions. This is to ensure

that the benefits envisioned with the targeted 2030 electricity universal access are realized. Additionally, KPLC, which sells electricity to customers should make their procedures and system easy, seamless and with less red tape to not only attract new customers and client base, but also to retain the existing clientele who may be tempted to seek alternative source of clean energy such as installation of solar energy due to poor services offered by the utility firm. The government should equally continue with the programme of lighting all public primary and secondary schools with electricity to boost electricity consumption. Equally important, public health centers and dispensaries should also be incorporated in the programme to ensure the benefits of increased electricity access rates extend to the citizens who seeks services in these facilities.

Corruption which exists in generation of alternative electricity such as geothermal and solar plants should be curbed to ensure that power is generated cheaply and result in tariffs that are affordable. This will assist in lowering the price of electricity, making it affordable, thereby increasing consumption rate. Additionally, the Ministry of Energy and Petroleum should review the existing contracts with independent power producers who have been accused of making the cost of electricity high. Again, this will help in ensuring affordability of the electricity which will increase consumption.

Contribution to knowledge.

The research is a great addition to the body of knowledge on electricity access- consumption nexus which has been sidelined over time. The study further adds clarity to the fundamentals of demand theory that access to a commodity doesn't amount to demand. Lastly, the study invites reviews and discussion on the existing electricity tariff system in Kenya.

Areas of Further research.

The study has explored the nexus between electricity access and electricity consumption in Kenya. Additionally, the study has also established the effect of tariffs on electricity consumption in Kenya. Future research can focus on establishing if the low levels of electricity consumption in Kenya is because of improved efficient usage of electricity. Moreover, future work can focus on the wider energy poverty matrix and how energy poverty remains a threat to attainment of sustainable development goals which are intertwined to energy poverty and alleviation of poverty in general.

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