ELECTRICITY ENERGY AND INDUSTRIAL GROWTH IN KENYA:

1983-2020

BY

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DECLARATION

Declaration by the Candidate

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DEDICATION

I dedicate this paper to my family, for their love and support; they are my source of encouragement.

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I thank God Almighty for the gift of life, good health and a sound mind as I worked on this research paper.

I am extremely grateful to my family, especially my husband Nixon Kamau, whose unyielding love, support and encouragement enriched and inspired me to pursue and complete this research. I am grateful to my children Reagan Kamau and Soraya Nyambura for their patience; I hope one day they understand why Mummy spent so much time on her computer.

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ABSTRACT

Kenya's economic growth is affected by among other factors slow industrial growth. Electricity energy is an important factor of production. Rapid industrialization is a function of among other variables adequate electricity energy. The main objective of this study was to analyze the relationship between electricity energy and industrial growth in Kenya. Specifically, the study sought to determine how electricity consumption affects industrial growth in Kenya; examine the effects of electricity supply on industrial growth in Kenya; evaluate how changes in electricity tariff affects industrial growth in Kenya and describe effects of electricity access on industrial growth in Kenya. This study was explanatory in nature and used time series data for the period 1983 to 2020, to establish the relationship between the variables. The study adopted the Endogenous Growth Model. Aggregate output was proxied by industrial output and technology was represented by energy. Energy was disaggregated to electricity consumption, electricity supply, electricity tariff and electricity access. The study used Johansen test to test for cointegration, thereafter the vector error correction model was specified. The coefficient of the error term was -0.062 implying that the model will settle in the long run. On average ceteris paribus in the short run, the coefficient for electricity consumption was 0.05; the coefficient of electricity supply was 0.41; electricity tariff was -0.06 and the electricity access was 0.02. The most important determinant for industrial growth in Kenya was found to be electricity supply. The study concluded that increase in electricity consumption, electricity supply and electricity access encourage industrial growth, on the contrary an increase in electricity tariff inhibits industrial growth. The study recommends that the government should ensure adequate electricity generation to meet the growing electricity consumption and electricity tariff should be managed to encourage industrialization.

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OPERATIONAL DEFINITION OF TERMS

Industrialization: Is the process of manufacturing consumer and capital goods which have the tendency of creating the necessary social overhead capital that would stimulate the development of other sectors of the economy (Olufemi, 2015).

Manufacturing Value Added: Is the net output of the manufacturing sector after adding up all outputs and subtracting intermediate inputs.

Electricity Energy: Energy plays an important role in the economy from both the demand side and supply side. On the demand side, energy is one of the basic items that a consumer buys to maximize utility. On the supply side energy is a key factor of production just as capital, labour, land and materials. Commercial sources of energy in Kenya are electricity and petroleum products. Electricity energy is derived from hydro, geothermal, wind, solar and thermal sources (Onuonga, 2012).

Electricity Consumption: Is the amount of electricity that has been consumed over a certain period of time. Industrial energy is predominantly used for production, lighting and other business uses in the manufacturing industries (Jordan, 2014). Electricity consumption is measured in kilowatt hours (kWh).

Electricity Demand: is the rate at which electricity is consumed; electricity demand is measured in kilowatts (kW).

Electricity Access: refers to the percentage of people in a given area that have stable access to electricity. It can also be referred to as the electrification rate.

Installed Generation Capacity: is the total capacity of currently installed generators, expressed in kilowatts (kW), to produce electricity. A 10-kilowatt (kW) generator will produce 10 kilowatt hours (kWh) of electricity if it runs continuously for one hour.

Peak Demand: is the highest electrical power demand that has occurred over a specified time period on an electrical grid. Kenya's maximum power demand crossed the 1,802 megawatt (MW) mark in June 2018.

Gigawatt hours: is a unit of energy representing one billion (1 000 000 000) watt hours and is equivalent to one million kilowatt hours. Gigawatt hours are often used as a measure of the output of large electricity power stations.

Load: is a general term that describes the electrical demand, or power draw, a project has on an electrical grid.

Load Shedding: is another term for scheduled electricity blackouts. Energy utilities shed load intentionally when there is more demand for power than they can supply.

Stationary Series: Is a flat looking series, without trend, with a constant variance over time and without periodic fluctuations.

Cointegration: is a statistical method used to test the correlation between two or more non-stationary time series in the long run or for a specified period (Gupta)

Johansen Cointegration: is a way to determine if time series are cointegrated. It assesses the validity of a cointegrating relationship, using a maximum likelihood estimates approach and also used to find the number of relationships

Vector Autoregressive model (Var): is an integrated model comprising multiple time series and is quite a useful tool for forecasting. Var models are best used on non-stationary and un co-integrated data forms (Maitra, 2019).

Vector Error Correction Model: imposes additional restriction to a vector autoregressive model, it utilizes the co-integration restriction information into its specifications. Through a vector error correction model, we can interpret long term and short-term equations (Maitra, 2019).

Vision 2030: A long-term development blueprint developed by the Government of Kenya in 2007. It aspires to meet the millennium development goals for Kenyans and is anchored on three key pillars: Economic, Social and Political Governance.

Per-capita power consumption: Total energy consumed by each person. a unit of energy equivalent to one million kilowatt hours

ABBREVATIONS & ACRONYMNS

KWh	Kilo Watt Hours
MW	Mega Watts
Kw	Kilo Watts
GWh	Gigawatt hours
EPRA	Energy and Petroleum Regulatory Authority
IPP	Independent Power Producer
KenGen	Kenya Electricity Company Plc
KPLC	Kenya Power and Lighting Company Ltd
KNBS	Kenya National Bureau of Statistics
LCPDP	Least Cost Power Development Plan
PPA	Power Purchase Agreements
MNGs	Millennium Development Goals
ADF	Augmented Dickey Fuller Test
VAR	Vector Autoregression
VECM	Vector Error Correction Model

CHAPTER ONE

INTRODUCTION

1.1. Overview

This chapter looks at the background of the study, statement of the problem, research objectives and hypothesis of the study, significance and finally the scope of the study.

1.2. Background of the Study

Economic development in Kenya during the 1970s and 1980s was characterized by continuous but modest, and at times rapid, economic growth, strong population growth, slowly changing economic structure and large income disparities. Although the modern sector exhibited all the signs of a rapidly developing economy, annual income per person has remained at approximately $300, which puts Kenya into the category of the poorer developing countries (Siggel, 1991).

Industrialization has been embraced by many developing countries as a means of achieving structural transformation of their economies. In Kenya, the goal of industrialization has long been held as a strategy for economic development. Recently it has received emphasis as the main strategy for addressing the principal challenges of development in Kenya, employment creation and poverty eradication (Ronge & Nyangito, 2020) .

Kenya has embraced the goal of industrialization to transform the structure of the economy. The current industrialization strategy aims to transform the economy into that of a newly industrializing country. The strategy emphasizes selective encouragement of industries to produce for export and in the process increase their employment potential.

The strategy, however, is different from past strategies because of two innovations. First, industry is for the first time taken to be the leading sector in economic development, and second, specific industries are for the first time earmarked for government support. The strategy for industrialization is to be implemented over a two-stage period. In the first phase, the government will selectively encourage labor-intensive, resource-based and light manufacturing industries, where the country enjoys comparative advantage. In the second stage, policy will target intermediate and capital goods industries that are more technology and capital intensive but that must wait until constraints of infrastructure, technology, human capital and savings are removed. These industries, which include metallurgical, non-petroleum-based chemical, petro-chemical, pharmaceutical, machinery and capital goods industries are expected to produce initially for the domestic market and eventually for the export market. If successful, this strategy will result in a diversified and dynamic industrial base (Ronge & Nyangito, 2020) .

Today most economic activities rely heavily on energy (such as electricity, natural gas, coal or gasoline) to produce and distribute goods and services. This implies that as economies increase their production and income, more energy is required to achieve high levels of production and consumption. It is natural to assume that there is a close relationship between energy use and economic growth in developed and developing counties, ceteris paribus.

Economic activities require energy not only to produce final goods and services, but also to distribute them in the market; therefore, energy prices and availability are factors to consider for economic growth. A growing economy will lead to increased energy needs and vice versa, so whether or not energy is being used efficiently, its availability needs to rise to boost economic growth (Zamarripa et.al., 2017).

1.2.1. Industrialization in Kenya

Industrialization is a potential key driver for economic growth and sustainability in Kenya. Since independence Kenya has made several initiatives towards the development and growth of industries. However, despite the efforts resulting into the country having a relatively larger industrial sector in the region, it has not been dynamic enough to function as the engine of economic growth especially when compared to newly industrialized emerging economies due to various challenges. The sector has been inward-looking and has had low value addition especially to the available agricultural and natural resources. Similarly, weak institutional support for the development and growth of the local Micro, Small and Medium Enterprises (MSMEs), which have the potential for employment and wealth creation, has resulted into slow industrial growth.

There is an obvious and immediate role for industrialization as a key driver for economic growth and sustainability in Kenya. Across the globe, industrialization has been credited for increased per capita income, growth in international trade, high levels of employment and increased investment (Ministry of Industrialization Trade and Enterprise Development, 2020).

Lack of long-term financing has resulted in declining levels of capital investment in the country, from 30% of GDP in the 1980s to below 15% in the late 1990s. Over the last 15 years, gross investment in plants and equipment as a proportion of replacement value has been less than 5% of 70% of the manufactures (Kenya Ministry of Planning and National Development and National Economic and Social Council, 2007). According to (Kenya National Bureau of Statistics, 2018) , the total loans advance to the manufacturing sector decrease from 290.1 billion in 2015 to 276.4 billion in 2016.

In 2017 Kenya Association of Manufacturers noted that most of the manufacturers in the country operate at about 53% capacity. Weak negotiating capability impedes the country's ability to negotiate for favorable trade agreements and therefore creates barriers against Kenyan companies. Weak enforcement of standards and tax laws has led to dumping of sub-standard imports and counterfeit goods into the domestic market, making it unfavorable for local manufacturers to compete (Kenya Ministry of Planning and National Development and National Economic and Social Council, 2007).

Interventions centered on ten broad areas namely are necessary for industrial growth and expansion: (i) Creating an enabling environment; (ii) High value addition to harness the agricultural, mineral, natural and forestry resources; (iii) development of priority industrial sub-sectors; (iv) Enhancing human resource skills through development of technical, entrepreneurial, production and managerial skills for industrial development; (v) measures for attracting local and foreign direct investment; (vi) Local and export market expansion and diversification for manufactured products; (vii) Enhancing standards, quality infrastructure and intellectual property rights regime; (viii) strengthening industrial research, development and innovation; (ix) facilitating the growth and graduation of the MSMIs for industrial expansion; and (x) provision of access to affordable and appropriate financial services for industrial growth and expansion (Republic of Kenya, 2012). The implementation of these interventions by the government will go a long way in stimulating industrial growth. Poor quality road network and infrastructure present a challenge to the manufacturing sector, in the form of increased manufacturing costs. Transport is required in the production procedures, from transportation of raw materials to delivery to the final consumer.

1.2.2. Electricity and Industrial Growth

Energy is a fundamental factor of production. Energy is an important input for economic development and electricity sector is an indispensable infrastructure in any economy. The process of economic development necessarily involves a transition from low levels of energy consumption to higher levels and where the linkages among energy, other factor inputs and economic activities changes significantly as an economy moves through different stages of development (Wolde-Rufael, 2006).

Electricity is considered an enabler of the world's economic growth and development (Ministry of Energy, 2021). A study by (Mose, 2021) identified electricity infrastructure as one of the determinants of growth in Kenya. The study implied that in order to effectively boost economic growth in Kenya, policies and resources should be directed at looking into the key factors which among other factors electricity infrastructure. Any expansion in electricity infrastructure is estimated to stimulate agriculture process and industrial activities at local level as an additional input in the production function. Access to affordable electricity power is a prerequisite for continued growth and a solution to poverty problems through increased production, consumption and output. Providing adequate and affordable electrical power is essential for economic development, human welfare and better standard of living. The Vision 2030 and the Big 4 Agenda identify energy as one of the enablers for sustained economic growth and a key foundation for Kenya's envisaged national transformation (Ministry of Energy, 2021). In the paragraphs below we look at electricity consumption, electricity supply, electricity consumption and electricity access.

1.2.2.1. Electricity Consumption

(Olufemi, 2015) Studied the relationship between electricity consumption and industrial growth in Nigeria, from 1980 to 2012. The study concluded that there was a long-run significant positive relationship between industrial growth and electricity consumption. The electricity consumption in Kenya increased from 6,581 GWh in 2012/13 to 8,272 GWh in 2016/17 which is approximately 26% growth (Ministry of Energy, 2018). The commercial/industrial sales which are the bulk of total electricity sales are driven by the performance of the manufacturing sector and large commercial establishments in the economy. The energy consumption increased from 9,280GWh in 2014/15 to 11,462GWh in 2019/20 representing an average growth of 4.5% over the six years period. There was a slowdown in electricity consumption in 2019/20 attributable to the COVID-19 which resulted in government containment measures creating economic shocks and adversely affecting the energy sector. The slowdown was followed by a gradual recovery as the government eased the containment measures enabling resumption of various economic activities. Energy use and economic growth go hand in hand. Kenya is expected to use more energy in the commercial sector on the road to 2030. Electricity remains the most sought-after energy source by our society and access to electricity is normally associated with rising or high quality of life (Ministry of Energy, 2018). According to (Privacy Shield Framework, 2019), Kenya’s estimated nominal GDP was $75 billion in 2017. In the same year Kenya’s per-capita power consumption was 178 kWh compared to 126 kWh in Nigeria, which has a per-capita GDP nearly 3 times higher.

Table 1.1 Kenya Electricity Consumption Patterns

	2015/16	2016/17	2017/18	2018/19	2019/20
National Annual Consumption (GWh)	7,867	8,250	8,435	8,742	8,755

Source (LCPD Kenya 2021)

1.2.2.2. Electricity Supply

A study by (Ellahi, 2011) showed that a sustained and incessant supply of electricity is an important determinant of industrial sector performance, which further contributes to better growth of economic indicators. Over the years, the installed generation capacity of Kenya has considerably grown, rising from 1,310 MW in 2008 up to 2,333 MW in June 2017. The positive growth of generation is related to positive growth in commercial/ industrial electricity consumption (Ministry of Energy, 2018). The installed capacity at the end of 2017 stood at 2333MW, a significant growth from 1800MW in 2014 but still low for a country with a population of 48 million. The government of Kenya is pursuing efforts that will increase power supply and lower the cost of electricity by injecting cheaper renewable energy sources such as geothermal, wind and solar; addition of coal to the energy mix and weaning off the more expensive HFO plants (Privacy Shield Framework, 2019).The installed generation capacity further increased to 2,840MW in FY 2019/20 representing an annual average growth rate of 4.49% over the past five years. As of December 2020, Kenya had a total interconnected effective capacity of 2,708 MW (Ministry of Energy, 2021). It is expected that development projects recommended under Vision 2030 and the overall economic growth will increase demand on Kenya's energy supply.

Table 1.1 Installed and Effective Capacity and Effective Power Generation as at 30th June 2020

	Installed Capacity (MW)	% Installed	Effective Capacity
Hydro	834	29.37%	805
Geothermal	863	30.39%	05
Thermal (MSD)	660	23.25%	640
Thermal (GT)	60	2.11%	56
Wind	336	11.81%	326
Biomass	2	0.07%	2
Solar	50	1.77%	50
Off grid thermal, solar and wind	35	1.22%	24
Total Capacity MW	**2,840**	**100%**	**2,708**

Source: Kenya Power

1.2.2.3. Retail Electricity Tariffs

(Korsakienė et al., 2013) In their study to find out if increasing prices of gas and electricity retard development of industrial sector of Lithuanian economy, found that an increase of energy prices has not had significant malign impact on industrial sector development. Kenya's electricity subsector is unbundled in nature with separate entities undertaking different functions pertaining to generation, transmission, distribution and retailing. The retail tariff is designed in a way that it incorporates costs associated with these functions. The average retail tariff has been considerably stable ranging between KShs. 14 and KShs. 15 (Ministry of Energy, 2018). An increase in electricity price in Kenya would be expected to make Kenyan manufacturers less competitive in a region where the pricing of energy plays a central role in determining the cost of consumer goods and services, and in attracting foreign investors.

Table 1.2 Income, Sales, and Average Retail Tariff of Electricity in Kenya

Year	2012/13	2013/14	2014/15	2015/16	2016/17
Total Units Sold (GWh)	6,581	7,244	7,655	7,912	8,272
Total Income from Electricity (KShs '000')	94,921	112,625	114,814	118,186	131,118
% Increase PA	(6.5)	18.7%	1.9%	2.9%	10.9%
Average Retail Tariff (KShs/kWh)	**14.42**	**15.55**	**15.00**	**14.94**	**15.85**

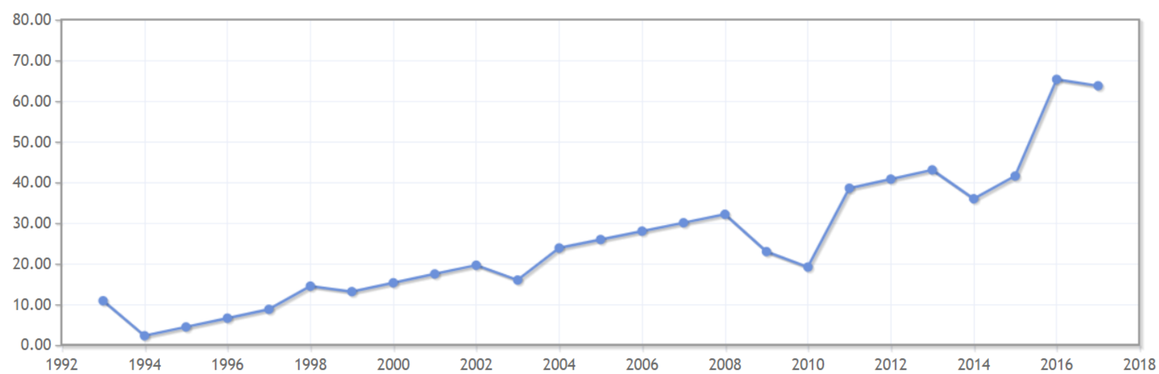
Source: LCPD Kenya 2018

1.2.2.4. Electricity Access

Policy makers around the world believe that access to modern energy (both electrical and non-electrical) is a necessary requirement for sustainable development. Of all modern energy types, electricity access is included most frequently as an explicit objective of national development strategies (Attigah & Mayer-Tasch, 2013). Access to power catalyzes economic development in rural areas and creates more jobs and new industries (Biteye, 2015).Electricity access rate in Kenya is the highest in East Africa according to the latest report from the World Bank tracking global achievements in sustainable energy for all. According to The Energy Progress Report that was released by the World Bank on 2nd May 2018 covering the period up to 2016, electricity access rate in Kenya stood at 56%, compared to Tanzania (32.8%), Rwanda (29.37%), Uganda (26.7%) and Burundi (7.5%). The electricity access rate in the country stood at 73.42% as at the end of April 2018.The national access rate has grown steadily from a low of 32% in 2013 due to accelerated investment in the distribution network and increased investment in renewable energy generation (KPLC, 2018). Kenya's electricity access stood at 76.49 percent in May

2021 (Maombo, 2022). The country has experienced a significant increase in the number of customers connected to the grid, from 3,611,904 recorded in financial year 2014/15 to 7,576,145 recorded in financial year 2019/20, of which rural connections were 1,502,943, accounting for 20% of total connections. This is an annual average growth rate of 19.14% and is attributed to accelerated electrification programs implementation across the country (Ministry of Energy, 2021). In a 2015 assessment, Power Africa lists major "bottlenecks" to electricity access in Kenya as inadequate early stage capital for project financing, land/right-of-way risks (i.e. for transmission projects) and IPP "procedural" and process issues. In addition, it points out that the inadequate transmission and distribution infrastructure prevents optimal deployment of the available power resource (Hankins, 2019).

Figure 1: Kenya Access to Electricity (% of Population)



Source: The World Bank

1.2.3. Electricity Demand Forecast

The Energy Regulatory Commission prepares indicative energy plans through the preparation of biennial Least Cost Power Development Plans (LCPDPs) in conjunction

with sector utilities. A realistic electricity demand forecast is critical for developing an optimal power system expansion plan. A high load forecast may lead to over-investment in redundant capacities, while a low demand forecast may result in capacity shortfalls that would slow down economic development (Ministry of Energy, 2021). The Updated Least Cost Power Development Plan for 2021 identifies the main drivers of projected electricity demand as: a) Demography of Kenya, this includes population growth and urbanization.
b) GDP growth directly impacts on household's income and activity of the productive sector translated into electricity consumption of commercial and industrial customers. c) Vision 2030 Flagship projects, these projects have an impact on GDP growth and contribute to demand growth based on their specific load requirements.

Three scenarios were considered in projecting electricity demand up to 2037: Reference Scenario**,** this is the base case scenario with development projected from the historical growth. High Scenario**,** this scenario is based on the development patterns highly driven by Vision 2030 growth projections and implementation of flagship projects and Low Scenario, the low scenario represents a low growth trajectory where most of the government plans are not implemented as planned. It is assumed that in this scenario economic development will be at the existing rate with no expected increase (Ministry of Energy, 2018).

Vision 2030 Flagship Projects

The vision identifies projects that have a significant bearing on future GDP growth as well as an effective spike in energy demand (Ministry of Energy, 2018).

Table 1.4 Flagship Projects and their Assumptions

Project	Reference				High			
	First year of operation	Initial load (MW)	Year of total load	Total Load (MW)	First year of operation	Initial load (MW)	Year of total load	Total Load (MW)
Electrified mass rapid transit system for Nairobi	2024	15	2030	50	2022	15	2027	50
Electrified standard gauge railway Mombasa – Nairobi	2022	98	2030	130	2021	100	2028	300
Electrified standard gauge railway Mombasa – Malaba	2026	61.74	2035	61.74	2024	63	2032	189
Electrified LAPSSET standard gauge railway	-	-	-	-	2035	30	2037	30
Oil pipeline and port terminal (LAPSSET)	2025	50	2037	150	2022	50	2032	150
Refinery and petrochemical Industries (LAPSSET)	2028	25	2037	100	2025	50	2030	200
Konza Techno City	2024	2	2037	190	2022	2	2034	200
Special Economic Zones	2021	5	2037	110	2020	30	2028	110
Integrated Steel Mill					2030	100	2035	200

Source: LCPD 2018

Demand Forecast Results

Annual electricity demand and peak load are expected to grow for all scenarios over the period 2017 - 2037. For the reference scenario, the gross electricity consumption grows from 10,465GWh in 2017 to 14,334GWh and 39,187GWh in 2022 and 2037 respectively as per Table 6. This represents an average annual growth of 6.7% per annum. Electricity peak demand is expected to grow to 9,790MW in 2037 which is more than five times of the peak demand recoded in 2017 in the high scenario. This is mainly driven by the utilization of load achieved through the implementation of the flagship projects. In this scenario the energy consumed grows by approximately 8.8% growth per year. In the low scenario, the electricity consumption growth is gradual over the planning period averaging 5% per annum. The energy consumed increases to 27,945 GWh by the year 2037 from 10,465 GWh in 2017 (Ministry of Energy, 2018).

Table 1.3 Projected Energy Demand by Scenarios

Least cost power development plan 2017 – 2037									
	Low			**Reference**			**High**		
Year	**GWh**	**Growth**	**MW**	**GWh**	**Growth**	**MW**	**GWh**	**Growth**	**MW**
2017	10,465	4.9%	1,735	10,465	4.9%	1,754	10,465	4.9%	1,754
2018	11,032	5.4%	1,842	11,169	6.7%	1,866	11,470	9.6%	1,917
2019	11,530	4.5%	1,928	11,820	5.8%	1,978	12,464	8.7%	2,088
2020	12,071	4.7%	2,021	12,546	6.1%	2,103	13,676	9.7%	2,293
2021	12,612	4.5%	2,114	13,312	6.1%	2,234	14,900	9.0%	2,516
2022	13,156	4.3%	2,207	14,334	7.7%	2,421	16,456	10.4%	2,766
2023	138,910	5.0%	2,319	15,293	6.7%	2,586	17,989	9.3%	3,027
2024	14,503	5.0%	2,438	16,327	6.8%	2,764	19,799	10.1%	3,342
2025	15,229	5.0%	2,563	17,750	8.7%	2,989	22,056	11.4%	3,705
2026	15,982	4.9%	2,692	19,098	7.6%	3,224	24,295	10.1%	4,078
2027	16,780	5.0%	2,829	20,393	6.8%	3,441	26,572	9.4%	4,450
2028	17,627	5.0%	2,975	22,082	8.3%	3,720	29,043	9.3%	4,854
2029	18,525	5.1%	3,129	23,593	6.8%	3,974	31,509	8.5%	5,261
2030	19,475	5.1%	3,293	25,195	6.8%	4,244	34,847	10.6%	5,780
2031	20,482	5.2%	3,466	26,864	6.6%	4,525	37,632	8.0%	6,251
2032	21,552	5.2%	3,651	28,640	6.6%	4,826	40,587	7.9%	6,752
2033	22,798	5.8%	3,872	30,529	6.6%	5,148	43,635	7.5%	7,272
2034	22,008	5.3%	4,081	32,542	6.6%	5,491	46,954	7.6%	7,842
2035	25,297	5.4%	4,305	34,691	6.6%	5,859	50,595	7.8%	8,468
2036	26,561	5.0%	4,523	36,848	6.2%	6,232	54,105	6.9%	9,094
2037	27,945	4.2%	4,796	39,187	6.3%	6,638	57,990	7.2%	9,790

Source: LCPD 2018

1.3. Statement of the Problem

One of the important factors affecting Kenya's development process is the low level of industrial development. There is an obvious and immediate role for industrialization as a key driver for economic growth and sustainability in Kenya. Across the globe, industrialization has been credited for increased per capita income, growth in international trade, high levels of employment and increased investment.

According to (Jucker et al., 2008) industrial and economic growth for all developing economies is strongly dependent on the supply levels of electrical energy and access to reliable supplies of electricity. (Isaksson, 2010) says that the most direct role of energy is that of an input to production. In effect, a world without electricity amounts to non-mechanized production. Erratic supply of electricity disrupts production, voltage fluctuations negatively affect the durability of machines.

Kenya has seen an upward trend in demand for electricity over the past decade. Rapid population and economic growth in Kenya have resulted in rapid rise in energy demand.
Kenya’s economic growth has put the country’s electricity supply under increasing pressure. Between 2004 and 2013 power demand rose by 18.9% annually (Eije (RVO.nl) & Mokveld, 2018). The Kenya’s National Economic and Social Council (NESC) recommend a reserve capacity margin of 30% to be commonly used to deal with peak electricity demand. It has been difficult for Kenya to meet its electricity demand and the 30% reserve margin so far (Kiprop et al., 2018).

The electricity supply in Kenya is relatively reliable. Kenya has not experienced load shedding since June 2011, when there was as a shortfall of up to 90MW caused by low water levels at Masinga Dam. Improved electricity generation mix has increased power reliability. Over the years (from 2008 to June 2017) installed generation capacity has grown at an average growth rate of 7.8% annually. If electricity supply is not accelerated to match the projected demand, Kenya will have generation shortfall of electricity before the year 2030 which will result in load shedding and curtailed industrialization.

Electricity energy in Kenya is expensive resulting in high costs of production. According to (Hankins, 2019), Kenyan industrialists have stated that exceptionally expensive electricity is among the main causes of manufacturer and investor migration to neighboring countries. In 2016, Sameer Africa, the manufacturer of Yana tires closed its Nairobi plant due to stiff competition from cheap tires from China and India. Kenya manufacturing firms are paying KShs. 21 per kilowatt of power while manufactures in Ethiopia are paying KShs. 4 per kilowatt of power (Omondi, 2017). Kenya is yet to achieve universal electricity access. The electricity access rate in the country stood at 73.42 percent as at the end of April 2018 (Njugunah, 2018). The Kenya government had targeted universal electricity access by 2020. The government has missed this target but is on course to meet the global target ahead of 2030. (Omusolo, 2019).

Escribano and Guasch in 2005 developed an econometric method to assess the impact of electricity shortages on firm-level productivity using variables from World Bank Investment Climate surveys. When applied to Guatemala, Honduras, and Nicaragua, they found that a 1 percent increase in the average duration of power outages decreased productivity by 0.02-0.1 percent. Since electricity is strongly complementary to other production inputs, it constitutes a bottleneck to production if not available.

Contrary to the widespread belief that electricity spurs productivity, a study by (Abokyi et al., 2018) showed that electricity consumption had a negative impact on manufacturing sector output in Ghana. The relationship between electricity energy and industrial growth in Kenya has not been studied. This research seeks to fill this gap in the body of knowledge

1.4. Objectives of the Study

General Objective

The general objective of this study is to analyze the relationship between electricity energy and industrial growth in Kenya.

Specific Objectives of the Study

1. To determine how electricity consumption affects industrial growth in Kenya.
2. To examine the effects of electricity supply on industrial growth in Kenya.
3. To evaluate how changes in electricity tariff affects industrial growth in Kenya.
4. To describe effects of electricity access on industrial growth in Kenya.

1.5. Hypotheses of the Study

Four null hypotheses will be tested relating industrial growth to the determinants postulated in the objective of the study. The hypotheses are as listed.

H_{O1} Electricity consumption has no significant effect on industrial growth in Kenya.

H_{O2} Electricity supply has no significant effect on industrial growth in Kenya.

H_{O3} Electricity tariff has no significant effect on industrial growth in Kenya.

H_{O4} Electricity access has no significant effect on industrial growth in Kenya.

1.6. Significance of this Research

Under Vision 2030, Kenya aspires to be a middle income, rapidly industrializing country and globally competitive by the year 2030. To achieve this, Kenya's GDP must grow by US$4-6 billion per year, which is a growth rate of 10% per year. Kenya is still in the process of industrialization. In order to avoid the adverse effects of electrical power shortages on industrial production, the government should ensure adequate power generation to meet the industrial electricity demand. Kenya's industrial growth and its global competitiveness will hinge on the availability of reliable and quality power at competitive rates to all consumers at all places. Development of the industries and the entire economy is not possible without matching development of the power sector. World Bank Investment Climate Surveys of businesses in LDCs have consistently identified electric supply as the most common constraint on economic output in developing countries. Electricity is identified as the most serious obstacle to operation and growth by manufacturing companies.

This study will act as a guide to policy makers and the Government of Kenya on the need to ensure increased generation, low cost of electricity and increase accessibility. This will reduce cost of production, making manufactured goods fairly priced, thus becoming competitive in the local, regional and international market. The study sheds light on the role of electricity in industrialization and achievement of vision 2030 goals in. Finally in the field of academia, the study adds to the field of knowledge.

1.7. Scope of the Research

The scope of this study was limited to Kenya. The study analyzed the relationship between electricity energy and industrial growth in Kenya for the period between 1983 and 2020.

The explanatory variables in the study were electricity consumption, electricity supply, electricity tariff and electricity supply. Industrial growth was the explained variable. The study used annual time series data from 1980 to 2022 and had a total of 38 observations for each variable. The study period was guided by the availability of newer data, which is more relevant, valid and has not been overtaken by time. Data for industrial growth and electricity supply was obtained from the KNBS Economic Survey. Data for electricity consumption and electricity tariff was obtained from the KPLC annual reports. Data for electricity access was obtained from the official website of The World Bank. Data for electricity supply, electricity consumption, electricity tariff and electricity access is for the entire Kenya, data for the entire country was used because it was available.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter provides a review of literature on electricity energy and industrial growth. In this chapter we also look at other studies carried out relating to electricity energy and industrial growth. The chapter starts with an introduction, followed by theoretical literature review, empirical literature and then theoretical framework.

2.2. Key Concepts

The invention and application of the electric power technology triggered the second industrial revolution in human history, which marked the human society entered the age of electricity. Electricity provides sustainable power for economic and social development. With the rapid development of an economy, electricity consumption also increases. The increase of electricity consumption has further promoted the progress of the industrial economy (Zhang et al., 2017).

As a typical kind of secondary energy, electricity is obtained from primary energy conversion. It is a kind of basic energy resource closely related to the growth of national economy and improvement of people's livelihood. Electricity is an important driving force to promote the economic and social development of a country. Increasing electricity consumption, especially industrial electricity consumption, is an important symbol of a country's economic development level. With the rapid development of China's economy, electricity demand is also growing rapidly. The production and consumption of electricity have a direct impact on the quality and speed of economic growth. It is believed that the amount of electricity consumption is a real-time reflection of the economic development situation, but the relationship between them is not precise one-to-one (Zhang et al., 2017).

It is generally believed that the economic development mode depends on the energy structure of a country, and the energy structure reflects the level of economic development conversely. Therefore, without changes in the energy structure, economic and social transformation will lack motivation and the development foundation will be unsustainable. In nowadays, constrained by resources and environment, the world is experiencing a new energy consumption transition from high carbon to low carbon (Zhang et al., 2017).

Electric power industry is the fundamental industry of the national economy, and electricity consumption is particularly sensitive to economic development. Therefore, electricity consumption is one of the important indicators to evaluate the economic growth of a country. It is necessary to conduct a comprehensive quantitative analysis on the relationship between electricity consumption and economic growth. In order to solve the contradiction between electricity supply and demand, many domestic and foreign researchers have analyzed the relationship between electricity consumption and economic development in China using a variety of methods. In 1970s, as the world's third largest energy consuming country, China was also a poor developing country. During this period, it was more important to build large power plants and promote the construction of large hydropower stations. However, there was no sustainable energy policy at that time (Zhang et al., 2017). In the paragraphs below we will look briefly at industrial growth in Kenya.

2.2.1. Industrial Growth in Kenya

Although it was an early leader in Africa's industrial development, Kenya's long-run experience with industrialization has been disappointing. Manufacturing as a share of GDP has remained virtually constant over the past 30 years. In 2010 it was 11.2%, only modestly higher than the Africa-wide average of 10% and well below the value predicted for its level of income. Between 1990 and 2010 the average rate of growth of manufacturing was less than 2% and manufacturing output per worker declined. Manufacturing sophistication, a key driver of overall growth has declined significantly over the past three decades (Page, 2016).

Three major policy regimes, namely import substitution, market liberalization and export promotion have greatly influenced Kenyan industrialization since independence in 1963. Overall, import substitution strategy was successful in establishing some primary industries but led to reduced domestic competition and low-capacity utilization. Market liberalization policies in 1980 failed as local industries were unable to compete with imports. The export orientation strategy in the 1990s was unsuccessful due to poor implementation of fiscal initiatives and macro-economic mismanagement. Reforms since 2003 have stabilized industrial production but challenges remain in infrastructure, energy and market access. The future of Kenyan industry lies in high-value production (Chege et al., 2014).

Kenya has one of the most developed power sectors in sub-Saharan Africa, having opened its market to Independent Power Producers (IPPs) in the mid-1990s. Kenya benefits from factors including: an active private sector; Kenya Power's long track record as a creditworthy off-taker; and abundant renewable energy resources, especially geothermal, wind and solar. Limited and aging distribution infrastructure, high technical and commercial losses, opaque procurement processes, right of way disputes, PPA inconsistencies, and other challenges affect sector growth (United States Agency for International Development, 2022).

2.2.1.1. Import Substitution Hangover 1963–70

Like many developing countries, Kenya's early years of independence pursued an industrialization strategy that relied on an import substitution (IS) strategy in which the government provided both direct support and tariff protection for the industry. This strategy was a carryover from colonial policies, and its objectives were rapid growth of industry, easing balance of payment pressures, encouraging indigenous participation in the sector, increasing productivity and high-income employment. However, the IS policy failed to create much-needed employment because of its capital-intensive nature. Its high import content also caused major balance of payment problems (Chege et al., 2014).

2.2.1.2. Structural Adjustment and Liberalization: The 1980s and 1990s

During the 1980s, the government introduced structural adjustment programs (SAP) in order to, inter alia, strengthen competitiveness and reduce excess capacity in the industrial sector and to address concerns raised about distortions caused by the import substitution strategy. In 1993, import licensing schedules were abolished and capital and current transactions were fully liberalized in 1994 with the removal of all price controls. In the same year, Kenya joined the World Trade Organization (WTO) and the Kenyan economy was declared 'open'. We can therefore conclude that the structural adjustment programs led to liberalization of the domestic economy, for both output and input markets and opened it to international competition. However, the industrial sector continued to be inward oriented, excessively import-dependent, capital-intensive, and incapable of absorbing an adequate proportion of the rapidly increasing labour force (Chege et al., 2014).

2.2.1.3. New Millennium Policies

Further relevant policy changes have occurred since the year 2000 that have had significant implications for industrial development and trade in Kenya. That year, the US government enacted AGOA that allowed African countries to export textiles and garments duty-free and without import quota restrictions. Kenya signed into AGOA soon after it was enacted, giving the EPZs a fresh push. The rise in exports of garments and apparel from Kenya from US$30 million to US$249 million between 2000 and 2005 has been attributed to export opportunities in the US fabric market. Kenya's export performance was further boosted by the revival of the EAC and greater participation by the country in the COMESA. The Kenyan government's efforts to improve the sector's performance culminated in drafting the National Industrial Policy (NIP), finalized in 2007. Under Vision 2030, the dream is to develop a diversified, robust and competitive manufacturing sector. This dream is to be realized through emphasis on local production, expansion in the regional markets, and identification of Kenya's niche in global markets (Republic of Kenya 2007). This means that Vision 2030 is preoccupied with external markets, and there is a significant preoccupation with export-oriented strategies, and anticipation of a greater role for the manufacturing sector. For this reason, there have been fresh efforts to promote special economic zones and industrial parks, as well as industrial clusters. Of special focus under Vision 2030 is also the development of business process outsourcing, exploiting the country's rapid growth in the information communications and technology sector. The building of a self-sustaining export-oriented industrial sector has been the central focus of the country's industrial development policy. Despite structural reforms undertaken, a close analysis of the manufacturing sector shows that supply responses to the policies have been poor (Chege et al., 2014).

2.3. Theoretical Literature Review

2.3.1. Classical Theory of Economic Growth

Economists have explained economic factors and their impact on economic growth using theories of economic growth. The Classical Growth Theory postulates that a country's economic growth will decrease with an increasing population and limited resources. Such a postulation is an implication of the belief of classical growth theory economists who think that a temporary increase in real GDP per person inevitably leads to a population explosion, which would limit a nation's resources, consequently lowering real GDP. As a result, the country's economic growth will start to slow (Corporate Finance Institute, 2021).

Classical growth theory was developed alongside the emerging conditions brought about by the industrial revolution in Great Britain. In formulating the theory, classical economists sought to provide an account of the broad forces that influenced economic growth and of the mechanisms underlying the growth process. Accumulation and productive investment, in the form of profits, were seen as the main driving force. Hence, changes in the rate of profit were a decisive reference point for an analysis of the long-term evolution of the economy. Analysis of the process of economic growth was a central focus of English classical economists, most notably Adam Smith, Thomas Malthus, and David Ricardo.

Scottish economist Adam Smith was the leading figure of the classical theory of growth. Smith wrote that the division of labor among workers into more specialized tasks was the driver of growth in the transition to an industrial, capitalist economy. As the Industrial Revolution matured, Smith argued that the availability of specialized tools and equipment would allow workers to further specialize and thereby increase their productivity. In order for this to happen, ongoing capital accumulation was necessary, which depended on the owners of capital being able to keep and reinvest profits from their investments. He explained this process with the metaphor of the "invisible hand" of profits, which would push capitalists to engage in this process of investment, productivity gains, and reinvestment by seeking their own personal gain, and indirectly the benefit of the entire nation (Kenton, 2021).

A limitation of the classical model of growth is that the theory ignores the role efficient technical progress could play for the smooth running of an economy. Advancements in technology can minimize diminishing returns (Corporate Finance Institute, 2021).

2.3.2. Neoclassical Growth Theory

The Neoclassical Growth Theory is an economic model of growth that outlines how a steady economic growth rate results when three economic forces come into play: labor, capital, and technology. The traditional, neo-classical model of economic growth was first developed by Solow and Swan in the 1950s (Muldera & Hof, 2001).The simplest and most popular version of the Neoclassical Growth Model is the Solow-Swan Growth Model. The basic version of the Solow-Swan model is built on two equations, a production function and a capital accumulation equation. The basic conclusion of the model is that physical capital cannot account for all the growth or geographic differences over time in terms of output per capita. The model begins with a simplifying assumption: there is no technological progress and hence, the economy reaches a long-run level of output and capital called the steady-state equilibrium. The model assumes a closed economy which produces one good using both labour (L) and capital (K). Labour grows at a constant exogenous rate and the saving rate is exogenously determined. All saving is invested, meaning that S = Y = sY; there is no government and a fixed number of firms in the economy. Each firm has the same production technology. Output price is constant and factor prices adjust to ensure full utilization of all inputs. Output is a function of labour and capital; the production function exhibits constant returns to scale and diminishing returns to individual factors of production, and has a unitary elasticity of substitution between factors. The first equation of the model is based on the production function that takes the form:

$Y = F(K, L)$ ……………………………………………………(i)

The function is neoclassical if three properties are satisfied. First, for all $K > 0$ and $L>0$, F (.) exhibits positive and diminishing marginal products with respect to each input:

$\frac{\partial F}{\partial K} > 0$ ………………………………………………………… (ii)

$\frac{\partial F}{\partial L} > 0$………………………………………………………… (iii)

F (.) exhibits constant returns to scale in all factors together

$F(\lambda K, \lambda L) = \lambda Y$…………………………………………………… (iv)

The marginal product of capital or labour approaches infinity as capital or labour goes to 0 and approaches to 0 as capital or labour goes to infinity. In the 1980s, during an economic slowdown, that model was criticized as it explained economic growth, and more specifically technological progress, by simply postulating it. Dissatisfaction with the traditional Solow-Swan model of economic growth resulted in two new classes of models of economic growth and technological change: neo-classical endogenous growth models, and evolutionary growth models. The first class of models has been labeled endogenous, because of its key feature of endogenizing technological change. The second class of models endogenizes technological change as well, but according to an evolutionary view on economic growth and technological change (Muldera & Hof, 2001).

2.3.3. Endogenous Growth Theory

Unsatisfied with Solow's explanation, economists worked to "endogenize" technology in the 1980s. The endogenous growth model incorporated a new concept of human capital, the skills and knowledge that make workers productive. Unlike physical capital, human capital has increasing rates of return. Therefore, overall, there are constant returns to capital, and economies never reach a steady state. Growth does not slow as capital accumulates, but the rate of growth depends on the types of capital a country invests in. Research done in this area has focused on what increases human capital or technological change (Elhanan, 2004).

The neoclassical growth theory is based is on the assumption of diminishing returns to capital, attributes long-run growth to technological progress, but leaves unexplained the economic determinants of that technological change. Due to strong empirical evidence against the neoclassical prediction that economic growth and saving rates should be uncorrelated in the steady-state, and other studies that found no convergence of per capita income in the world economy, endogenous growth models relaxed the assumption of diminishing returns to capital and essentially showed that with constant or increasing returns, there can be no assumption of the convergence of per capita incomes across countries reaching a long-run steady-state growth equilibrium at the natural rate. Thus, if there are no diminishing returns to capital, it is easy to deduce that investment is important for long-run growth and therefore, growth is endogenous in this respect.

Endogenous growth theory encompasses a class of models that goes beyond Solow-Swan by endogenizing technological change. One of the first attempts to endogenize technology was made by Arrow, who assumed that the growth rate of the effectiveness of labor is a result of workers' cumulated experience in producing commodities, or in other words, the result of ''learning by doing.'' This implies that the labor productivity is now endogenous, being an increasing function of cumulated aggregate investment by firms. An important characteristic of the Arrow model is that learning is considered as a public good; it is the result of experience at the level of the whole economy and can be applied by all firms at no cost. This also means that in deciding how much to invest, firms ignore the effect of their investment on the total amount of knowledge in the economy because the effects are external to each individual firm. A major step forward in endogenizing technological progress was set by Romer, who builds upon the contributions of Frankel and Arrow. The basic idea of his approach is that technology grows in proportion to the macroeconomic capital stock, potentially offsetting the effects of diminishing returns. Capital in such a setting should be considered as a broad concept, including human and intangible capital. This approach is currently known as the ''AK approach'' because it results in a production function of the form Y = AK with A constant. The individual firm's production function reads:

$Y = AK$………………………………………………………. (i)

Long-run economic growth can be sustained in the long run without relying on exogenous technological progress. The rationale for this approach in which technological development or learning is external to the firm, lies in the difficulty of dealing with increasing returns in a general equilibrium framework. By introducing a (Marshallian) externality, a competitive equilibrium, in which capital and labor receive their marginal products can exist. In other words, there exist constant returns to scale at the firm level and increasing returns at the economy level due to increasing knowledge. In conclusion, the essential idea of the Romer model is that knowledge can be considered as a kind of renewable capital good, where K should be interpreted as knowledge (Muldera & Hof, 2001).

The study of Electricity Energy and Industrial Growth was guided by the endogenous growth theory because the theory emphasizes that economic growth is an endogenous outcome of an economic system, not the result of forces that impinge from outside. The Solow-Swan model was not used for this study because it assumes that technological progress is exogenous and has no optimization in it since the saving rate is assumed exogenous and constant. The Solow-Swan model gives an incomplete picture of the growth process, because the driving force in long-run growth (technological progress) is outside the model is exogenous (Hernández, 2003). This study did not use the Classical growth theory because the model ignores the role efficient technical progress could play in an economy. The Classical growth theory does not recognize that advancement in technology can minimize diminishing returns.

2.4. Empirical Literature Review

Electricity energy is an important factor of production and crucial for industrialization and economic growth. The quest for rapid and firmly economic growth is a function among other variables, an adequate supply and distribution of energy particularly electricity.

Electricity is an important promoter of socioeconomic development. Growth in industrial electricity energy use is recognized as an instantaneous indicator of a country's economic progress (Abokyi et al., 2018).

(Enu & Havi, 2014) Examined the extent to which electricity energy influences economic growth in Ghana and if it is electricity consumption that causes economic growth in Ghana or otherwise. The study employed Augmented Dickey-Fuller test, Cointegration test, Vector Error Correction Model and Granger Causality test. The study revealed that, in the long term, a hundred percent increase in electricity power consumption will cause real gross domestic product per capita to increase by approximately fifty-two percent. However, in the short run, electricity consumption negatively affects real gross domestic product per capita. The study again revealed that unidirectional causality run from electricity consumption to economic growth meaning that any policy actions taken to affect the smooth consumption of electricity in Ghana will affect her gross domestic product per capita.

(Onuonga, 2012) Studied the causal relationship between economic growth and energy consumption. The paper investigated the causal relationship between energy consumption and economic growth in Kenya using published data. By using the Ganger-causality and Error Correction Model, the results suggested that economic growth causes energy consumption in Kenya. The implication of the study was that energy conservation measures would not lead to negative effects on the country's economic growth.

(Odhiambo, 1991) analyzed the manufacturing sector in Kenya; his study was based on a time series regression model, Ordinary Least Squares. The findings of his study were that per capita income, export of manufactures, government expenditure and import substitution had statistically significant influence on manufacturing output growth.

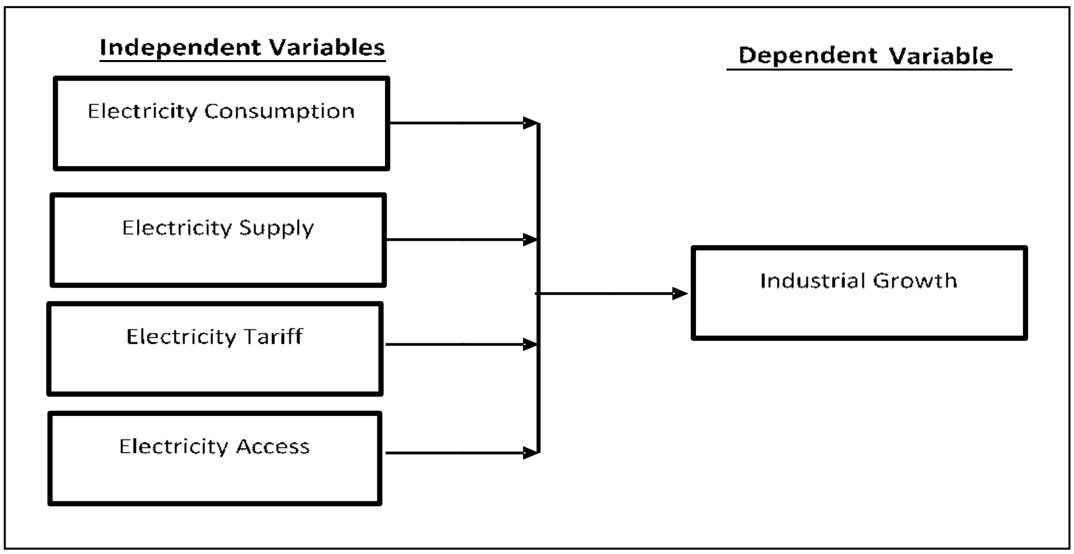
(Mulea, 2011) Studied elasticity of demand for electricity in Kenya, using secondary annual time series data from 1971 to 2012. The study employed Ordinary least Squares and the Error Correction Model in data analysis. The results indicated that in the short run industrial production and kerosene prices were key factors that determine demand for electricity. In conclusion, Mulea noted that the government should strive to improve efficiency through modernizing industrial technology. The government should also increase production of electricity to match the industrial growth. In order to analyze the dynamic relationship between energy and economic growth in Mexico (Zamarripa et al., 2017) used the neo-classical production function with labor, capital and energy as separate inputs in the production technology. The results showed that there is a long run relationship between industrial output and electricity output, and that energy is key for economic growth.

A study by (Olufemi, 2015) analyzed the relationship between electricity energy and industrial growth in Nigeria. The study used time series data covering the period between 1980 and 2012 and the data collected were analyzed using co-integration and error correction techniques to estimate the short-run and long-run dynamics of the research models respectively. The model specification used in this research followed the model of Romer. Romer takes investment in research technology as endogenous factor in terms of the acquisition of new knowledge by rational profit maximization firms. The result established that in the long run, there is a significant positive relationship between industrial growth and electricity consumption, electricity generation, labour employment and foreign exchange rate while it showed a negative relationship between industrial growth and capital input.

2.5. Conceptual Framework

The conceptual framework for this study is as shown in figure 2 below.

Figure 2: Conceptual Framework



2.6. Operationalization of Research Variables

Industrial growth is the increase of the output of manufactured consumer and capital goods in an economy. Manufacturing value added growth rate will be the proxy for industrial growth in this study. Manufacturing Value added is measured in Kenya Shillings (KShs). This is guided by the fact that growth in manufacturing output is interpreted as increase in industrial growth.

Electricity consumption is the actual energy demand made on existing electricity supply; it is measured is measured in kilowatt-hours (kWh).

Electricity supply is a measure of electricity produced over time; in this study installed capacity of electricity will be used as the measure of electricity supply. Installed capacity is the total capacity of electricity generation devices in a power station or system is usually expressed in megawatts (MW).

Electricity tariff is the average price paid by electricity consumers at a given time and is measured in Kenya Shillings per kilowatt hour (KShs/kWh).

Electricity access is a measure of share of people with electricity. Electricity is crucial for improved living standards is therefore an important social and economic indicator. Electricity access is measured as a percentage (%) of a population.

2.7. Summary of Gaps to be Filled

There is a general consensus among researchers that a relationship exists between industrial electricity consumption, economic growth and development (Abokyi, Appiah-Konadu, Sikayena, & Oteng-Abayie, 2018). According to (Muchira, 2018), manufacturing sector is the largest electricity consumer, consuming about 65 per cent of all power produced in Kenya. (Abokyi et al., 2018) Studied consumption of electricity and industrial growth in Ghana in the case of Ghana. The study covered the period 1971 to 2014. Contrary to the widespread belief that electricity consumption spurs productivity, the study revealed that electricity consumption has a negative impact on manufacturing sector output in Ghana. This occurrence could be explained by the fact that while the average growth in electricity consumption in Ghana is positive, the share of electricity consumption by industries continues to decline on average. (Onuonga et al., 2011) studied the demand for energy in the Kenyan manufacturing sector using secondary data for the period 1970-2005.

The results showed that oil and electricity were significant substitutes in the Kenyan manufacturing sector. The study found that that the substitution possibilities were low, and electricity and oil were price inelastic. (Okwiri, 2006) studied the relationship between electricity consumption and economic growth in Kenya using secondary data for the period 1970-2004. The results of the study indicated a bidirectional relationship running from electricity consumption to GDP and vice versa. An increase in electricity consumption would raise real GDP while improved economic growth would trigger higher electricity consumption. (Onuonga, 2012) studied the causal relationship between economic growth and energy consumption in Kenya using secondary data over the period 1970-2005. The paper investigated the causal relationship between energy consumption and economic growth in Kenya using published data. The study suggested that economic growth causes energy consumption in Kenya and the implication of the study is that energy conservation measures would not lead to negative effects on the country's economic growth. In Kenya the relationship between economic growth and energy consumption has been studied, also the relationship between electricity consumption and economic growth has been studied. This study seeks to drill down on economic growth and narrow on industrial growth in Kenya. This study will also concentrate on electricity energy in Kenya breaking it down into its various components namely, electricity supply, electricity consumption, electricity tariff and electricity access.

CHAPTER THREE

METHODOLOGY

3.1. Overview

This chapter outlines the methodology used to conduct the study. It specifies the research design, study area, model specification, diagnostic tests, data collection and data analysis. The various tests performed to ascertain the validity and reliability of data and robustness of the model are included in the chapter.

3.2. Study Area

The study area is the republic of Kenya. The study focused on some of the factors that influence industrial growth, which include electricity consumption, electricity supply, electricity tariff and electricity access.

3.3. Research Design

Research design is the methodology used to carry out a research. The research design to be applied in a study is guided by the purpose of the study. According to purpose, research could either be descriptive, exploratory or explanatory. Explanatory research tries to establish the relationship that exists between variables. It aims at identifying how one variable affects the other; it seeks to provide an empirical explanation to the causality and causes and effects relationship between one or more variables (Saunders, Lewis, & Thornhill, 2007). This study was explanatory in nature because it sought to identify how industrial growth in Kenya is affected by electricity consumption, electricity supply, and electricity tariff and electricity access.

Research may be deductive or inductive. Deductive research approach begins with the development of a theory or hypothesis and later the development of a strategy to test it in a context to verify or reject its claims. It is thinking from general to specific (Saunders, Lewis, & Thornhill, 2007). In this study, existing empirical theories were selected and applied and tested in assessing the relationship between industrial growth and electricity energy. Therefore, this study was deductive. Research strategy is a general plan of how a researcher intends to answer the research questions. A Researcher's strategy will determine, to a large extent, the choice of data collection methods. A case study involves a study of a particular situation and its impact in order to have a more accurate detail and in-depth of the nature of the phenomenon as it relates to a specific environment. It is mostly used where the purpose of a study is to gain a rich and an in-depth understanding of the context of the research. Mostly it is related explanatory and exploratory research that seeks to find out 'why', 'what' and 'how' issues in the case context (Saunders et al., 2007). In order to carry out this research successfully case study approach was applied. Secondary data for the period 1983 to 2020 was obtained from Kenya Power Annual Reports, Statistical Abstracts, Economic Surveys (the Statistical Abstracts and Economic Surveys are official government publications provided by the Kenya National Bureau of Statistics). The focus of the study was on the Kenyan economy with Industrial growth as the dependent variable and electricity consumption, electricity supply, electricity tariff and electricity access as the independent variables.

First, time series data of the variables was collected. Log transformation of the data followed in order to reduce the variability of the data, to improve linearity between the independent and dependent variables and to boost validity of the statistical analyses.

3.4. Target Population

All items in any field of inquiry constitute a 'Universe' or 'Population. A complete enumeration of all items in the 'population' is known as a census inquiry (Kothari, 2004). A population may be studied using one of two approaches: taking a census or selecting a sample. A sample is a subset of units in a population, selected to represent all units in a population. It is a partial enumeration because it is a count from part of the population.

Sample enumeration was used in the study. The target population comprised of the Kenya economy over the period 1983-2020. The sample selected was representative of the total population; the study period was guided by the availability of newer data, which is more relevant, valid and has not been overtaken by time.

3.5. Data Collection

Annual time series data for Industrial growth, electricity consumption, electricity supply, electricity tariff and electricity access in Kenya was collected. The study used secondary data covering the period 1983 to 2020. Data used in the study was obtained from Kenya Power Annual Reports and official government publications namely Statistical Abstracts and Economic Surveys.

3.6. Model Specification

The model specification in this research followed the endogenous model of Paul Romer. Technology is represented by energy and is an endogenous variable in this study. The aggregate production function of the endogenous model is as follows:

$Y = f(A, K, L)$.

Adopting this model, Y or the aggregate real output represented industrial output. Energy was disaggregated to electricity consumption, electricity supply, electricity tariff and electricity access. The model specification excluded two important factors of production; labour and capital, in order to get a more in-depth analysis of the relationship between electricity energy and industrial growth.

The general model **Y =f (X1, X2, X3, X4)** took the form below:

Where:

Y:	Industrial Growth
X1:	Electricity Consumption
X2:	Electricity Supply
X3:	Electricity tariff
X4:	Electricity Access

The analytical model was estimated using the vector error correction model which combines levels and differences.

$$\mathbf{Y = C + \beta X_1 + \beta X_2 + \beta X_3 + \beta X_4 + \varepsilon}$$

Where:

LNINDG:	Growth in manufacturing value added	β: Slope
C:	Autonomous growth	ε: Error

Log-linear transformation using natural log was carried out in the values of the variables to enable the regression coefficients to be interpreted as percentages.

3.7. Definition and Measurement of Variables

The table below summarizes the variables, and how they were measured.

Table 3.1 Definition and Measurement of Variables in the Model

Variable	Measurement
Industrial Growth	-Measured in KShs. It is the dependent variable and is proxied by manufacturing value added growth; this is because growth in manufacturing output is interpreted as increase in industrialization. Manufacturing value added was preferred as a proxy industrial growth over total output, because it is less affected by variations in the product mix. -Industrial growth is expected to have a positive sign.
Electricity Consumption	-Measured in kilowatt hours KWh. Electricity consumption is the actual energy demand made on existing electricity supply. - Electricity consumption is expected to have a positive sign.
Electricity Supply	-Measured in megawatts (MW). Electricity supply is a measure of electricity produced over time; in this study installed capacity of electricity is used as the measure of electricity supply. Installed capacity is the total capacity of electrical generation devices in a power station or system. - Electricity supply is expected to have a positive sign.
Electricity Tariff	-Measured in Kenya Shillings per kilowatt hour (KShs/kWh). Electricity tariff is the average price paid by electricity consumers at a given time. - Electricity tariff is expected to have a negative sign. As the tariff increases demand for electricity was expected to fall.
Electricity Access	-Measured as a percentage (%) of people in a given area, that have stable access to electricity. -Electricity access is expected to have a positive sign.

3.8. Descriptive Statistics

Descriptive statistics were used to describe the basic features of the data in the study. They provided simple summaries about the characteristics of a data set. Measures of central tendencies; Mean is the average value of each of the variables, median value shows us the middle value of each variable after sorting the data from the smallest to the largest, and mode is the most appeared value. The minimum and maximum values show us the highest and lowest figures in each of the variables.

Measures of dispersion show how spread out the data is. Standard deviation shows how far observations are from the sample average. The skewness and kurtosis of the series were calculated to show the shape of the distribution curves. Knowing the shape of the distribution curve is crucial, it guides the use of statistical methods in research analysis, this is because most methods make specific assumptions about the nature of the distribution curve. Skewness is a measure of asymmetry and shows the manner in which items are clustered around the average. In a symmetrical distribution, the items show a perfect balance on either side of the mean, but in a skewed distribution the balance is thrown to one side. The amount by which the balance exceeds on one side measures the skewness of the series (Kothari, 2004). If the skewness is between -0.5 and 0.5, the data are fairly symmetrical, If the skewness is between -1.0 and – 0.5 or between 0.5 and 1.0, the data are moderately skewed. If the skewness is less than -1 or greater than 1, the data are highly skewed. Kurtosis is the measure of the flat-topedness of a curve (Kothari, 2004). The kurtosis values for the variables in the series ranged between -0.79 and 0.55. For kurtosis, if a number is greater than +1, the distribution is too peaked. Likewise, a kurtosis of less than –1 indicates a distribution that is too flat.

3.9. Data Analysis

To establish the relationship between the dependent variable and the independent variables, the model was estimated using the vector error correction model. Data was analyzed using

E-views 12 software due to its availability and ease in running vector error correction models. First, stationarity of all variables was checked, the optimum lag length of the model was determined. The Johansen cointegration test was performed to determine whether there was cointegration in the model. Finally, a vector error correction model was used to estimate the long run equilibrium. As part of quality assurance, recorded values for all variables were reviewed for completeness.

3.9.1. Stationarity Test

Time series trends to exhibit unit root (s) over time. Unit root tests are used to test for stationarity of variables. These tests are crucial because non stationarity data yields spurious regression results. Spurious regression yields unreliable data with no economic inference, the outcome of a spurious regression cannot be used for prediction or forecasting or hypothesis testing.

The Augmented Dickey Fuller Unit Root Test (ADF) was used to test for stationarity. It analyses the existence of systematic and linear relationship between the past and the present values of variables. This study adopted ADF test hypothesis stated as follows:

H0: There is unit root in a variable.

H1: There is no root in a variable

If null hypothesis is accepted the presence of unit root is accepted.

3.9.2. Cointegration Analysis

Cointegration means that the non-stationary series moves simultaneously over time and the difference between them is stable. The cointegration equation is interpreted as the long run relationship between the variables. The Johansen Test for cointegration was used to test for cointegration. It is the most appropriate method for multivariate models. The trace statistic and eigen-max statistic were used to determine whether a linear combination of the variables reveals cointegration. The cointegration test was performed on the level form of the log-transformed variables.

The Johansen Cointegration Test hypotheses are stated as:

Ho: There are no cointegrating equations in the model

H1: There are cointegrating equations in the model

The Decision Criteria was, to reject the null hypothesis if the value of the Trace and Max-Eigen statistics are greater than the 5% critical value, otherwise accept the alternative hypothesis.

3.9.3. Vector Error Correction Model

A vector error correction model was applied to explain the relationship between industrial growth and electricity consumption, electricity supply, electricity tariff and electricity access. Short run effects were captured through individual coefficients of the differentiated terms. The coefficient of the error correction term measured the tendency of each variable to return to the equilibrium.

When a set of variables are found to have one or more cointegrating vectors, the vector error correction model which adjusts to both short run changes in variables and deviations from equilibrium is a suitable analysis technique. The optimum lag length for estimating vector error correction model is determined before specifying the model.

The general form of VECM model used in the study is:

$$\Delta Y\ t = a_1 + a_2\ ect_{t-1} + a_3\ \Delta Y_{\ t-1} + a_4\ \Delta X_{\ t-1} + \epsilon_{\ t}$$

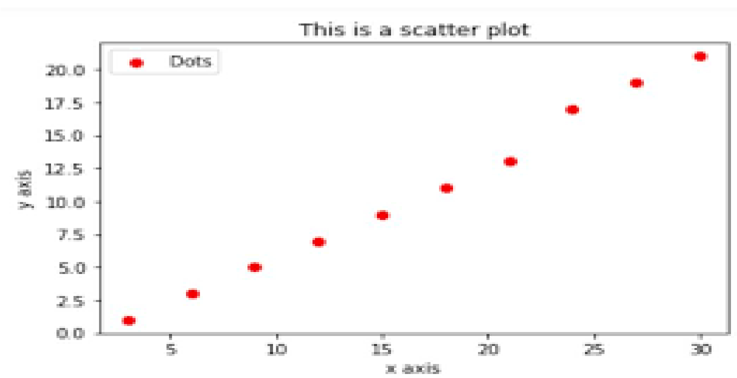
A crucial parameter in the estimation of the vector error correction dynamic model is the coefficient of the error correction term, (ect_{t-1}), which measures the speed of adjustment of economic growth to its equilibrium level (Andrei & Andrei, 2015) .

3.10. Diagnostic Tests

3.10.1. Test of Linearity

A linear regression model is assumed to be linear in parameters though it may or may not be linear in the variables (the regressand Y and the regressor x may be nonlinear). Scatterplots were used to visually assess the relationship between the explanatory variables (placed on the X axis) and the dependent variable (placed on the Y axis). If the scatter plot follows a linear pattern (i.e., not a curvilinear pattern) that shows that linearity assumption is met.

Figure 3: Scatter Plot



3.10.2. Test for Normality

One of the assumptions of the error term is that it is normally distributed. However, if this assumption is violated, the regression estimates will not have the minimum variance property in the class in the class of unbiased estimators.

To test for normality, the probability that the sample was drawn from a normal population was tested using the Jarque-Bera statistic test.

The hypotheses used to test for normality were:

Ho: The variable is normally distributed

H1: The variable is not normally distributed

3.10.3. Test for Autocorrelation

Linear regression analysis requires that there is little or no autocorrelation in the data. Autocorrelation occurs when the residuals are not independent from each other. In other words when the value of y(x+1) is not independent from the value of y(x). VEC Residual Serial Correlation LM Tests test was used to test for autocorrelation. The VEC Residual Serial Correlation LM test allows researchers to test for serial correlation through several lags besides one lag that is a correlation between the residuals between time t and t-k (where k is the number of lags). The null hypothesis states that there is no serial correlation between the variables.

Ho: There is no serial correlation between the variables

H1: There is serial correlation between the variables

3.10.4. Test for Stability

The estimate procedure cannot be expected to produce good forecast if the estimated model was only stable over the sample period. The estimated model should be stable over the forecasting period. The stability system VAR can be from the inverse roots characteristics polynomial of AR. A VAR system is said to be stable (stationary) if all roots have a modulus of less than one and all are contained within the unit circle (Usman, Fatin, Barusman, Elfaki, & Widiarti, 2017).

3.10.5. Variance Decomposition Test

The Cholsky variable decomposition method was used to show for each time period, the proportion of change in each variable. variance decomposition also can be introduced to experiment if we are able to see how a shock to one variable affects other variable in subsequent periods (Maitra, 2019).

3.11. Ethical Considerations

The study was carried out in compliance with Moi University research requirements. Ethical guidelines and principles of honesty and integrity were the guiding values. The National Commission for Science and Technology and Innovation (NACOSTI) gave approval for the research to be carried out, the approval is attached in appendix 1. Information collected throughout the study was maintained and only utilized for the study purposes. Borrowed concepts have been referenced accordingly using APA fifth edition to avoid plagiarism.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter presents the descriptive statistics, cointegration test results and the analysis of the data obtained through the vector error correction model and diagnostic test results. As explained in the research design, quantitative data was used in the study.

To recall, this study sought determine the relationship between electricity energy and industrial growth in Kenya. The specific objectives of the study were:

1. To determine how electricity consumption affects industrial growth in Kenya.
2. To examine the effects of electricity supply affects industrial growth in Kenya.
3. To evaluate how changes in electricity tariff affects industrial growth in Kenya.
4. To describe effects of electricity access on industrial growth in Kenya

4.2 Descriptive Statistics

Before carrying out any regression analysis it is important to have a good idea of the data you will be working with. Descriptive statistics were used to provide information on whether the data was normally distributed and whether there are outliers in the data. Descriptive statistics provided information on central tendencies, measures of dispersion, measures of normality. Raw data (not transformed data) of the variable was used to come up with the descriptive statistics.

Table 4.1 Descriptive Summary of Data

	Variable				
Statistic	**Industrial growth**	**Electricity consumption**	**Electricity supply**	**Electricity tariff**	**Electricity access**
Observation	38	38	38	38	38
Mean	11,266.60	4,420.64	5,524.04	54.20	24.69
Median	10,276.35	3,729.47	4,439.80	52.76	18.37
Max	18,056.80	8,553.00	11,466.90	93.98	75.00
Min	6,020.39	1,035.36	1,862.00	33.80	2.30
Std. Dev.	3,400.17	2,106.66	2,864.60	13.06	21.39
Skewness	0.81	0.50	0.70	0.66	1.02
Kurtosis	2.50	2.10	2.33	3.58	3.01
Jarque-Bera	4.52	2.88	3.85	3.30	6.56
Probability	0.10	0.24	0.15	0.19	0.04

(Researcher, 2021)

Central tendencies (mean and median) were estimated to show the center of the data distribution. The largest and smallest observations were summarized (sample maximum and sample minimum show the most extreme observation in a data set). The standard deviation was also estimated to show the variance or how dispersed the data collected for the variables was distributed around the mean. In the measure of skewness, a value of zero shows the variable has normal skewness. The skewness values for industrial growth, electricity consumption, electricity supply, electricity tariff and electricity access are greater than zero, this shows that the variables have a long right tail (positive skewness).

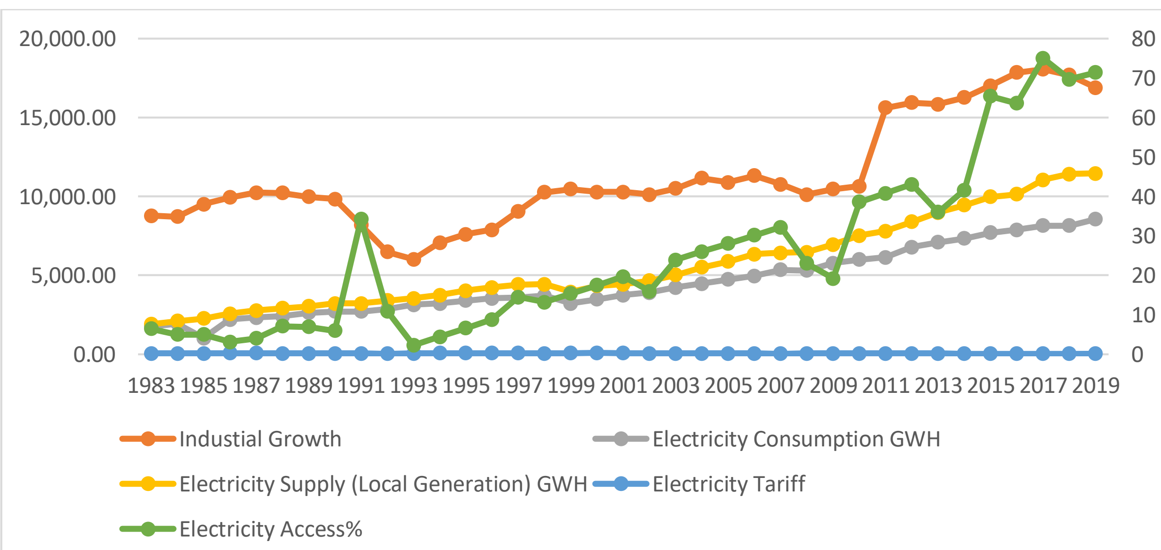
Normal kurtosis also known as mesokurtic has a value of 3. The data set below shows that electricity access is mesokurtic, normally distributed. On the other hand, industrial growth, electricity consumption and electricity supply are leptokurtic, the variables have a peaked curve (their kurtosis values are > 3). Electricity tariff is platykurtic, the variable has a flatted curve (because 3.58<3).

From our data set the probability value of Jarque Berra test for industrial growth, electricity consumption, electricity supply and electricity values are more than 0.05. We accept the null hypothesis that the distribution is normal because the probability values of Jarque Berra are not statistically significant. On the other hand, the probability of the Jarque Berra statistic for electricity access is less than the significance level of 5%. In this case we reject the null hypothesis of normal distribution because the probability value is significant.

4.3 Trends in Industrial Growth, Electricity Consumption, Electricity Supply, Electricity Tariff and Electricity Access

A pictorial trend to show the movement of the variables over time is represented in figure 4 below.

Figure 4: Trend Diagram of the Dependent and Independent Variables



Industrial Growth, electricity consumption, electricity supply and electricity tariff were plotted on the primary axis while electricity access was plotted on the secondary axis. This is because electricity access being a percentage is in tens while the rest of the variables are in thousands.

The graph shows that industrial growth in Kenya had a continuous but modest growth except in 1991 to 1993 and 2007 to 2008. The slowing down of industrial growth in these years can be attributed to the country's general election seasons. Elections generally pose the risk of destabilizing an economy should the resultant period be chaotic and unstable politically. This leads to a ripple effect whereby production decreases in the country due to decreased business activities. This also leads to low investor confidence in the country and leads to negative capital net flows. Investor sentiments are generally expected to be poorer with the more apprehensive and risk averse expected to sell off their investment holdings while moderate risk-appetite investors hold off on new investments (Cytonn, 2022). In the 1980's industrial growth was driven by structural adjustment programs (SAPs) put in place to revive economic growth and to liberalize the market, this was after the failure of the import substitution policy in the 1970s. In 1994 price controls in Kenya were abolished and Kenya joined the World Trade Organization (WTO), and this led to the upward trend in industrial growth from 1994 to 2005. In 2000 the US enacted the African Growth and Opportunity Act (AGOA), which has been important for Kenya's industrial development, as it has allowed for the duty and quota free export of garments and textiles to the US this improved the industrial growth (Ngui et al., 2016).

The average electricity tariff in Kenya is considerably stable, as explained in chapter one of this study, this is because the energy sector in Kenya is highly regulated, with EPRA setting electricity tariffs.

The electricity consumption and electricity supply have had an upward trend except for the period 1999 to 2000. During this period, a severe drought was experiences in Kenya leading to low water levels in Masinga dam this resulted in a 90MW electricity shortfall. This resulted in decreased generation and consequently consumption as Kenya primarily relied on hydroelectric sources. Electricity supply in Kenya has not experienced load shedding since June 2011, improved electricity generation mix has increased electricity reliability.

Kenya has dramatically increased electricity access, from 2.3 million connections in 2013 to 8.2 million by the end of April 2021 thereby achieving electricity access rate of over 75%. Universal access to electricity is a key requirement for meeting Kenya's development goals under Vision 2030 the country's development plan and blueprint to become an industrialized and middle-income country providing a high quality of life to all its citizens (Gakunga, 2021).

4.4 Estimating the Vector Error Correction Model

The first step in estimating the VECM model was to check and confirm whether all variables were stationary at first difference and not at second difference.

4.4.1 Stationarity Test Results

To test for stationarity, the Augmented Dickey Fuller Test (ADF test) was carried out. The Null hypothesis of the ADF test is that a variable has a unit root (the variable is stationary). The decision criterion is that if the absolute value of the t-statistic is larger than the 5% critical value, we reject the null hypothesis and conclude that the variable does not have a unit root (the variable is stationary). On the other hand, if the absolute value of the t-statistic is lesser than the 5% critical value, we accept the null hypothesis and conclude that the variable has a unit root (the variable is non-stationary). The results of ADF test are shown in table 4.1 below.

Table 4.2 Augmented Dickey Fuller Test Results

	Constant			Constant & Trend			1st Differencing Constant		
Variable	**ADF Test Statistics**	**5% Test Critical Value**		**ADF Test Statistics**	**5% Test Critical Value**		**ADF Test Statistics**	**5% Test Critical Value**	
LNIND-GROWTH	1.112144	2.94584	Non Stationary	2.461356	3.540328	Non Stationary	4.24765	2.945852	Stationary
LNACCESS	0.196467	2.96041	Non Stationary	4.857189	2.954021	Stationary	4.327156	3.54849	Stationary
LNCONS	1.131521	2.94343	Non Stationary	5.357253	3.536601	Stationary	10.07754	2.945842	Stationary
LNSUPPLY	0.942127	2.94343	Non Stationary	2.265979	3.536601	Non Stationary	5.41251	2.945842	Stationary
LNTARIFF	1.730908	2.94343	Non Stationary	2.589948	3.536601	Non Stationary	5.704083	2.948404	Stationary

(Researcher, 2022)

The ADF test results showed that at level all the variables had a lower ADF test statistic compared to the respective 5% critical value. This means that all variables were nonstationary at level. At constant and trend the variables were mixed; electricity access and electricity consumption were stationary while industrial growth, electricity supply and electricity tariff were nonstationary. After first differencing with constants the ADF test statistic results for all the five variables were larger than the 5% critical values, meaning that the variables were now non-stationary. The Akaike Info Criteria was chosen when carrying out the ADF test. After performing A Review of Kenya's Current Industrialization Policyhe stationarity test, the series were found to be integrated of order 1 or stationary at first difference.

4.4.1 Determination of Optimal Lag length for the Model

To avoid challenges associated with arbitrary choosing of lag lengths, the optimum lag length was determined from the vector auto regressive estimates. By choosing too many lags in a model one loses degrees of freedom, the coefficients of the model may turn out to be statistically insignificant, or the problem of multicollinearity may arise. Choosing too few lags may result in specification errors. Using the Akaike info criteria (AIC), two lags were found to be appropriate for the model as shown in figure 5 below.

Figure 5: Optimal Lag Length

VAR Lag Order Selection Criteria
Endogenous variables: LNINDG LNCONS LNSUPL LNTARF LNACES Exogenous variables: C
Date: 10/09/22 Time: 01:41
Sample: 1983 2020
Included observations: 35

Lag	LogL	LR	FPE	AIC	SC	HQ
0	3.095056	NA	7.67e-07	0.108854	0.331047	0.185555
1	155.4603	252.4910*	5.39e-10*	-7.169160	-5.836004*	-6.708955*
2	180.4840	34.31817	5.91e-10	-7.170512*	-4.726394	-6.326803
3	199.1999	20.32011	1.09e-09	-6.811421	-3.256339	-5.584207

* Indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level) FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

(Researcher, 2022)

4.4.2 Johansen Cointegration Test

Johansen cointegration test was carried with two lags. Johansen Cointegration Test trace statistic and max-eigen statistic gave the following results.

Table 4.3 Trace Statistic Test Results

Hypothesized No. of Cointegrating Equations	Trace Statistic	0.05 Critical Value	Probability
None*	108.9807	69.81889	0.0000
At most 1*	50.89317	47.85613	0.0252
At most 2	29.07002	29.79797	0.0605
At most 3	12.42268	15.49471	0.1378
At most 4	2.183795	3.841465	0.1395

(Researcher, 2022)

The hypothesized number of cointegrating equations were four as shown in the table above, the four equations form the null hypothesis. In Johansen cointegration test an asterisk on any of the hypothesis means that we are rejecting the null hypothesis. For the trace statistic, ‘None’ has an asterisk therefore we reject the null hypothesis. The None* trace statistic value is greater than the 5% critical value (108.98>69.82), the probability value of None* is very low (P= 0.0000 <5%). We therefore reject the null hypothesis that there are no cointegrating equations in the model and accept the alternative hypothesis that there are cointegrating equations in the model.

Table 4.4 Max-Eigen Statistic

Hypothesized No. of Cointegrating Equations	Max-Eigen Statistic	0.05 Critical Value	Probability
None*	58.08749	33.87687	0.0000
At most 1	21.82315	27.58434	0.2296
At most 2	16.64734	21.13162	0.1893
At most 3	10.23888	14.2646	0.1967
At most 4	2.183795	3.841465	0.1395

(Researcher, 2022)

Our decision using the Max-Eigen statistic results is not different from the decision arrived at using the trace statistic, we reject the null hypothesis that there are no cointegrating equations in this model.

The Max-Eigen statistic ‘None’ has an asterisk, its trace statistic value is greater than the 5% critical value (58.09>33.88), also the probability value of None* is very low (P= 0.0000 <5%). We therefore reject the null hypothesis that there are no cointegrating equations in the model and accept the alternative hypothesis that there are cointegrating equations in the model. The presence of cointegration implies that there exists a long run relationship in the model and that the variables can be combined in a linear fashion.

From the results of the Johansen Cointegration test it was concluded that there was cointegration in the model. After concluding that cointegration was present in the, the unrestricted VAR model was not estimated. The next step was to estimate the long run equation using the Vector Error Correction Model

4.4.3 Specification of the Vector Error Correction Model

The vector error correction model was estimated with one lag. The number of lags were reduced by one from the optimal lag length of two, because a vector error correction model is similar to a vector auto regressive model in first difference. If you differentiate a vector auto regressive model you get a vector error correction model and by that you lose one lag.

The breakdown of the error correction term shows the cointegrating equation and the long run model.

The results of the VECM model are shown in the Table below whereby:

Y = Industrial Growth

X1= Electricity consumption

X2= Electricity supply

X3= Electricit tariff

X4= Electicity access

C=Constant

From the vector error correction model the breakdown of the error correction term is as shown in table 4.

Table 4.5 The Breakdown of the Error Correction Term

Variable	Coefficient
Y	1.000
X1	2.125
X2	-3.449
X3	-0.497
X4	-0.207
C	3.856

(Source, Researcher 2022)

The equation of the error correction term (ECT) is as follows; Cointegrating equation, error correction equation signifying the long run relationship among the variables.

$$\mathbf{ECT_{t-1} = 1.00Y_{t-1} + 2.125X1_{t-1} - 3.449X2_{t-1} - 0.497X3_{t-1} - 0.207X4_{t-1} + 3.856}$$

The short run coefficients are shown below in table 4.6.

Table 4.6: The Short Run Coefficients

Variable	**Coefficient**
CointEq1	-0.062
Y	0.236
X1	0.050
X2	0.408
X3	-0.064
X4	0.017
C	0.075

(Source, Researcher 2022)

The short run equation is as shown below.

$$\Delta\ Y_{t-1} = -0.062\ ECT_{t-1} + 0.236Y_{t-1} + 0.050X1_{t-1} + 0.408X2_{t-1} - 0.064X3_{t-1} + 0.017X4_{t-1} + 0.075$$

The Error correction term (CointEq1) is the adjustment coefficient. The adjustment coefficient signifies the previous period deviation from long run equilibrium is corrected in the current period at an adjustment speed of 6.2%. The coefficient of the dependent variable is 0.236, the constant in the model is 0.075.

From the model it was observed that the coefficients of electricity consumption, electricity supply and electricity access were positive while the coefficient for electricity tariff was negative. The coefficients for the variables are as defined by theory. Increase in electricity consumption, electricity supply and electricity access encourage industrial growth, on the other hand an increase in electricity tariff inhibits industrial growth.

From the results above, holding all other independent variables constant in the short run, the following results were obtained. Every unit change on electricity consumption positively affects industrial growth by 0.05%, electricity supply positively influences industrial growth by 0.41% and electricity access positively influences industrial growth by 0.02%. On the other hand, a 1% increase in electricity tariff negatively influences industrial growth by 0.06%.

Electricity supply was found to be the most important variable in the study, followed by electricity tariff, electricity consumption and finally electricity access.

These findings show that electricity supply, electricity consumption and electricity access are important factors for industrial development in Kenya. High electricity tariff results in local manufacturers struggling to meet their production costs, these costs are passed on to consumers, a move that slows down the industrial and manufacturing sector's growth.

The four explanatory variables (electricity consumption, electricity supply, electricity tariff and electricity access explain 15.73% of the total variation in industrial growth. This indicates that the variables in the model are important determinants or predictors of industrial growth.

From the results above, the null hypothesis that electricity consumption has no significant effect on industrial growth in Kenya was rejected and the alternative hypothesis accepted. Electricity consumption was found to have a positive and significant effect on Kenya's Industrial growth. The null hypothesis that electricity supply has no significant effect on industrial growth in Kenya was rejected and the alternative hypothesis accepted. Electricity supply was found to have a positive and significant effect on Kenya's Industrial growth.

The null hypothesis that electricity tariff has no significant effect on industrial growth in Kenya was also rejected and the alternative hypothesis accepted. Electricity tariff has a negative and significant effect on Kenya's Industrial growth. The null hypothesis that electricity access has no significant effect on industrial growth in Kenya was rejected and the alternative hypothesis accepted. Electricity access was found to have a positive and significant effect on Kenya's Industrial growth.

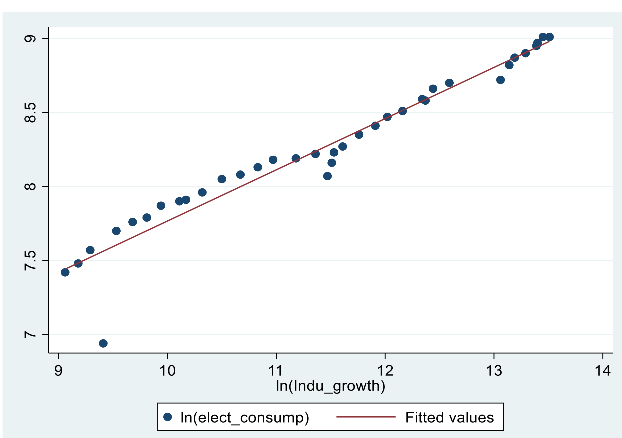
4.5 Post Estimation Diagnostic tests

Before drawing a conclusion or policy inference from a regression model, it is important to perform diagnostic tests to verify the validity of the regression model. These tests include linearity test, normality test, serial correlation test, stability test and variance decomposition test. These diagnostics are required to verify the reliability of the estimated coefficients and there may be a need for model restructuring depending on the results of the diagnostics.

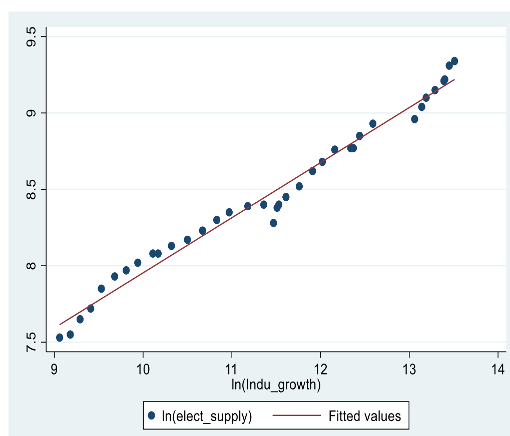
4.5.1. Linearity Test

Linearity test was carried out on the data to determine whether the relationship between the independent and dependent variables was linear. This was done through a scatter plot between the dependent variable (industrial growth) and the independent variables (electricity supply, electricity consumption, electricity tariff, and electricity access). The scatter plots showed that the relationship between independent variables and the dependent variables were linear as shown figure 6 below.

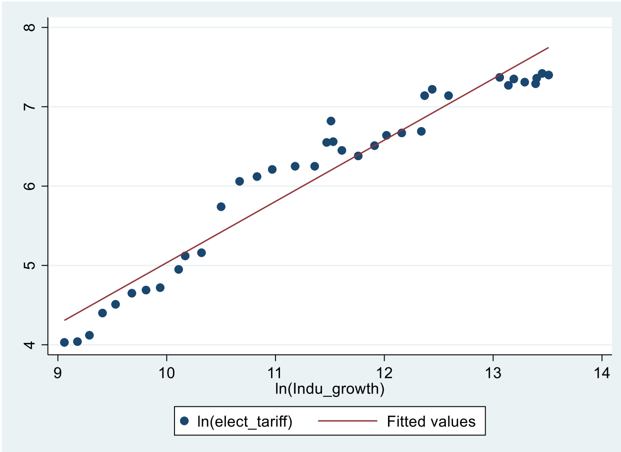
Figure 6: Linearity Test



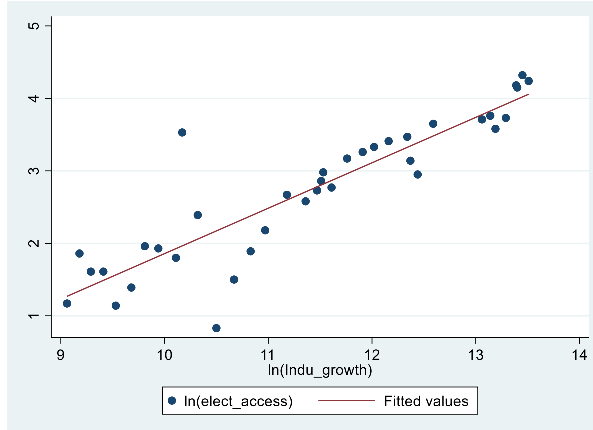
Electricity consumption & industrial growth



Electricity supply & industrial growth



Electricity tariff & industrial growth



Electricity access & industrial growth

(Researcher, 2022)

4.5.2. Serial Correlation Test

The Serial correlation LM test was also carried out to test for serial correlation and the findings are as shown in figure 7 below.

Figure 7: Serial Correlation Test

VEC Residual Serial Correlation LM Tests
Date: 09/25/22 Time: 00:10
Sample: 1983 2020
Included observations: 36

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	31.46955	25	0.1739	1.315925	(25, 75.8)	0.1813
2	17.93076	25	0.8453	0.691316	(25, 75.8)	0.8496

Null hypothesis: No serial correlation at lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	31.46955	25	0.1739	1.315925	(25, 75.8)	0.1813
2	66.88936	50	0.0554	1.450624	(50, 71.8)	0.0736

*Edgeworth expansion corrected likelihood ratio statistic.

(Source, Researcher 2022)

The probability values were higher than the 5% significance level. The null hypothesis that there is no serial correlation in the model was accepted, it was concluded that there was no evidence of serial correlation.

4.5.3. Normality Test

To test for normality, the probability that the sample was drawn from a normal population the Cholesky (Lutkephol) method was used. The Jarque- Berra statistic obtained from the (Lutkephol) method was chosen as a means of checking for normality, because the test factors both skewness and kurtosis in its computation. Each component in the statistic represents a variable in the model, residues for electricity tariff were found to have a normal distribution. Residues for industrial growth, electricity consumption, electricity supply and electricity access were found not to be normally distributed. This can seen from the p-values of the test statistics. The null hypothesis was rejected, and the conclusion that the residuals of the variables were not normal was reached.

Table 4.7: The Normality Test

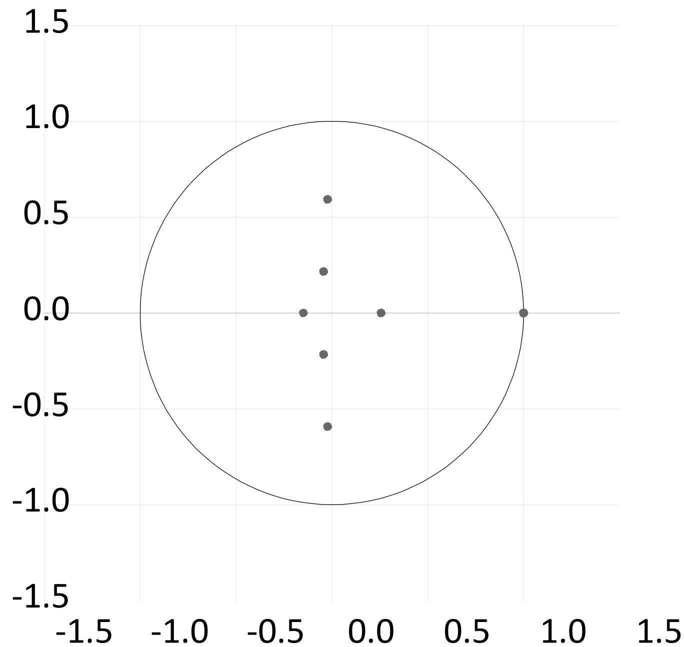
Component	Jarque-Bera	df	Probability
1	87.71642	2	0.0000
2	35.95263	2	0.0000
3	8.366685	2	0.0152
4	0.913517	2	0.6333
5	10.46879	2	0.0053

4.5.4. Stability Test

The AR roots graph method was used to test for the model stability. In the outcome of the test, the dots should be inside the circle, no dots should be outside the circle. No dots were found to be outside the circle, only one dot was found on the circle. The model was therefore found to be stable.

Figure 8: Stability Test

Inverse Roots of AR Characteristic Polynomial



4.5.5. Variance Decomposition

Variance decomposition shows the proportion of each variable to be explained for each time period. It explains how the independent variables play their role in influencing the dependent variables; and shows effectiveness of variables used in the model. In first time period, there was 100% change in industrial growth. In the second time period, electricity supply caused the biggest change in the dependent variable followed by electricity access.

Electricity consumption effect on the dependent variable was found to be increasing gradually, electricity supply effect on the dependent variable was also found to be increasing gradually. Electricity tariff effect on the dependent variable was found to be declining gradually. Electricity access effect on the dependent variable at first increased then it started to decline gradually.

Figure 9: Variance Decomposition Test

Variance Decomposition of LNINDG1:

Period	S.E.	LNINDG1	LNCONS	LNSUPL	LNTARF1	LNACES
1	0.079839	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.125853	95.65349	0.161951	2.256969	0.793358	1.134227
3	0.163125	92.13652	0.430497	4.600218	0.640457	2.192304
4	0.194567	91.16832	0.970875	5.312069	0.461970	2.086764
5	0.221522	91.05451	1.215586	5.419805	0.383660	1.926443
6	0.245414	90.86278	1.285556	5.573546	0.356581	1.921537
7	0.267263	90.63357	1.349561	5.746401	0.329262	1.941206
8	0.287501	90.50310	1.417585	5.847514	0.304098	1.927704
9	0.306379	90.42849	1.464139	5.907683	0.287137	1.912554
10	0.324147	90.35887	1.495086	5.962540	0.275177	1.908322

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

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

5.2 Summary of Findings

This paper analyzed the impact of energy on industrial growth in Kenya between the period 1983 and 2020. Industrial growth was the dependent variable while electricity supply, electricity consumption, electricity tariff and electricity access were the independent variables. The vector error correction model was used to estimate the empirical model. The study used data from Kenya Power Annual Reports and official government publications namely Statistical Abstracts and Economic Surveys for the period 1983 to 2020.

Descriptive statistics of the data on the variables under study revealed that average industrial growth was KShs 11,266.60 million over the study period. The statistics also revealed that the average electricity consumption was 4,420.64 GWh while the average electricity supply was 5,524.04 GWh. The average Electricity tariff was KShs 54.20 while the average electricity access was 24.69%. Graphical analysis of the data showed that all variables under study had an upward trend from 1983 to 2020 suggesting the existence of a relationship among the variables. The ADF test of stationarity test of the variables showed that all the variables were integrated of order one at first difference with constant.

The Johansen Cointegration test produced a trace statistic test and max-eigen statistic test result value larger than 5% critical value. From the results of Johansen cointegration test it was concluded that there was cointegration in the model. After establishing the presence of cointegration the vector error correction model was estimated.

The coefficients of the vector error correction model showed that electricity supply was the main determinant of Kenya's industrial growth in the short run holding all other independent variables constant on average ceteris paribus in the short run. This was indicated by the coefficient of electricity supply of 0.408. This means that a 1% increase in electricity supply would cause industrial growth to increase by 0.4% in Kenya, implying that the pace of growth in electricity supply positively affects industrial growth in Kenya. The sign of the coefficient matched expectations as it was positive. This finding was in agreement with that of (Chigozie, 2015) who found that adequate electricity generation gave rise to industrial production.

The coefficient of electricity consumption was 0.05, the coefficient was positive as expected. The interpretation was a 1% increase in electricity consumption increased industrial growth in Kenya by 0.05%. This finding agreed with that of (Olufemi, 2015) who found out that there existed a positive relationship between industrial growth and electricity consumption in Nigeria. This finding, however, contradicts the finding of (Abokyi et al., 2018) who found out that electricity consumption had a negative impact on industrial growth in Ghana.

The coefficient of electricity tariff was negative as expected. This finding implied that an increase in electricity tariff made manufacturing expensive thereby reducing the rate of industrial growth in Kenya. A 1% increase in electricity tariff reduced industrial growth by 0.06% in Kenya, holding all other independent variables constant and on average ceteris paribus in the short run.

Lastly the coefficient of electricity access was 0.02, this outcome was in line with prior expectation, that an increase in electricity access would lead to an increase in industrial growth. A 1% increase in electricity access was found to increase industrial growth in Kenya by 0.02%, holding all other independent variables constant and on average ceteris paribus in the short run. This finding agreed with the findings of (Kassem, 2018).

5.3 Conclusion and Policy Recommendation

The conclusions summarized in this research provide encouraging evidence that there is interaction between electricity consumption, electricity tariff, electricity access and industrial growth in Kenya. Since it has been established through the study that electricity energy plays a positive role in industrial growth in Kenya, Various Policy Recommendations are crucial if Kenya is to realize the goals set in vision 2030. The recommendations include;

As an important secondary energy, electricity is the most direct form of energy consumption by industrial development. The current electricity energy infrastructure should be expanded and upgraded to increase electricity supply and keep in pace with the increasing electricity consumption, this is crucial for Kenya to achieve its Vision 2030 target of transforming the country into a newly industrializing, middle-income country by 2030.

Electricity tariff in Kenya should be managed through price regulation to encourage industrialization and to attract investments. The government of Kenya should consider zero rating electricity energy for power generated for industrial output. Doing so will bring down the cost of electricity. The cost of energy used in production of goods is passed on to consumers, raising the final cost of goods. By managing the electricity tariff, locally produced goods will be able to compete better in the international market. The local populace in Kenya is already grappling with the high cost of living, which significantly reduces their purchasing power. This means that the consumption of locally produced goods continues to be less and less.

The Government of Kenya has really tried by increasing electricity access to 76.49% as at May 2021.The government should work towards achieving universal access to electricity because electrification attracts more firms to manufacturing resulting in positive industrial growth.

5.4 Limitations of the Study

The major limitation of this study is that it focused exclusively on the formal manufacturing sector. The study did not take into consideration the informal sector activities (the jua kali sector). The informal sector accounts for a significant portion of manufacturing in Kenya.

5.5 Areas of Further Study

The role played by electricity energy in industrial growth is significant, further studies should be carried out to find out if electricity energy impacts the informal industrial sector.

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Appendix 1:- Research Approval

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Appendix 2:- Data Collection Table

	RAW DATA				
	DV	IV1	IV2	IV3	IV4
Year	Value Added in Manufacturing (KShs Million)	Electricity Consumption "000 kwh"	Electricity Supply (Local Generation)	Average Yield KShs- in cents	Electricity Access%
1983	8,582	1,676	1,862	56.12	3.23
1984	9,694	1,775	1,906	57.03	6.45
1985	10,856	1,944	2,109	61.64	4.98
1986	12,165	1,035	2,258	81.48	5.02
1987	13,803	2,205	2,563	90.97	3.14
1988	15,951	2,337	2,772	104.18	4.01
1989	18,138	2,412	2,907	109.02	7.13
1990	20,827	2,627	3,044	111.82	6.92
1991	24,685	2,708	3,227	141.23	6.02
1992	26,178	2,719	3,215	167.60	34.2
1993	30,257	2,857	3,396	175.00	10.90
1994	36,157	3,143	3,539	309.63	2.30
1995	43,185	3,223	3,747	429.49	4.47
1996	50,444	3,408	4,041	456.58	6.65
1997	58,300	3,555	4,240	495.98	8.83
1998	71,600	3,615	4,420	516.67	14.50
1999	85,700	3,717	4,432	516.91	13.19
2000	96,100	3,211	3,958	700.28	15.36
2001	99,777	3,490	4,338	911.95	17.53
2002	101,748	3,742	4,447	709.20	19.68
2003	109,959	3,910	4,662	633.03	16.00
2004	127,443	4,234	5,033	591.96	23.92
2005	149,162	4,484	5,519	672.39	26.01
2006	166,777	4,752	5,884	764.33	28.08
2007	190,165	4,965	6,347	787.55	30.14
2008	228,304	5,356	6,431	802.85	32.21
2009	234,556	5,318	6,468	1,258.37	23.00
2010	252,122	5,785	6,946	1,368.88	19.20
2011	292,401	5,991	7,526	1,257.81	38.58
2012	469,104	6,144	7,812	1,594.11	40.79
2013	506,612	6,791	8,399	1,439.83	43.05
2014	537,666	7,090	8,980	1,552.22	36.00
2015	588,896	7,330	9,456	1,497.38	41.60
2016	654,456	7,701	9,971	1,467.50	65.40
2017	659,141	7,881	10,130	1,564.63	63.59
2018	690,592	8,147	11,052	1,661.97	75.00
2019	734,609	8,154	11,409	1,629.03	69.7

Appendix 3:- Johansen Cointegration Test Results

Date: 09/24/22 Time: 22:58
Sample (adjusted): 1986 2020
Included observations: 35 after adjustments
Trend assumption: Linear deterministic trend
Series: LNINDG LNCONS LNSUPL LNTARF LNACES
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.840599	123.7445	69.81889	0.0000
At most 1 *	0.631013	59.47293	47.85613	0.0028
At most 2	0.401800	24.57815	29.79707	0.1771
At most 3	0.162566	6.594122	15.49471	0.6253
At most 4	0.010931	0.384680	3.841465	0.5351

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.840599	64.27157	33.87687	0.0000
At most 1 *	0.631013	34.89478	27.58434	0.0048
At most 2	0.401800	17.98403	21.13162	0.1304
At most 3	0.162566	6.209442	14.26460	0.5865
At most 4	0.010931	0.384680	3.841465	0.5351

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNINDG	LNCONS	LNSUPL	LNTARF	LNACES
2.350868	15.81954	-21.35604	-5.323578	1.676698
6.429110	20.67113	-20.64783	6.241577	0.300691
-1.404875	-7.500975	1.788194	0.536806	3.940361
-5.746643	6.061425	-5.547426	0.387251	1.834039
-1.591424	2.384892	-5.298306	3.436565	1.654428

Unrestricted Adjustment Coefficients (alpha):

D(LNINDG)	-0.022195	-0.008041	-0.024153	0.025942	0.003324
D(LNCONS)	-0.084382	-0.027319	0.031938	-0.020965	0.002494
D(LNSUPL)	0.004288	0.002777	0.005480	-0.002196	0.003639
D(LNTARF)	0.043522	-0.075493	-0.039518	0.015592	0.000800
D(LNACES)	-0.046756	0.158239	-0.169627	-0.068113	-0.005604

1 Cointegrating Equation(s): Log likelihood 175.0875

Normalized cointegrating coefficients (standard error in parentheses)

LNINDG	LNCONS	LNSUPL	LNTARF	LNACES
1.000000	6.729232	-9.084321	-2.264516	0.713225

Appendix 4:- Vector Error Correction Model Results

Vector Error Correction Estimates
Date: 09/25/22 Time: 00:08
Sample (adjusted): 1985 2020
Included observations: 36 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LNINDG1(-1)	1.000000
LNCONS(-1)	
	2.1
	24993
	(0.38276
	)
	[5.55184]
LNSUPL(-1)	-
	3.44941
	6
	(0.41069
	)
	[-8.39903]
LNTARF1(-1)	-
	0.49726
	0
	(0.07944

Error Correction:	D(LNINDG1)	D(LNCONS)	D(LNSUPL)		D(LNTARF1)
CointEq1	-0.061837	-0.536181	0.034660	0.043910	
		0.687677 (0.07776)			
		(0.12025)	(0.04126)	(0.15007)	
		(0.51040)			
	[-0.79526]	[-4.45882]	[0.83997]	[0.29259]	[1.34734]
D(LNINDG1(-1))	0.235683	0.200557	-0.074720	0.377658	
		0.240405 (0.18347)		(0.28373)	
		(0.09736)	(0.35410)	(1.20427)	
	[1.28462]	[0.70685]	[-0.76745]	[1.06654]	[0.19963]
D(LNCONS(-1))	0.050133	0.042519	-0.065787	-0.025807	-
	0.280692 (0.11841)		(0.18313)	(0.06284)	
		(0.22854)	(0.77726)		
	[0.42337]	[0.23218]	[-1.04691]	[-0.11292]	[-0.36113]
D(LNSUPL(-1))	0.407696	-0.647390	0.240147	-1.002520	
		3.367575 (0.40079)		(0.61984)	
		(0.21269)		(0.77356)	
		(2.63083)			
	[1.01722]	[-1.04446]	[1.12907]	[-1.29599]	[1.28004]
D(LNTARF1(-1))	-0.063480	0.001186	0.075015	-0.076639	
		0.828218 (0.09496)		(0.14686)	
		(0.05040)		(0.18329)	
		(0.62334)			
	[-0.66847]	[0.00808]	[1.48851]	[-0.41814]	[1.32867]

R-squared	0.157369	0.567786	0.111159	0.243386	0.155709
Adj. R-squared	-0.016968	0.478362	-0.072739	0.086846	-0.018972
Sum sq. resids	0.184852	0.442111	0.052059	0.688593	7.964586
S.E. equation	0.079839	0.123472	0.042369	0.154093	0.524062