THE IMPACT OF POWER SECTOR REFORMS ON EFFICIENCY, ACCESS AND HOUSEHOLD WELFARE IN KENYA

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Declaration

This is my original work and has not been presented for the award of a degree in any other university.

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Abbreviations and acronyms

AFREPREN Africa Energy Policy Research Network

COLS Corrected Ordinary Least Square

CRS Constant returns to scale

DEA	Data Envelopment Analysis
DMU	Decision making unit
ILO	International Labour Organization
KPLC	Kenya Power and Lighting Company
PGTMP	Power Generation and Transmission Master Plan.
RISE	Regulatory Indicators for Sustainable Energy
SFA	Stochastic Frontier Analysis
TE	Technical efficiency
TFP	Total factor productivity
VRS	Variable returns to scale
WDI	World Development Indicators

Abstract.

Electricity is a key enabler of socio-economic development. Provision of adequate and affordable electricity is necessary for economic growth and wellbeing of a people. Since the 1980s electricity sector in many countries has been subjected to reforms. In Kenya reforms have

been driven by donors and the government together. After more than 20 years of reforms in Kenya's electricity sector, this study asks whether the expected outcomes of the reforms have been realized. The first essay uses data obtained from Information Administration (EAI), World development indicators (WDI), Africa Energy Policy Research Network (AFREPREN), Africa infrastructure country diagnostic database, International Labour Organization (ILO) Annual reports and statistical abstracts from the respective countries to assess the impact the reforms have had on the sector's efficiency. The results obtained from DEA, Malmquist productivity index and stochastic frontier analysis showed that the power sub-sector in Kenya has improved in technical efficiency after the reforms, even though there is room for further improvement to draw near to the best performers in the developing world. Countries which have implemented reforms to a larger extent were found to be more efficient. An analysis of panel data obtained fromWorld Bank national accounts, IEA, Center for Systemic Peace and various national accounts spanning 25 years using fixed effectmodel, showed that among the reforms considered namely restructuring, regulation, legislation, competition and private sector participation, competition is a key positive driver of both electricity access and supply. The third essay used data obtained from KNBS of 2005/2006 and 2015/2016 Kenya Integrated Household Budget surveys. The study using 2SLS (IV)estimation model confirmed that the welfare of households connected to electricity in Kenya was better relative to that of unconnected households. Specifically, household expenditure on both food and non-food items arehigher in electrified household than in those without electricity. Household members in electrified home spend more time in income earning activities and also earn higher incomes than those without electricity.Findings show significant impact on school enrollment for all children. The impact is however higher for boys than for girls. The study also concluded that households connected to the grid spend more income on education than their counterparts. The overall positive effect on the selected education outcomes was found to be higher in poor households and in rural areas than in wealthy urban households. It is important, however, to fast track competition in transmission and distribution of electricity since these two reforms have lagged behind. This will, hopefully, improve efficiency in electricity production, lower user electricity tariffs, encourage electricity consumption and hopefully spur overall economic development.

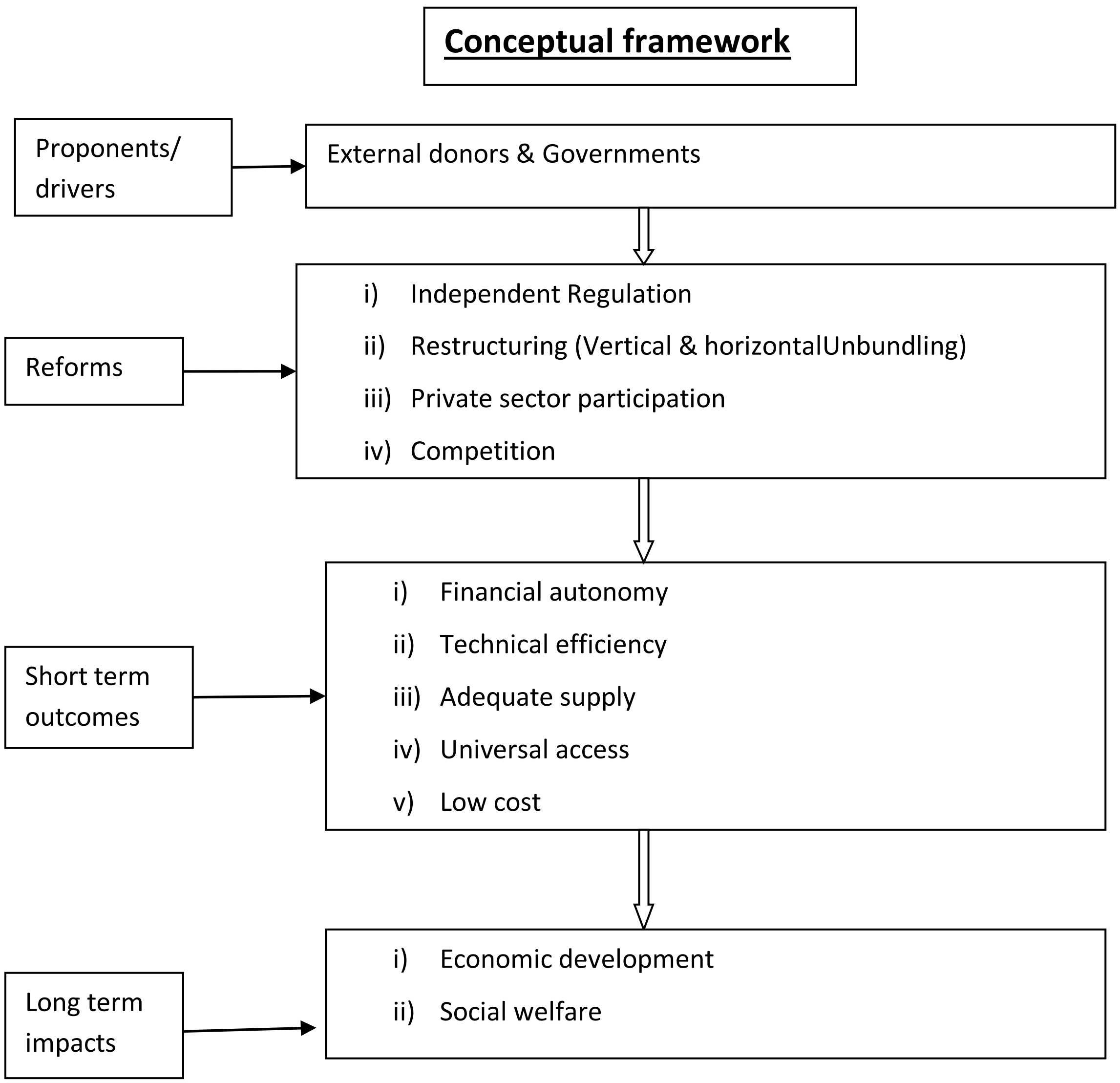
CHAPTER 1: ENERGY SECTOR REFORMS

1.0 Introduction.

Many countries embarked on energy sector reforms in the early 1980s (Beasant, 2006). The driving force behind the reforms varied among developed and developing countries. In most developing countries reforms were initiated as a result of underperformance and inefficiency in state-run utilities. Failure by state-run utilities to provide adequate power to satisfy demand and over-reliance on government subsidies also calledfor reforms.

The global reforms were motivated by economic principles and achievements in countries such as Chile and the then England and Wales arising from the reforms. These countries improved the quality of energy supply and production after the reforms. They also experienced efficient utilization of existing capacities, attracted investments in the sector and reduced energy losses (Pollitt, 2004). In the developed countries,reforms were seen as means to improving economic efficiency, enhancing competition among the players, inter regional trade and to offer customers choice (Erdogdu, 2013).

The electricity sector reforms in developing countries on the other hand, hoped to expedite electricity access to the underprivileged (Jamasb et al., 2015). It was anticipated that restructuringthe sub-sector would induce competition, strengthen governance and market regulation, and that competition would lower electricity prices and compel suppliers to improve service delivery (Beasant 2006).



1.1History of energy sector reforms globally

In the late 1870s to early 1920s power utilities in most countries were owned by private companies or municipal governments. They were largely unregulated and served public street lighting, private enterprises and a few privileged households (Besant- Jones, 2006). From 1920s, there was a growing demand for electricity which prompted governments to take more control of the sector, a situation which gave rise to growth of monopolies. Because of the high investment costs required to meet rising electricity demand, state funding was the obvious choice at the time. Economic efficiency, consumer welfare, national security, and industrial growth were also used to justify state control (Besant- Jones 2006; Brown & Mobarak, 2009). It was also considered that the governments are better placed to guard public interest and coordinate the different functions of energy sector (Erdogdu, 2014).

In the 1940s most countries established power sector monopolies which performed considerably well given low inflation and low debt levels characterizing economies at that time.It was assumed that a public owned, vertically integrated entity was ideal given the strategic nature of energy industry. Some countries like Japan, Germany and Hong Kong established private monopolies that were regulated by the government (Erdogdu, 2014). However, the 1970 oil crises, global economic recession, debt crises and other political issues triggered a paradigm shift away from state control/ ownership to more market oriented arrangements.

Chile was among the first countries to pursue market oriented power sector reforms (Bacon, 1995). The reforms at this time we experiments from economic theory advanced by free- market economist who were opposed to Keynesian theory which advocates for government spending to control the economy. (Lee & Usman, 2018). Chile was then followed by the then England of Wales and United States who focused on reforming power sector by establishing wholesale market and introducing independent power producers to counteract the oil crises. In the 1990s reform of the power sector was embraced globally. The stages of reforms recommended were, regulation, restructuring, privatization and introduction of competition.

World Bank and IMF were the main instruments that pushed for these market oriented reforms. They were very influential because of the high demand for borrowing at the time. Very minimal attention was given to the applicability of the reforms. It was assumed that the reforms will suit all economies irrespective of their existing conditions. Governments would later come in, in the second wave of the reforms in response to the observed limitations of the donor driven reforms.

1.2 Energy sector reforms in the Africa

The four major reforms in Africahave been: i) Unbundling of state utilities, this involves dividing integrated utilities into independent entities. It can take two forms: vertical unbundling in which case, vertically integrated entities are divided into independent entities of generation, transmission and distribution or/and horizontal unbundling in which case a state monopoly is split so that each region has its own generation, distribution and transmission entities. ii) Corporatization of state-owned utilities.In this case, publicly owned utilities are transformed into limited liability companies with hope these willprovide better services at lower costs with fiscal benefits.iii) Enactment of electricity regulatory law.Where there is an electricity Act, it is amended to pave way for anotherlegislation that may provide for formation of an independent electricity sector regulatory body. This body oversees the operation of the electricity sector and market participants. It protects the interests of investors and ensures that they access information required to make decisions. It also protects consumers from market power abuse. iv)Management contracting. In this case, the day to day running of a non-performing power utility is assumed by a private entity with a view to turn it around(Beasant, 2006). However, major investment decisions and assets of the utility remain under the government. This model has been adopted in Kenya Uganda, Tanzania and Ghana. v) Commissioning of Independent power producers.A provision is made in law for independent power producers (IPPs). IPPs are expected to enhance supply under appropriately structured contracts (Jamasb, 2004). In countries where contracts are not well structured, the obligation to purchase power from IPPs has exposed governments to huge financial losses.

1.3 Reforms in Kenya's electricity sub-sector

The restrictive trade practices, monopolies and price control Act of 1989 sought to spur competition in Kenya. It aimed to prohibit unfair trade practices, control monopolies and improve efficiency through price controls (Republic of Kenya, 1989). The aims were not achieved and this led to the repeal of the Act and enactment of new laws to achieve the aims.

One of the new lawsisthe Electric Power Act, 1997 that initiatedmarket restructuring and regulatory reforms in the energy sector. This Act set up the Electricity Regulatory Board (ERB) in 1998 as an independent sub-sector regulatorwhichwould control consumer tariffs and encouragecompetition in the industry (Republic of Kenya, 1997).ERB was, however, found to be inadequate in providing incentives for private sector growth and in resolving regulatory challenges facing the sector.Subsequently, Sessional Paper No.4of 2004 on energy facilitated enactment of an umbrella Energy Act that transformed ERB into Energy Regulatory Commission (ERC)and established Geothermal Development Company (GDC). ERC was charged with the duty of reviewing and adjusting customer tariffs, approving power purchase agreements, resolving customer complaints and promoting competition in the sector. GDC was formed to oversee the development of geothermal power in the country(Republic of Kenya,2006).

In 2006, the Energy Sector Actwas enacted providing for the establishment, powers and functions of (ERC) as an independent regulatory agency. ERC main objectives and functions are control of electric, renewable and petroleum power subsectors. The Act also provides for the establishment of Rural Electrification Authority (REA). The Act put together all laws relating to energy in Kenya.

The Energy Act 2006 and the follow-up Electric Power Act, 1997 laid the basis for restructuring (unbundling)the monopoly, Kenya Power & Lighting Company. The task of power generation wastaken up by Kenya Electricity Generating Company (Kengen) while KPLC was tasked with power transmission and distribution. The Electric Power Act, 1997 set to liberalize the energy sector by providing for the participation of private sector in electricity generation. At the time of writing the Sessional Paper No. 4 of 2004, the government also sought to change the power transmission system into an open access system (Republic of Kenya, 2004). To achieve this, Kenya Electricity Transmission Company Limited (KETRACO) was formed in 2008 to build high voltage electricity transmission lines and associated substations (Republic of Kenya, 2004). The creation of KETRACO was also aimed at protecting electricity consumers from the high electricity costs that would arise from construction of power transmission infrastructure (Republic of Kenya, 2004). The government absorbed the capital cost of the infrastructure.KETRACO took over the transmission task from KPLC.

From the foregoing, the reforms undertaken in Kenya so far are: setting up of an independent regulator, corporatization/commercialization of state-run power utilities, restructuring (unbundling) of the utilities, and development of independent power producers. The reforms are required to also improve quality of customer service through enhanced efficiency, increase electricity supply at competitive prices and accessibility to the grid. The reforms are also expected to improve government revenue from sale of public utilities, reduction in subsidies and increase in tax revenue. The resulting electricity sub-sector structure is shown in Fig1.

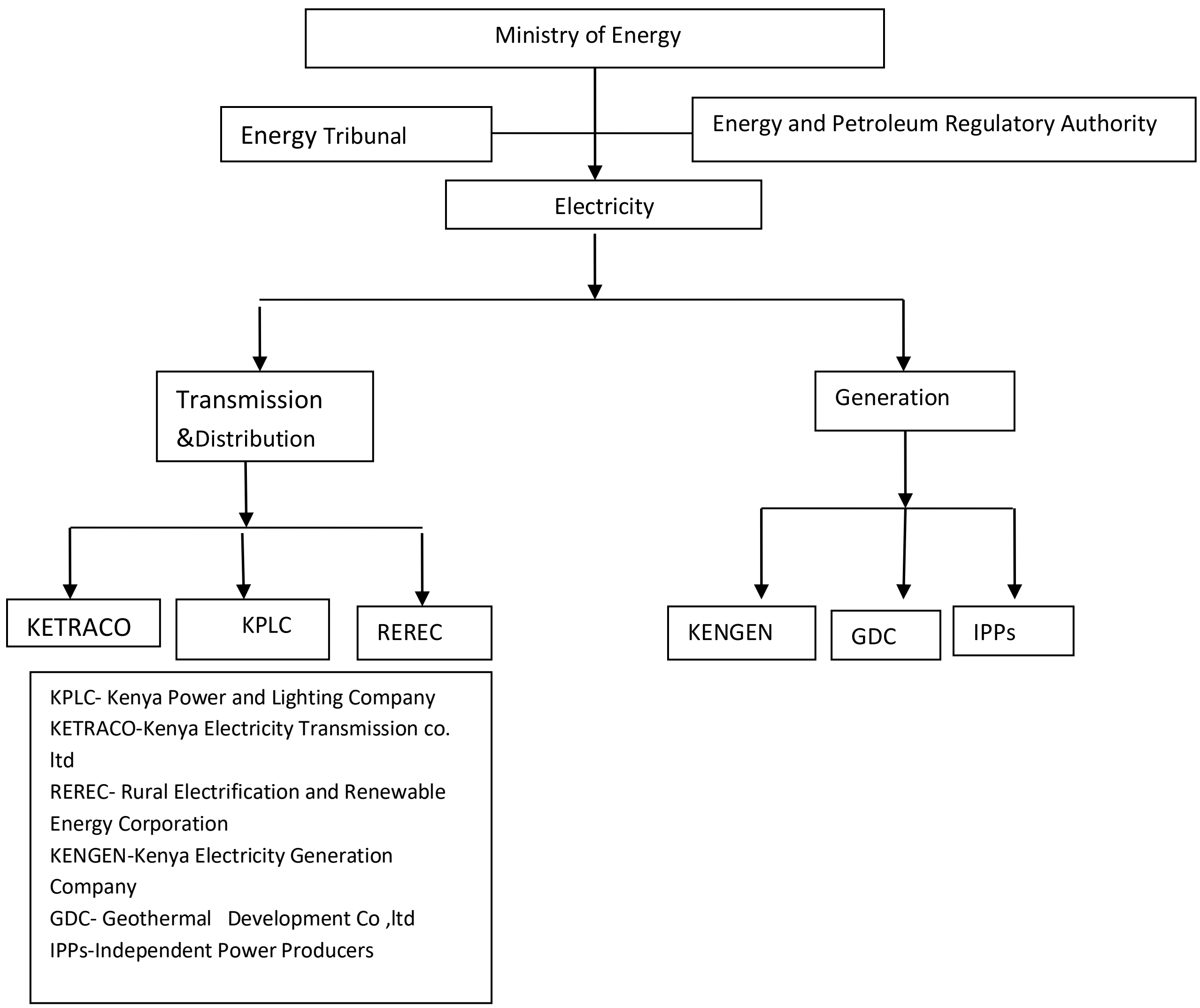


Figure 1 Structure of Kenya's electricity sub-sector Source: Ministry of Energy(n.d)

1.4Problem statement and study Justification

Power sector reformshave been embraced by many countries since early 1980s. Kenya's reformsin the electricity sub-sector started from late 1980s as spelt out inthe Restrictive Trade Practices, Monopolies and Price Control Act(1989). However, major reforms began in 1997. Kenya's vision 2030 also identifies energy as key infrastructural enablerinachieving the country's social, economic and political targets.

In the Kenyan context, besides the benefits advanced by donors as motivations of undertaking the reforms, the capacity of the power sector to deliver adequate, clean and reasonably priced power to all is crucial for a number of reasons; firstly for Kenya to become a middle-income country, economic development will to great extent depend on the capacity of the energy sector to support industrialization, infrastructure development and other social economic development. Understanding of how reforms impact on this sector is therefore important in guiding how well the country can support economic expansion, secondly understanding the contribution of the private sector participation in this sector so far, is crucial in crafting policies and regulations that are effective in ensuring a fair playing field and at the same time attracting investments to foster economic growth and finally, reforms are aimed at facilitating electricity access to both rural and urban areas, assessing their impact so far will help in gauging whether the country is reducing energy poverty and therefore improving living standards of all Kenyans.

1.5 Research questions

This study evaluates the performance of Kenya's electricity sector following reforms. The study aims to answer these questions:

i. Have the reforms impacted on the relative efficiency of electricity generation in Kenya vis-à-vis other developing countries?

ii. Have the reforms impactedon supply ofelectricityin Kenya?

iii. What are the household welfare impacts of increased electricity access after reforms?

The overall objectiveis to assesswhether reforms have had any impact the electricity sub-sector's performance. Specific objectivesare to:

i. Examine the impact of the reforms on relative efficiency of electricity production vis-à-vis other selected developing countries
ii. Assess the impact of the reforms on supply ofelectricity in Kenya.
iii. Examine the impact of the household's electricity access after reforms and the associated welfare outcomes.

1.6 Thesis Outline

This thesis is organized into three essays. The first essaydiscussesthe technical efficiency of electricity generation in Kenyavis-à-vis other selectedcountries. The second essay looks at the impact of reforms on electrification and powersupply in Kenya while the third essay assesses household welfare outcomes of the increased access to electricity after the reforms.

CHAPTER 2: EFFECT OF REFORMS ON TECHNICAL EFFICIENCY OF ELECTRICITY PRODUCTION IN KENYA RELATIVE TO OTHER DEVELOPING COUNTRIES

2.0Introduction

Electricity sector reforms have resulted in significant organizational transformation in the power sector. These reforms include vertical unbundling, private sector participation, competition, and regulation, legislation, and policymaking. Supporters of these reforms believed that they would improve sector efficiency and performance (Vickers and Yarrow, 1988; Joskow, 1998).

By 2016, Kenya had an installed capacity of 2,341 MW which was expected to serve its population of over 44 million people (KPLC Annual Report, 2016).The government targeted to increase the capacity to 15,000MW by 2030 (GoK, 2007).To achieve this, the government hoped to invest and attract private investors in electricity generation.

Kenya's electricity generation before and after sector reforms.

Situation before the reforms

Inthe pre-reform period(before1997), the key source of electricity supply was hydro. Several government-owned hydro power stations had been established. The stations include: Tana, Wanjii, Kamburu.Gitaru,Kindaruma,Masinga, Kiambere, Turkwel and other small stations. Thermal power was mainly generated from Kipevu power station while geothermal power was generated from Olkaria power stations. The contribution of both thermal and geothermal was very minimal owing to the fact that little investment had been done to expand the two sources.

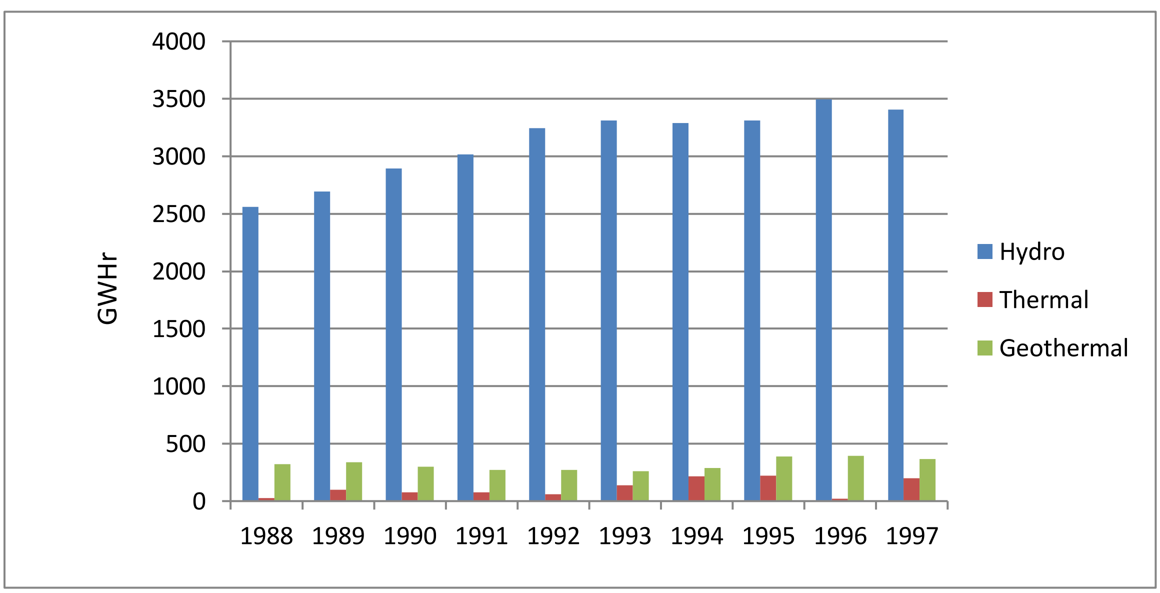


Figure 2 Electricity production during the pre-reform period in Kenya

Source: Author's computation from various KPLC Annual Reports

Post -reform periodsituation

The mainsource of electricity in Kenya over the years has been hydro followed by geothermal and thermal power. In 2015 the share of hydroelectricity was 36 %, geothermal 34 % and thermal 5 % of the total electricity produced. At the time of this study geothermal power takes about 43 percent of the power sources in Kenya.This has been occasioned by government effort to invest and diversify geothermal power. Imports of power from other countries have been very minimal given that Kenya has a fairly secure generation capacity and diversity of energy sources. Thermal power has been rising marginally as this source has been replaced overtime by geothermal energy which is much cheaper.The figure 3 below gives a picture on these changes.

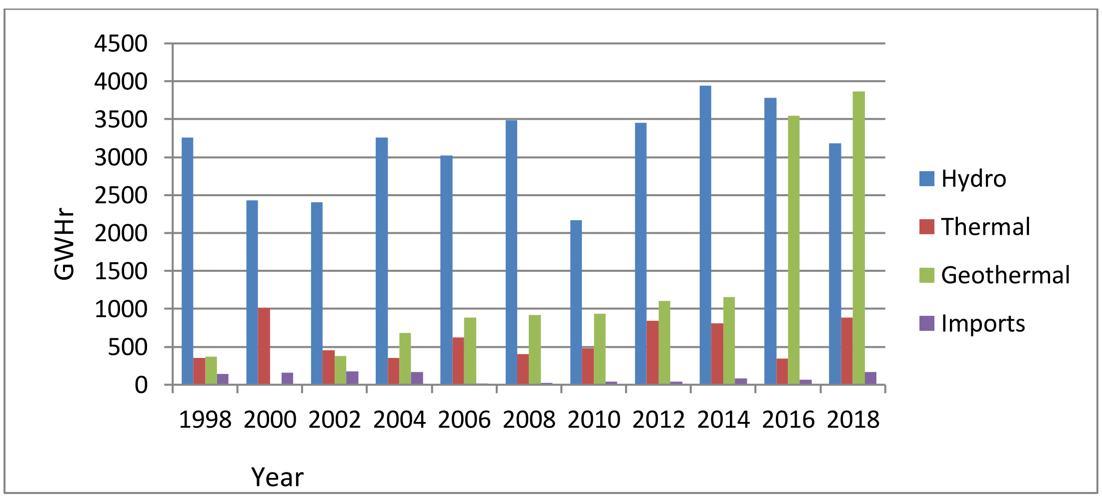


Figure 3Electricity generation during the post -reform period.
Source: Author's computation from variousKPLC Annual Reports

With the exception of year 2002, the amount of electricity generated and consumed has been on an upward trend as shown on the chart below. The drop in 2002 can be explained by the drought that set in 1999-2002.The rise in power output can be attributed to among other factors, deliberate government policy to secure adequate supplies from geothermal, wind and thermal power.On the consumption side, improved economic growth and increase in number of customers have seen consumption increasethoughmoderately over the years.

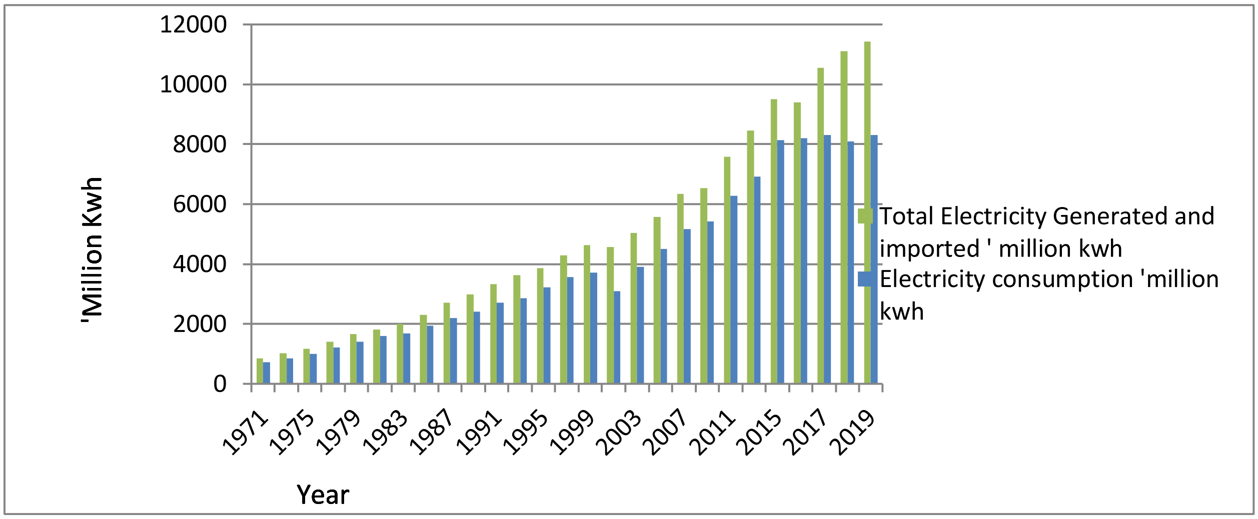


Figure 4 Electricity generation and consumption in Kenya during pre- and post-reform period

Source: Author's computation from KPLC annual reports.

Overall achievement of the sector can be enhanced significantly by reducing system losses which arise mainly from operational inefficiencies. Electricity losses as a percentage of electricity generated in Kenya has ranged from 16% to 21.5% during the reform period as shown on the table below. Data from World development indicators (2016) indicates that in 2013 system losses in sub Saharan Africa were on average 11.8%. Mauritius had the lowest loss at 6.3%, but this was higher thanBelgium's4.8%. It is therefore clear that there is an opportunity for the reduction of the level of losses.Strategies aimed at reducing losses are necessary to conserve the electricity already generated.

Optimum use of available electricity generation capacity is one way of also increasing efficiency and increasing energy savings. To find out how well the installed electricity generation capacity is being utilized in Kenya, we assessed the data on load factor as reported in KPLC annual reports. For example, a load factor of 100% implies that the plant is operating at its maximum capacity all day. Aload factor of 60% implies that the capacity is utilized for about 14 hours in a day. The annual load factor for Kenya ranges between 64.4% in 2000 and 72.2 % in 1998 as shown in the table below. The existing capacity can generate more power if used more effectively.

Table 2.1: System load factor and losses in Kenya's electricity industry. 1994-2021

Year	SystemLoad factor	Losses as % of generation
1994/95	72.6	15.6
1995/96	72.3	16.2
1996/97	72.1	16.4
1997/98	71.5	18.6
1998/99	72.2	19.2
1999/00	71.9	21.5
2000/01	64.4	21.3
2001/02	69.0	20.5
2002/03	69.4	20
2003/04	69.4	18.8
2004/03	68.4	18.1
2005/06	70.9	19.6
2006/07	71.5	17.9
2007/08	69.5	16.6
2008/09	69.1	16.3
2009/10	68.8	16
2010/11	69.8	16.2
2011/12	70.8	17.3
2012/13	68.2	18.6
2013/14	68.7	18.1
2014/15	70.1	17.5
2015/16	70.6	19.4
2016/17	70.3	18.9
2017/18	67.8	21.0
2018/19	69.7	23.7
2019/20	67.9	23.46
2020/21	69.3	23.95

Source: KPLC annual reports.

2.0.1 Statement of the problem.

The primary objective of any power sector in a country is to provide sustainable and affordable electricity as demanded. (Meibodi, 1998). However, sector investments can be quite large and if coupled with sector inefficiencies, this may not be achieved (Meibodi, 1998).Improving energy efficiency is therefore one of the best strategy of ensuring a that the sector meets its mandate. (Kenya Power Generation and Transmission Master Plan, 2016). The Ministry of Energy has taken a lot of initiatives to promote efficiency in the power sector. However, as pointed out in the PGTMP, the measures' impact has been modest. The plan asserts that energy efficiency strategies would reduce generation costs by about 6 percent. The government had implemented several reforms to address the issue of inefficient power generation and improve the country's competitiveness as an investment destination. Despite the measures taken, the cost of power has risen throughout the reform period, as illustrated in Figure 5.High electricity tariffs have forced some manufacturing firms to close or relocate to other countries. This begs the question: how do reforms affect the technical efficiency of Kenyan electricity production?

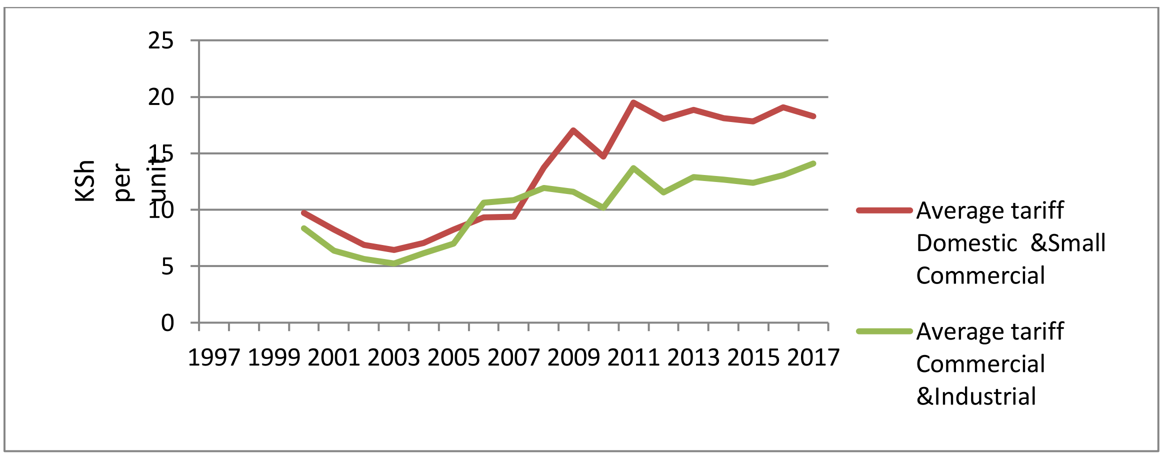


Figure 5: The trend of electricity tariffs in Kenya, 1997-2017
Source: Author’s computation from various KPLC annual reports

Available literature shows that reforms have had mixed effects onefficiency. Whileprivatization has not resulted in improvement in efficiency of the energy sectorin Malaysia or Brazil (Yunos and Hawdon 1996, Mota, 2004),restructuring and privatization in UK, Côte d'Ivoire and Chile has enhanced efficiency of the power sectorssignificantly (Newberry and Pollit, 1997, Plane, 1999, Fischer, Gutierrez and Serra 2003).Estache et al. (2008) observed no apparent relationship between reforms and improvements in efficiency in 12 southern African electricity distribution plants. This makes a case for examining the effect of reforms on efficiency in the Kenyan electricity sector. Is the effect on efficiency of electricity generation in Kenya positive, negative or none?

This also compares the efficiency of Kenya'selectricity sector to that of three other reforming countries namely Uganda, Tanzania and Senegal. This will be achieved through use of data from the sector's annual reports and from internationally recognized databases. This essay therefore attempts to find out whether the sector reforms have been successful in resolving the technical inefficiencies in the electricity generation in Kenya.

2.0.2 Research questions

i. What is the technical efficiency of Kenya's electricity production during the reform period?

ii. How does Kenya's relative efficiency scores compare with those of other selected reforming developing countries?

iii. What policy changes would assist in increasing efficiency of the electricity production in Kenya?

2.0.3Study objectives

To assess the technical efficiency of Kenya's electricity sub-sector within the reform period (1987-2017) vis-à-vis other developing countries. Specifically the objectives are:

iv. To assess the technical efficiency of Kenya's electricity productionduring the reform period.

v. Contrast and account for the relative efficiency scores inelectricity productionduring the reform period in Kenya against the scores in other selected reforming developing countries.

vi. Suggestpolicy changes for increasing efficiency of the electricity production in Kenya drawing lessons from practices in more efficientreforming developing countries.

2.0.4 Justification

Electricity generation is a key process in the power sector that determines the amount of energy available for economic development and industrial growth. In Kenya like in many developing countries the power sector is confounded by many challenges among them inefficiencies arising from use of infrastructure that requires upgrading and lack of finances to improve the power systems. This has resulted in less than optimal power generation which is also expensive for firms and households.

The Kenya National Energy Policy 2014, and Kenya's National Energy Petroleum policy, (2015) are among the key policy documents that have highlighted the depth of the power losses occasioned by inefficiencies in the system. The two documents have gone further and proposed measures that if undertaken consistently would reverse this dire situation. Pioneers of the 1990s reforms in the power sector advanced that these reforms would deal with this problem and improve technical efficiency of the sector. The expected end result was optimal use of the available inputs to generate maximum possible output which would hopefully ensure adequate supply and affordable electricity.

Empirical assessment of the impact of reforms in Kenya is important for decision makers to know the impacts so far and to inform further policy decisions. The study, by comparing Kenya with other reforming countries will also help in identifying best practices and therefore give recommendation on areas of improvement. By using a combination of non-parametric (DEA) and parametric (SFA) methodologies the study will also improve the robustness and understanding of efficiency in this sector. While studies have extensively been done in developed countries, few studied have been carried out in developing countries like Kenya. This study will there fill this gap and contribute to the current power sector reforms discussions. The study will also hopefully propose policies that would positively impact on household welfare in Kenya and other developing countries

2.1 Literature review

2.1.1 Theoretical literature

Neoclassical theory of the firm identifies the main actors in the economy as households, firmsand the government. These actors are assumed to be rational and that they try to maximize utility, output,profitor welfare subject to some constraints. They are assumed to possess all relevant information but face technological and price constraints (Varian, 1996).

Traditional theory of production assumes the firm to be efficient. How effective a firm is in production, does not matter. Depending on the firm's objective, it is seen to operate at the lowest cost frontier, the maximum production frontieror the maximum profit frontier for profit maximizers (Varian, 1992). Whether a firm adopts a new technology and the question of how prompt a firm is in adopting this technology is another issue that the traditional theory fails to address. The traditional theory does not therefore address the issue of the effectiveness with which the inputs are utilized neither does it address the effectiveness of cost minimization by the firms.

Koopmans and Debreu (1951) defined technical efficiency as a situation where increasing any output is feasible only by reducing some other output or reducing any input which is feasible only by increasing some other input. Farell (1957) recognized that the producers have the capacity to choose the most efficient vector of input and output given the cost of the input and expected price of the output. Farrell therefore defined productive efficiency as a product of both technical and price efficiency. Technical efficiency was further decomposed by Fare, Grosskopf, and Lovell (1983) into pure technical efficiency, input congestion andscale efficiency. The decomposition can also be towards the output side. Efficiency of the firm can thereforebe gauged by comparing the actual and the optimal level of output and input. Productivity of the firms varies also with the type of technology used, efficiency of the firm and the environment in which the firm is operating. Consideration of the possibility of inefficiencies in the firm provides important information that can be used to improve the outcome of the firm

Another idea of efficiency is X- efficiency outlined by Leibenstein (1966). According to the theory, inputs can be used with varying degree of effectiveness. The higher the degree of effectiveness the more the output (Leibenstein, 1966). The difference between the actual output arising from input which has not been used effectively and the maximum possible output is a measure of the level of X-inefficiency. This measure serves to distinguish the difference between the allocation of inputs to a firm and the effectiveness with which the inputs are utilized. The ratio of the difference between the actual inputs used and the minimum inputs necessary to yield a certain level of output is also a measure of X-inefficiency.Leibenstein (1966) compares and contrasts the conventional theory of the firm with X-efficiency theory as follows:

X-Efficiency versus Neoclassical Theory

The neoclassical model assumes that economic agents (firms and or households) always maximize profits or minimizecosts. Economic actors are assumed to have all relevant information required in decision making and operate in a competitive market that eliminates inefficient firms.Capital and labour are the only inputs in production and are assumed to be homogeneous.Management role is only to determine the proper mix of these inputs. Firms operate at the production frontier always.

The traditional theory has been criticized by for example Leibenstein (1966) who came up with X-efficiency theory.Economic agents do not always have maximizing behavior.An average person is seen to have a selective rationality (Simon, 1959)due to lack of information, inertia among other reasons. Individuals and firms do not always possess all the information necessary to make rational decisions. Individuals /employees do not exert homogeneous effort as assumed in the traditional theory.Assumption of homogeneous factors of production does not hold in real life. Firms are characterized as being competitive, this assumption may not hold given the constraints faced by firms for example barriers to entry, inefficiencies, and financial constraints among others. The principal-agent problem may also arise when the managers are not the firm owners.In micro theory agents are assumed to make decisions in the interest of the principal, in X- efficiency theory agent may make decisions in the interest of the principal or in their own interest. Conventional microeconomic theory disregards many aspects of reality which are significant in determining the productivity of a firm.

Internal and external factors dictate the effectiveness of a firm's production process. A competitive market for example reduces inefficiencies thus enabling a firm to produce more outputs given a level of inputs. Ownership is also another important internal factor. Due to lack of incentives, public sector operates sub-optimally compared to the private sector. Efficiency is also positively correlated with firm size and technological investment. Other internal factors include shifts in demand, advances in technology, and management changes, among others, all of which can have an impact on efficiency, either positively or negatively.

Efficiency and productivity measures have been employed to assess how effectively power utilities transform inputs into outputs. The selection of inputs and outputs employed in the analyses has been widely debated as well as the determination of the combination of inputs and outputs used in a firm's production process.

Installed capacity is commonly used as an input when assessing the efficiency of power utilities. Many developing countries have limited installed capacity due to a limited resources, which is seen to hinder production (Yunos and Hawdon, 1996; Kumbhakar and Hjalmarsson, 1998).

Almost all of the efficiency research studies evaluated treat labour as an input. Number of employees is the most common measure of labor. Data for this input is fairly easy to get. Energy is used as an input to generate electricity. As a result, fuel consumption plays a major role in the production process. In assessing the technical efficiency of electricity /power utilities, the main concern is therefore to compare the effectiveness with which different entities are able to employ the resources/inputs in generating a given amount of electricity.

2.1.2 Empirical Literature.

Changes in the power sectors that resulted from the market- driven reforms were designed to enhance the efficiency and therefore the output of the energy sectors(Joskow, 1998). Reforms also followed the need to create a sector that would have the outcomes similar to those of a competitive market. This was to ensure that public interest was well taken care of in terms of quality of the service, favorable tariffs, access to the grid.

In Chile privatized firms were more efficient, more profitable and resulted to higher labour and physical productivity (Fischer, Gutierez and Serra, 2003). . Power supply per worker increased as did the number of clients. Sales also more than doubled. Electricity customers benefited more from energy price declines (Fischer, Gutierrez, and Serra 2003).

In India, a study by Fatima and Barik, 2012, concluded that reforms had not brought the desired results. During the post- restructuring period Technical efficiency had declined. This however varied from state to state. The rich states had high technical efficiency in comparison to the poor states. The authors attribute this to positive externalities in the rich states. The findings however were at a state level and not at the plant level

A study of12 distribution companies in Africa, found that the reform had no significant impact on technical efficiency (Estache et al. 2008). This is due to a failure to utilize labor and capital efficiently. The companies have however adopted better technologies and commercial practices. This has resulted in increase in electricity generated, increase in sales and higher level of access. The study period was however too short (1998- 2005) to be conclusive on the impact the reforms have had on efficiency.

Privatization did not enhance the efficiency operation of the power utility in Malaysia (Yunos and Hawdon, 1996).Technical efficiency was far short of the best practice among the least developing countries where competition was lacking. Excess capacity and low efficiency levels were seen as the main contributors to this. There was also no productivity growth over the study period (1975-1990)

Yuno (1996) compares the efficiency of Malaysian power utility with that of 27 other electricity generating companies in different countries using cross section data. The study compares the efficiency of Malaysian power utility firm with that of Thailand and United Kingdom using time series data. Labour, installed capacity (MW), generation capacity factor (%)and total system losses (%)are used as inputs. Gross electricity produced (GWh) is used as the output. The efficiency of Malaysia was found to be approximately 70%, and fell far short of the best frontier. Comparison with Thailand and UK confirmed that Malaysia was less efficient. Malaysia could reduce costs by 30% by adopting the reference frontier.

Estache, Tovar and Trujillo (2008)analyseefficiency of power companies in the Southern African Power sector for the years1998-2005using DEA. The outputs used in this analysis are, electricity generated (GWh), total number of customers and total electric power sales (GWh). For inputs the study uses installed capacity (MW) and the total number of workers. Use of better technology and better commercial practices contributed to performance improvement observed.No observable change in technical efficiency was noted during the study period an indication that the inputs had not been used effectively. Technological improvement was significant in the 6-year study period. Reforms therefore appeared to have achieved some success.

Jain et al (2010) studied technical efficiency of India's electricity using DEA. The studyused total cost incurred in the supply of electricityas the input variable.Units of energy generated (GWh) and energy sold (GWh) are used as the outputs. The overall efficiency of India's electricity generating companies is 46%and technical efficiency is 75%,the study also concluded that the generation cost can be reduced by 25%.

The technical efficiency of India's thermal generating utilities for the period 2000-2008 using stochastic trans-log production frontier was found to have declined over time(Fatima and Barik, 2012).Fatima and Barik estimated a stochastic production frontier using energy generated as the output, labour, energy, capitaland material as the inputs.

Burns and Weyman-Jones (1996) apply stochastic frontier analysis method in studying 12 Regional Electricity Companies in the United Kingdom. They observe an insignificant cost-efficiency from privatization of several companies and economies of scale.Meibodi (1998) concluded that results from DEA and SFA did not have much variation. Outputs employed were residential customers 'electricity sales (Gwh), industrial customers'electricity sales (Gwh) and number of both residential industrial customers. The inputs were thenetwork size (KM), labour and r capacity of thetransforme (MVA)
Results from DEA and SFA on the reform process in Brazil indicated, majority of the firms evaluated were more efficient after the reforms. Using operating expenditure (OPEX) as an input in Brazil, the impact of privatization was positive butinsignificant, whereas using total expenditure as an input variable, the impact of privatization on efficiency was significantly negative. (Motta,2004).

Competition is expected to improve the efficiency of firms (Lovell, 1993). A study in USA by Caves and Barton(1990) concluded that high levels of competition results in more efficient choices. An analysis of the market in the UK also showed that firms in a highly competitive market have a powerful drive to enhance efficiency in their operations(Hay and Liu, 1997). A study by Gumbau and Maudos (2002) of Spanish manufacturing sector found out that the size of the firm and the amount of physical investment are positive drivers of efficiency. Firms with low levels of competition and public owned firms had the lowest levels of efficiency. The impact of innovation and level of investment in physical assets on efficiency is ambiguous. According to Torii, (1992), technological changes may lead to disturbances in the operations of the firm resulting in inefficiencies. Another ambiguous determinant of efficiency is the ownership of the firm. Reasons raised attributing inefficiency to public owned firms are not conclusive neither are those affirming the private owned firms as more efficient.

2.1.3 LiteratureOverview

Research studies are inconclusive about the outcome of the reforms in terms of efficiency enhancement. Studies indicate either positive, negative or no impacton the sector's efficiency improved following the reforms. More empirical research is therefore necessary especially in developing countries such as Kenya.

2.2 Methodology

2.2.1 Theoretical Framework.

Measurements of efficiency.

The frontier methods originated fromKoopmans and Debreu (1951), and later furthered by Farrell (1957). The frontier method measures efficiency as the distance to a best practice frontier. Farrell,

(1957) demonstrated the efficiency concept by considering a firm employing two inputs to produce one outputunder constant returns to scale. The commonest frontier method is DEA.

2.2.2Data Envelopment Analysis (DEA)

To carry out this study, we use DEA, and compare the results under both constant returns to scale and variable returns to scale

DEA's failure to recognize possible measurement errors, and also the fact that efficiency levels are dependent on inputs and outputs chosen and their magnitudes are the its main shortcomings. Its main advantage is the fact that the functional form of the error term is not required and that it easily accommodates multiple inputs and output as the study may deem necessary(Charnes, Cooper, and Rhodes, 1978)..

2.2.3 The Stochastic Frontier Analysis (SFA)

In the SFA approach, we specify the production frontier:

$$q = f(\mathbf{X},\boldsymbol{\beta})\exp(\varepsilon) \quad \ldots\ldots 2.5$$

$$\varepsilon = (v-u),\ u>0$$

where,

q is output,

f is theproduction frontier function,

X represents inputs,

$\boldsymbol{\beta}$ are the parameters to be estimated, v representsstochastic shocks

u captures inefficiency, while ε = (v-u)

$E(v_i) = 0$, $E(v_i^2) = \sigma_v^2$,

$E(v_i v_j) = 0$ s.t $i \neq j$, and

$E(u_i^2)$ = constant,

$E(u_i u_j) = 0$ s.t $i \neq j$.

From equation 2.5

$\ln q_i = \beta \ln x + v_i - u_i$……………………………………………………………………….2.6

Cobb-Douglas stochastic production frontier model,

$q_i = \exp(\beta_0 + \ln \beta_1 x_i) * \exp(v_i) * \exp(-u_i)$

$\exp(\beta_0 + \ln \beta_1 x_i)$ is the deterministic part, $\exp(v_i)$ is white noise, and $\exp(-u_i)$ is the technical inefficiency parameter.

Thus, technical efficiency is measured by

$TE = q / [\exp(x_i\beta' + v_i] = \exp(-u_i)$ ……………………………………………………………………….2.7

$(0 \leq TE \geq 1)$

Consistent estimators of equation 2.6 can be obtained by OLS, COLS or MLE.

2.2.4 Malmquist productivity index analysis

To decompose technical efficiency scores in the DEA, we use Malmquist productivity index.The decompositions provide insights into sources of productivity change. A shortcoming of this efficiency measure is that the vectors of inputs chosen are not necessarily the most efficient subset of the input set(Fare et al., 1994).

When interpreting the Malmquist total factor productivity, values that are above one imply an increase in productivity, values below one reflects a decline in productivity and values equal to one indicate no change in productivity.

The efficiency index computed in a DEA is dependent on the input and output variables chosen. Input variables reflect a direct cost to the Decision-Making Unit (DMU)while the output variables reflect the DMU's goals and objectives (Fare et al. 1994). A shortcoming of this measurement is that the input vector used is not necessarily the most efficient input vector(Seiford& Thrall,1990).

To allow for comparison with other countries, hydro, thermal and renewable energy were put together as a single decision-making unit following Chen et al (2013). In addition, the net installed capacity, number of permanent employees and fuel consumed and average power sector reform scores were used as the inputs while net electricity generated was the output.Installed capacity was the maximum power that a plant produced at any point in time.

2.2.5Analytical framework and data sources.

In this essay, we estimate an output oriented DEA specified as:

$Max_{\Phi,\lambda},\Phi,$

St $-mi + M\lambda \geq 0,$

$\Phi k_i - K\lambda \geq 0,$

$N1'\lambda = 1$, and $\lambda \geq 0$

M and K represents the output and the inputs respectively.The value of Φ is the efficiency score that show the amount a DMU can increase output by and still remain within the production possibility space. Malmquist productivity index is used to decompose the efficiencyinto technical efficiency change which is the movement of a DMU to a given efficiency frontier and the technical change which is the movement of a DMU to a new technically efficient frontier.

Stochastic Frontier Analysis

The industries' production function is assumed to be a function of labor, installed capacity, fuel consumed (kteo), and electricity generated measured in gigawatt hours. We use maximum likelihood method to estimate the the followingmodel..

$LnY_{it} = \alpha + \beta_1 lnL_{it} + \beta_2 lnK_{it} + \beta_3 lnE_{it} + \beta_4 lnR_{it} + v_{it} - u_{it}$ ……………………2.20

Y is gross electricity generated (Gwh), L is labour, K is installed capacity(Kilowatts) and E is fuel consumed (kteo)

In computing the technical efficiency using SFA we also used the reform score (R) computed using a Power Sector Reform Index from the World Bank in order to predict the impact of the reforms on the efficiency of the sector. The extent of the reforms undertaken so far in the selected countries was obtained from ESMAP. The reform index was constructed using the four reform components prescribed by the donors in the early 1990's. These are (i) vertical and horizontal unbundling of the power utilities. If a utility was still vertically integrated it was given a score of zero, if vertically or horizontally unbundled, a score of 67 and if vertically and horizontally unbundled a score of 100(ii) establishment of an independent regulator; if there was no regulator the country is given a score of zero and if there one a score of 100. (iii) competition in power generation; A score of zero if monopoly, 25 if there are IPPs, 50 if the country has single buyer, and 100 if the sector is competitive and (iv) private sector participation; computed as the percentage of distribution capacity and or generation capacity with private sector participation. Reforms in the selected countries were implemented between the late 1990s and the early 2000s, for this reason we use the same score for each country for the period between 2010 and 2017.

Data source

Data set is of 1987 and 2015. Data sources are as below.

Table 2.2 Variables description, measurement and source

Variables	**Description**	**Source**
Installed capacity(Capital)	Installed generation capacity in Mega watts	World Bank database
Labour	Number of permanent employees in electricity generation	International Labour Organization
Fuel (Energy)	Fuel used in electricity generation	United Nations Energy Statistics
Reform score	An average score ranging between 0-100, of the extent of four donor prescribed reforms	World Bank
Gross electricity generated	Units of energy generated (GWh)	World Bank database

Source: Author's

2.3Results

2.3.1 Summary statistics

The key characteristics of our dataset are provided in the table below

Table 2.3 Summary statistics

Variable	N	Mean	Std. deviation	Min.	Max.

Installed capacity(Capital)	32	1190.906	487.9095	546	2270
Labour	32	6845	5815.558	1248	18934
Fuel (Energy)	30	45.15667	48.53625	9	270.9
Reform score	32	47.99805	10.40658	35.6875	61.8125
Gross electricity generated	32	5356.601	2471.502	2456	10129

Source: Author's computations.

2.3.2Technical Efficiency indices for selected countries,1987and 2015

Table 2.4 below shows technical efficiency score of the period befor the rorms and after the reforms using both CRS AND VRS

Table 2.4 Technical efficiency scores.

DMU	1987			2015		
	crst	**vrst**	**scale**	**crst**	**vrst**	**scale**
Kenya	.097	.336	.288	.098	.394	.251
Senegal	.618	1.000	.618	.507	1.001	.505
Tanzania	.563	.738	.751	.488	.6477	.753
Uganda	1.000	1.000	1.000 -	1.000	1.000	1.000 -
Mean	.568	.772	.663	.524	.761	.627

Source: Author's computations.

Under both VRS and CRS Uganda is the most technically efficient DMU before and after the reforms. Senegal's electricity utility is also technically efficient under variable return to scale model.Kenya was the least efficient of the selected countries in 1987, and it remains so in 2015, with a minimal progress. Tanzania shows slight improvement following the reforms. From the results obtained, we also note that the utilities are more efficient under VRS than under CRS. The four selected DMUs were operating at an increasing return to scale implying that they could have increased output with the available inputs if they were run more efficiently. In Kenya for example 60.66 percent of inputs could have been saved by increasing efficiency.

2.3.3Efficiency change in the electricity sectorsof selected countries,2010-2017

Table 2.5 Malmquist indices

DMU	**Efficiency change**	**Technical change**	**Pure efficiency change**	**Scale efficiency change**	**Total factor productivity change**
Kenya	1.000	1.447	1.000	1.000	1.445
Senegal	1.003	1.463	1.003	1.000	1.481
Tanzania	1.026	1.469	1.028	1.000	1.481
Uganda	1.038	1.524	1.026	1.000	1.563
Mean	1.022	1.471	1.471	1.000	1.489

Source: Author's computations.

There was a reasonable efficiency improvement in both Tanzania and Uganda. Senegal improved marginally while Kenya remained unchanged.Between 2010 and 2017, all examined countries experienced positive technical change (technical change > 1). Uganda saw the most technological changes. Technical efficiency of the four DMUs was comparable under both vrs and crs. All countries depicted consistent scale efficiency. Uganda experience the highest increase in total factor productivity.Technical change accounted for the entire 44.6% increase in total factor productivity in Kenya.

Table 2.6 Malmquist index for Kenya's electricity sector, 2010-2013

Period	**Efficiency change**	**Technical change**	**Pure efficiency change**	**Scale efficiency change**	**Total factor productivity change.**
2010/2011	1.004	0.993	1.008	0.996	0.996
2011/2012	0.942	1.054	0.950	0.991	0.993
2012/2013	0.943	1.066	0.929	1.015	1.006
Mean (Kenya)	**0.963**	**1.037**	**0.962**	**1.001**	**0.998**
***Mean (All DMUs)**	**0.992**	**1.051**	**1.002**	**0.990**	**1.042**

Source: Author's computation.

*All other DMUs;Senegal,Uganda, Tanzania

Assuming crs, the rate of efficiency change in Kenya's electricity sector wasnegative over the three years,2010/2011 to 2012/2013. This period was characterized by increase in generation from thermal sources due to poor hydrology experience, high global fuel prices which resulted in an increase of 62% in fuel cost and also discontinuation of government subsidies in capacity charges for emergency power. The technical change improved over theperiod from –1% in 2010/2011 to 6.6% in 2012/2013. From a variable returns perspective, the change was also positive over the entire period.

2.3.4 Stochastic Frontier Analysis results

Table2.7 below shows regression results from the SFA.

Table 2.7 Stochastic frontier regression results, 2010-2017

Parameter	True fixed-effects model (truncated-normal) estimate and z-values
Labour	.2837(2.79)**
Capital	.641(4.63)**
Energy	.1681(2.54)**
Reform score	.4976 (.53)
Sigma_ u = σ_{μ}	.3654(.81)
Sigma_ v = σ_v	.0637(4.68)**
Prob>chi2 Wald chi(3) Log likelihood	.0000 70147.96 30.5429

** Significant at 1% significance level .Source: Author's computations.

The findings verify that labor, capital, and energy are important inputs in the generation of electric power countries studied. The variance parameters are represented as follows (Aigner, Lovell, and Schmidt 1977);

$$\sigma^2 = \sigma_v^2 + \sigma_u^2$$

$$\lambda^2 = \frac{\sigma_u^2}{\sigma_v^2} \geq 0$$

λ represents change in the error term caused by inefficiency. Technical efficiencies were predicted from the above SFA results. The results are shown in table 2.8 below

Table 2.8 Stochastic Frontier results of average technical efficiency scores, 2010 -2017

Country	**Average reform score**	**Average Technical efficiency score**
Kenya	51	0.9852
Senegal	35.6881	0.8774
Tanzania	40.8810	0.9623
Uganda	61.8136	0.9911

Source: Author's computations.

Uganda has the highest average technical score. Kenya moved up to second place after accounting for the reform variable, followed by Tanzania and Senegal. SFA results demonstrated a positive relationship between the reform score and technical efficiency. The higher a country's reform score, the greater its technical efficiency.

Uganda leads in the implementation of the 1990s power sector reforms in SSA . In just under six years after the announcement of the reforms, Uganda restructured the power sector and opened the sector toprivate operators, it had established an independent regulator and operated under cost-reflective tariff (Godinho &Eberhard, 2019). The reforms were also adopted quite rapidly compared to other countries. It took 4 years from the enactment of Electricity Act for Uganda to implement 80% of the prescribed reforms. On the other hand reform in Kenya power sector were considerably delayed even after passing of the law. Only about 70% of reforms had been implemented by 2015. The delays were mainly politically driven. This situation was later to change after a new government came into power. Tanzania and Senegal were very slow in embracing reforms especially the restructuring power utilities. The two also allowed very minimal private sector participation, by 2015 this stood at 3% for Tanzania and 13% for Senegal.

2.4 Conclusion and policy direction.

Kenya's power sector structure has been greatly altered by reforms instituted since 1996. The initial reforms which were donor driven, unbundledgeneration from transmission and distribution, policy and regulatory changes were also made and tariffs that were cost-reflective introduced. Major reforms driven by the government from 2002 which strengthened the energy regulatory led to accelerated rise in power generation, private sector participation and scaling up of electrification country-wide. Various aspects of the sector have undoubtedly been impacted by these reforms:supply, financial access and technical performance. This study estimated the technical efficiency of Kenya's power sector benchmarking onselected countries; - Uganda, Tanzania and Senegal. . The countries were selected based on the availability of data on their reform journey and the commonality inlevel of development.

The efficiency scores were computed using DEA and SFA methodologies.To allow for comparison, the study used the same variables in the two methodologies namely; net installed capacity, number of permanent employees and fuel consumed as the inputs while net electricity generated was the output.

All the four countries considered in this study saw an increase in technical efficiency during the reform period. Efficiency increased from 33.5% to 39.3% in Kenya. This clearly indicates the need to lay more emphasis on measures directed towards sector efficiency improvement.Uganda and Senegal emerged as the most efficient DMUs during both periods. In all four countries, labour capital and energy play a significant role in electricity generation. The only difference from the DEA findings is that Kenya is now considered more efficient than Senegal after accounting for the reform score. However, Uganda continues to lead. According to these findings, the sector's efficiency has improved as a result of the reforms implemented thus far.

Technical efficiency in Kenya has been influenced by reforms in different ways and to the extent to which a reform has been actualized. Establishment of an independent Regulatory Authority has provided the much needed sector oversight thus promoting efficiency and transparency in the sector. Introduction of IPPs although still at a low scale compared to other countries, has introduced competition and therefore more efficient practices in the sector. Failure to fully embrace reforms may have contributed to Kenya's low technical scores. Competition is one of the key reform that is lagging behind, Feed-in tariff policy of 2008 has not taken off due to challenges particularly lack of expertise and finance. If implementation of this policy is fast tracked completion would improve and contribute to higher levels of efficiency in the sector. Further research can be done on the efficiency of transmission and distribution components of the power utilities.

CHAPTER 3: IMPACT OF ENERGY SECTOR REFORMS ON ELECTRICITY SUPPLY AND PENETRATION IN KENYA RELATIVE TO OTHER REFORMING DEVELOPING COUNTRIES.

3.0 Introduction

The electricity sector plays a crucial role in economic development, influencing access to energy, supply, and overall societal well-being. Over the past few decades, many countries have embarked on electricity sector reforms aimed at improving efficiency, accelerating electrification, and ensuring a reliable and affordable power supply. This chapter examines the impact of these reforms on electrification rates and the security of power supply, with a focus on policy changes, market liberalization, regulation and the restructuring of state-owned utilities. The chapter seeks to understand whether reforms have met their intended goals and the extent to which they have influenced access to electricity, particularly in underserved rural and urban areas. In this chapter we attempt to uncover factors that drive successful reforms and the challenges that may hinder progress in achieving sustainable and equitable electrification.

3.0.1 An overview of global electricity access

Over 1.5 billion people globally have no access to electricity. This translates to about 16% of world population (World Energy Outlook (WEO), 2016). The highest percentage (95%)of these people live in Africa and Asia (AGECC, 2010).However, over the last two decades, India and China have had significant growth in access to modern energy. This has been attributed to rapid economic development, higher rate of urbanization and access to electricity programmes (WEO 2016).

Approximately 3billion people globally rely on traditional biomass whose use results in illnesses and deaths due to air pollution. Failure to access clean forms of energy leads to overstretching of health sector services; women spend a lot of time fetching firewood;income generating activities are impended; and children cannot do school homework in the evening without proper lighting. Energy production and consumption patterns globally contribute to greenhouse gasesresulting in climate change (AGECC, 2010).

The international community is heightening interest on access to clean energy for all. In 2010, United Nations committedits members to work towards universal access to clean energy by 2030. The Sustainable Development Goal No. 7 hopes tosteer access to affordable and clean energy by all. Low-income countries are called to increase access to clean energy,and middle income countries to improve the energy systems to reap maximum growth from energy consumption and improved efficiency. High income countries should de-carbonize their energy sector (AGECC, 2010).

Poverty alleviation strategies formulated at the national and regional levels, have all made a significant contribution to increased energy access. Most SSA countries have energy policies in place, as well as plans to expand the sector. The national policies have set goals for universal access to electricity, which have rarely been met (WEO, 2014). To fully address energy poverty, additional efforts and resources are required.

The on-going global reforms in the power sector since the mid 1990's has as one of its many objectives expansion of access to electricity (Bacon 1995, Bacon and Beasant,2001). Access to electricity has however remained very low across sub-Saharan Africa.While the average world electrification rate is 84percent,that of sub-Saharan Africa's rate was 35percent in 2014.

Table 3.1 Electrification rate in selected sub-Saharan African countries,2020

Country	**Electrification rate**	**Urban electrification rate**	**Rural electrification rate**
Sub-Saharan Africa	**48%**	**78%**	**27%**
Benin	41%	66%	18%

Botswana	72%	91%	26%
Cameroon	65%	94%	25%
Congo, Dem.Rep.	19%	66%	15%
Ethiopia	51%	93%	39%
Gabon	91%	98%	28%
Ghana	86%	95%	74%
Kenya	71%	94%	63%
Mauritius	100%	100%	100%
Mozambique	31%	75%	45%
Namibia	56%	75%	36%
Nigeria	55%	84%	25%
Senegal	70%	95%	47%
South Africa	86%	88%	75%
Tanzania	40%	73%	22%
Togo	54%	94%	24%
Uganda	42%	70%	33%
Zambia	44%	82%	14%
Zimbabwe	53%	85%	37%

Source; World Bank Global Electrification database, 2021.

Within SSA, there are wide disparities. While Mauritius, Gabon and South Africa electrification rate is over 80%, Uganda, Kenya, Ethiopia, Tanzania and Zambia's rate below 30%.It is worthwhile noting also that rural areas at both the global level and in Africa have the lowest levels of electrification

3.0.2Electricity energy access in Kenya.

In the recent past Kenyan Government has prioritized electrification as one of its major policy agenda. The government has sought out resources both financial and human locally and from global partners to see this agenda come to fruition. This move has seen electrification in Kenya grow at a high rate compared to other developing countries. In particular, there has been a deliberate effort to electrify rural households, public schools and market centers. As at the time of this research the programmes to electrify and generate more affordable clean energy were ongoing.

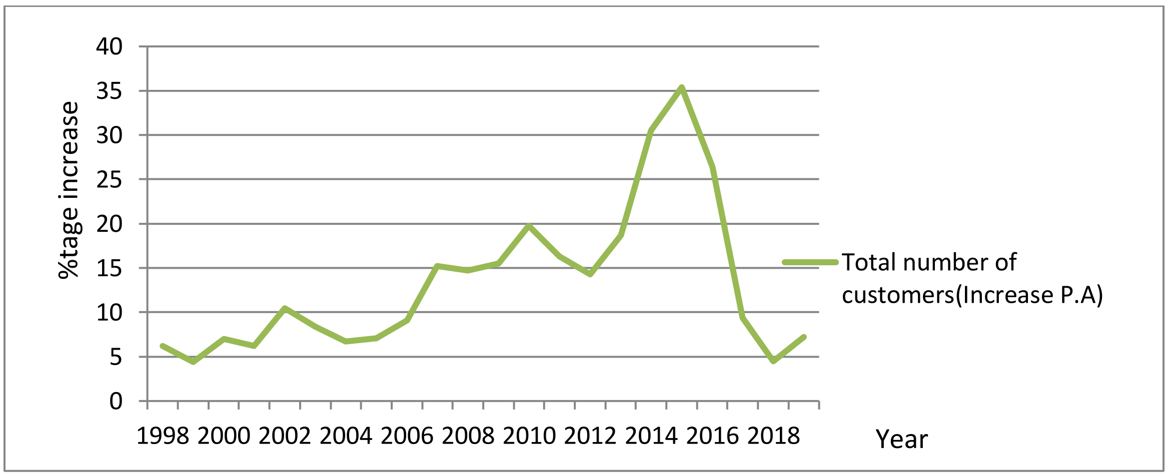


Figure 6: Annual increase in number of electricity customers in Kenya

Source: Author from KPLC Annual reports data.

The growth rate jumped in 2006/2007 from 9.1 to 15.2% (KPLC annual report 2006/2007)with the Rural Electrification programme. The government between 2014 and 2017 put a lot of focus on electrification with the aim of having universal access this saw accelerated growth in the number of households connected to the grid. KPLC also eased connection charges and formalities and more so for the informal settlements. Figure 3.2 shows the growth trend of domestic customers.

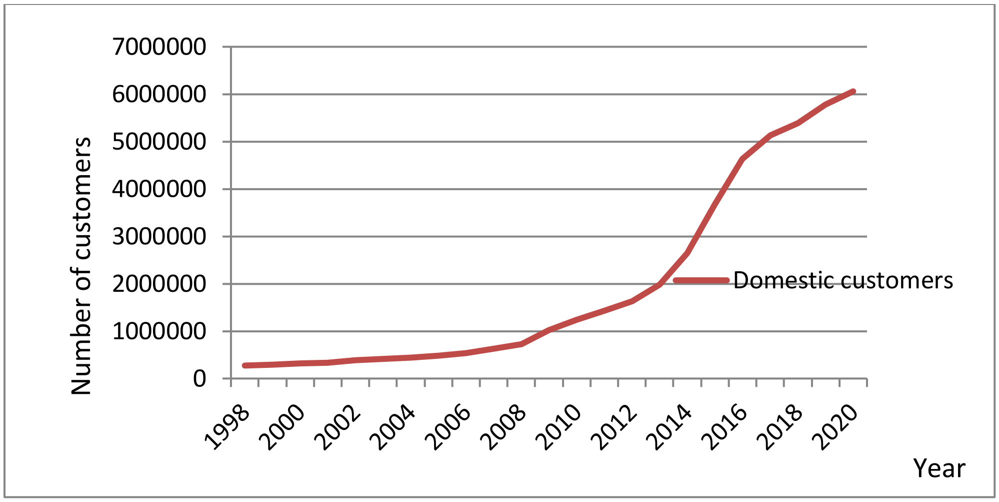


Figure 7 Growth in domestic electricity customers in Kenya, 1998-2020.*Source: Author from KPLC Annual reports data*

Despite the rapid increase in electrification level and therefore in the number of customers, this has not been reflected in an equal trend in electricity consumed per capita as shown below.

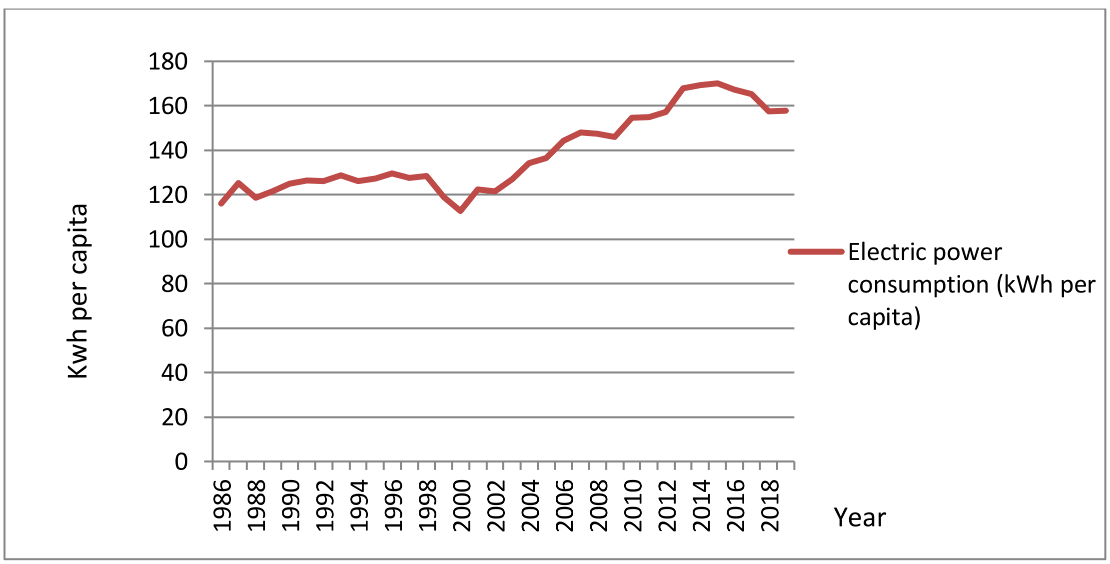


Figure 8 Electricity consumption per capita in Kenya

Source: Author using data from KPLC Annual reports

It would be expected that the drastic rise in the rate of connectivity depicted in figure 3.2 and electricity supply would translate into an equal increase in the rate of per capita electricity consumption. This has not been the case in Kenya

Kenyan households use electricity mainly for lighting. High domestic electricity tariffs coupled with low incomes limit extensive use of electricity by the households.

3.0.3Electricity energy supply in Kenya.

Kenya's power energy mix has been dominated by hydro power for many years. Other energy sources such as geothermal, thermal, wind, solar and biomass have had very minimal contribution to the overall energy mix up until 2000's. The overreliance on hydro power resulted in insecurity in power supply especially in the mid 1990's as a result of drought. During this time the Kenyan economy was struggling from the aid embargo imposed by donors. The government then, had no financial capacity to support power generation which was by then under public ownership. This is also the time when donor driven reforms kick started.

To scale up supply of electricity the government increased production from thermal generation stations (Kipevu I and II). This resulted in increased power tariffs owing to the high cost of thermal generated power. At the same time the government commissioned geothermal power plants in Olkaria. The process of unbundling the power sector to generation, transmission and distribution also started at this time in a bid to meet donor condition to facilitate access to donor funds.

Power generation sub sector has since undergone major changes. The once government owned generation company (Kengen) has been partially privatized with the government owning 70% andthe remaining 30% now owned by the private sector. Kengen is now the major power supplier in Kenya followed by other IPPs who are mainly thermal power generators. As of 2018, energy mix in Kenya had changed dramatically with geothermal sources contributing 47% of total power, Hydro power 30.15% and thermal power plants contributing 20.6% of total energy supply. These changes have resulted from both donor driven reform and government-initiated reforms.

Empirical research has mixed finding on the impact played by the reforms in power sector on electrification and supply of electricity to households. A lot has been done in increasing electricity generation and electrifying households as well as public facilities. To what extent the power sector reforms have contributed or otherwise to these outcomes are the focus of this paper.

3.0.4Problem Statement.

The reforms in the electricity sub-sector in Kenya have been ongoing since mid-1990, starting with donor driven reforms followed by government-initiated reforms. With the reforms, the government planned that 70% of Kenyan households would access electricity by 2017 and all Kenyans by 2020(KPLC annual report, 2017). On the supply side Kenya had an installed capacity of 2,819MW and a peak demand of 1912MW as at the time of this study.The access from both grid and off-grid had risen to 73 percent as at June 2018 (KPLC Annual Report, 2018).This has been achieved through various government projects aimed at providing electricity to all Kenyans inorder to bring about socio-economic transformation and development (KPLC Annual Report, 2018).On the other handelectric power consumption in Kenya had risen from 127 Kwh per capita in 1993 to 161 kWh per capita in 2018. With this achievement, have the power sector reforms speeded up electrification and supply of electricity in Kenya?

3.0.5 Research questions

1. How have electricity sector reforms impacted electrification rates, particularly in rural and urban areas?

2. What has been the effect of electricity sector reforms on power supply?

3.0.6Objectives of the study

i. To assess the impact of electricity sector reforms on the electrification.

ii. To evaluate the effect of electricity sector reforms on power supply.

3.0.7 Justification of the study

Kenya's energy sector has undergone significant transformations as a result of reforms and other government policies implemented since the mid-1990s. These reforms include: vertical unbundling of KPLC, the formation of the Energy Regulatory Authority, the enactment of the Energy Act, private sector participation in the sector. More government initiatives are underway to fully electrify households and increase supply of affordable electricity to the Kenyans. Literature suggests that these initiatives will propel economic development and the wellbeing of all Kenyans

Literature on the reforms suggests that power utilities have the capability of improving accessibility and supply of electricity particularly in developing countries where these have been lagging behind. Reforming of the previously state owned utilities is one of the measures seen to positively impact on these outcomes. In this paper we evaluate the role played by these reforms in impacting on electricity access and supply.

3.1 Literature Review

3.1.1 Theoretical literature review

To understand the impact of reforms on access and supply of electricity we need to consider some of the characteristics of energy sector that differentiate it from an ordinary firm. To begin with, the sector is characterized by large sums of sunk costs in form of assets that cannot be put into any other use. Secondly the sector is characterized by political influence especially in pricing of electricity. These characteristics create the necessity to regulate in-order to safeguard the interest of the various players. Regulation minimizes the contracting problems that are likely to arise and make it impossible for the market mechanism to operate effectively (Levy &Spiller, 1990).

A regulatory system that is effective is important for the protection of both the consumer and investor (Zhang et al 2006). Good regulatory system can give private investors the confidence by protecting them from arbitrary decisions from political systems. It can also protect consumers from monopolistic abuse in cases where only one firm is in operation. On the other hand, a regulation that is burdensome will negatively impact on firms' productivity and inhibit private investment. An effective regulatory body can therefore promote investment by reducing regulatory risks, promoting efficiency and therefore increase productivity and capacity utilization.

Unbundling of vertically integrated power utilities is considered indispensable in encouraging competition in generation.It facilitates expansion of generation capacity by allowing new entrants and reducing distribution and transmission losses through more efficient operations (Nagayama 2010). In many developing countries the rate of electrification and electricity supply are quite low. Proponents of reforms attribute this position to supply side and demand side constraints. On the supply side, state owned, vertically integrated sectors lack financial resources necessary to establish adequate generation capacity. On the demand side, the cost of electricity connection and consumption may be prohibitive especially for the households.However unbundling also comes with a cost as pointed out by Hattori and Tsutsui (2004), a country risks a loss of economies of scale associated with a vertically integrated sector.

Theoretical arguments in favor of privatization dwell mainly on the effect on efficiency. The argument is that privatization results in higher productivity and better capacity utilization (Zhang et al, 2006). In case of state-owned firms, an important objective is to provide electricity to as at an affordable price. On the other hand, when the sector is privately owned, the key objective is likely to be profit maximization. A possibility of government not keeping their promise on agreements, make private investors cautious on investing on capacity. Private players may also be hesitant to electrify if it is unprofitable to do so.

How competition impacts on electrification and demand is unclear. Competition encourages evolution of organization to facilitate better changes in running the firm. This offers an inexpensive and very effective way of monitoring firm's operations controlling operating costs and generally enhancing the level of efficiency in operations. Benefits accruing from these changes in form of low per- unit cost when passed on to consumers results in increasedelectrification and generation of electricity. However, competition will only be beneficial if the economies of scale present are such that one entity is unable to meet the demand at lower cost than if there is competition. When this is not the case, and firms are allowed to enter the market, economic theory says the firm will provide services at higher costs. If the firms are allowed to vary prices, they will do so to recover cost otherwise they will operate at a loss which means there will be no motivation to increase electrification rate or to generate more electricity.

3.1.2: Empirical Literature

The ultimate motive of power sector reforms is to facilitate access to adequate and affordable electricity. Other motives such as enhancing efficiency, removing reliance on government subsidies etc are all geared towards achieving this goal. It is clear that electrification rates globally have been rising as is the amount of electricity generated (Haanyika, 2006). For example Tanzania had 1.7%

access to electricity in rural areas in 1998, which increased to 18% in 2018, Senegal from 9.5% in 1998 to 20% in 2018, and Kenya from 6.6% in 1998 to 74% in 2018. In Chile, rural electrification increased from 53% to 76% in the seven years following reform, while in Peru it increased from 5% in 1993 to 20% in 1997 (Haanyika, 2006).

Several studies have examined how reforms impact on different the power sector outcomes. Research findings have differed between these studies. We carry out a review of a number of these studies in this section.

In 1997, Newberry and Pollit evaluated the impact on one of the pioneer countries to initiate reform in the energy sector. The then England and Wales is considered among the first countries to start reforming a formally government owned and run power sector. The observable achievements of an industry which had been publicly owned since 1948 contributed a lot to the spread of the reform agenda to other countries. Among the achievements highlighted by Newberry and Pollit, (1997) are increase in labour productivity, lower power costs, increase installed capacity and power supply.

Argentina was also among the pioneer countries in implementing power sector reform.Pollit 2004 researched on the effect of reforms in Argentina. He showed positive changes in expansion of generation capacity, growth in electrification and a fall in price of electricity following the reforms. He also observed decline in transmission and distribution losses which came about from improvement in operations efficiency.

Among the reforms proposed and adopted by many countries is establishment of a regulatory authority/agency to oversee and ensure smooth and fair operation of the sector. Most power sector regulatory authorities are charged with a number of responsibilities among them; regulation of energy tariffs, ensuring fair competition, licensing of industry players, consumer protection among others. A study by Cubbin and Stern (2006), focused on how these authorities have performed in 28 developing countries. The study concluded that enacting a regulatory authority has had a positive impact on governance, electricity supply and efficiency in the countries assessed.

The fact that power utilities as earlier mentioned were publicly owned before the reforms, meant that there was zero competition in this sector. Economic theory has advanced many benefits that accrue in a competitive market. An investigation in 36 developing countries confirmed this theory that completion in the power sector indeed improves the sector performance (Zhang, Parker and KirkPatrick ,2008). As a result of competition, the 36 countries experience increase labor productivity, higher efficiency levels and increase power supply.

Results of a panel data regression analysis show that reforms such as unbundling of generation and transmission, introduction of independent power producers (IPPs), introduction of wholesale market and establishment of independent regulatory agencies contributes to increased electricity generation per capita as well as reduction of transmission and distribution losses on of 85 developed and developing countries (Nagayama, 2010)

The search for evidence on reforms performance has also resulted in inconclusive evidence. Clark et al.(2005) study in 4 Sub- Saharan African countries found significant increase in electrification rate and improvement in quality of power supply. The study could not however attribute these positive findings to the reforms. The study alluded that the improvements could be as a result of other government and donor driven initiatives as opposed to 1990s reforms.

A few studies have attempted to investigate how reforms have impacted on electrification in different countries. Kozulj (2004), basing his study in Latin America and Caribbean found evidence that reforms accelerated electrification level and electricity consumption despite increase in tariffs. Prasad

(2008) came up with similar findings in a study conducted in Botswana, Senegal, Ghana and Honduras. His study suggested that reforms led to increased access to electricity when adjusted. Erdogdu (2014) conducted an empirical investigation using panel data in 55countries to assess whether reforms in power enhance security of supply. Results suggest that liberalization of the power market enhances self-sufficiency in power supply in developing countries.

There is therefore no conclusive evidence for or against power sector reforms. However, most studies indicate competition and regulation as critical in improving performance in this sector.

3.2 Methodology

3.2.1 Theoretical framework

The approach in this analysis has been applied in most empirical literature looking at how reforms have impacted on the performance of state utilities. The main empirical research papers that we follow are Cubbin and Stern(2006) and Gutierrez(2003)

In this study we used the fixed effects model, we employed dummy variables to represent the time period before and after a specific reform. This method has been used in the literature by for exampleFoster, Vivien, and Rana (2020), Zhang, Kirkpatrick& Parker(2002)and Dinkelman(2010)though it does not give a lot of information about the extent to which a particular reform has been implemented. It nevertheless gives a fair indication of the impact of the reforms on several sector outcomes.

Data was obtained from the World Bank's Energy database. We examine Regulation, competition, private sector participation and restructuring reforms.To account for differences between countries and over time we includeGDP per capita,net installed capacity and Political Democratic Index (PolityIV) as control variables.

Following Steiner,(2000), Balza et al (2013),Cubbin and Stern(2006), Gutierrez(2003) in the panel data analysis, the reform steps are represented by a dummy variable . 1 indicates whether a reform has been undertaken and zero otherwise. For example, the measure of regulation is 1 from the year when a regulatory authority was established and zero before that year.

3.2.2Analytical framework

In this section we analysehow reforms impact on electricity access and generation in Kenya relative to the situation in Uganda, Tanzania and Senegal. Following the reviewed literature, the model was expressed as;

$Y_{it} = f(R_{it}, Xit)$……………………………………………………………………3.1

$Y_{it} = \beta_0 + \beta_1 R_{it} + \beta_2 X_{it} + \alpha_i + \varepsilon_{it}$……………………………………...…………3.2

$E(\varepsilon|x) = 0; Cov(x_{i,}\varepsilon) = 0$

Yit is access to electricity and electricity generation per capita, R represents the four reforms namely; restructuring, regulation, legislation, private-sector participation, and competition. X represents the control variables discussed above. β's are the parameters to be estimated, and α_i is a country-specific residual.

Equation 3.1 can be writtenas:

$Y_{it}=(Restr_{it},Reg_{it},Leg_{it},PSP_{it},C_{it}.GDP_{it},IC_{it},PolityIV_{it})$ ………………..3.3

Presentedas a loglinear model Equation 3.3can be written as follows:

$$Y_{it}=\beta_0 + \beta_1 \text{Restr}_{it} + \beta_2 \text{Reg}_{it} + \beta_2 \text{Leg}_{it} \ \beta_3 \text{PSP}_{it} + \beta_4 \text{C}_{it} + \beta_5 \, ln \, \text{GDP}_{it} + \beta_6 \ \ln(\text{IC})\text{it}, + \beta_7 \text{lnPolity IV}_{it} + \alpha_i + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots 3.4$$

Where:

$Y_{1\text{-}4(it)}$ represent; national electrification rate,rural electrification rate, urban electrification rateand log of electricity generation per capita,

$Restr_{it}$ represents restructuring, Reg_{it}represents regulation, Leg_{it}represents legislation

PSP_{it} stands forprivate sector participation,

C_{it} stands forcompetition

GDP_{it}stands forgross domestic product,

IC_{it}stands for installed capacity

$PolityIV_{it}$stands for democratic index

This equation isestimated using a fixed effect model. Fixed effects model is preferred because of its wide applicability. It focuses more on within group variations, providing more insights on the impact of reforms over time within the chosen countries. By controlling for time-invariant country characteristics fixed effect model also ensure that our estimates are robust.

3.2.3Data source

The study's data came from World Bank national accounts, the International Energy Agency, the Center for Systemic Peace, and other national accounts The table below describes the variables and their respective data sources.

Table 3.2 Variable description, measurement and source.

Variables	Description	Source
Independent variables		
$Y_{1\text{-}3(it)}$	Electrification rate (National, Rural,Urban) (%)	World Bank

$Y_{4(it)}$	Electricity generated (Kwh)/population	IEA
GDP_{it}	GDP per capita (constant 2010 US dollars)	World Bank
IC_{it}	Net installed capacity	National accounts
$PolityIV_{it}$	Political Democratic Index	Center for Systemic Peace
Reg_{it},	Dummy variable.	IEA
$Restr_{it}$	Dummy variable	IEA
C_{it}	Dummy variable	IEA
PSP_{it}	Dummy variable	IEA
Leg_{it},	Dummy variable	IEA

Dummy variable, 0 for the period prior to the reforms and 1 for the period following the reforms

Source: Author.

3.3Results and discussion

3.3.1 Summary statistics

Table 3.3shows the characteristics of the variables used in the estimations in this study.

Table 3.3 Summary statistics

Variable	**Unit of measurement**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
$\mathbf{Y_{1(it)}}$	Percentage	25.23	18.56	0.993	75
$\mathbf{Y_{2(it)}}$	percentage	13.29	14.72	0.184	71.68
$\mathbf{Y_{3(it)}}$	Percentage	56.35	17.73	24.21	92.4
$\mathbf{Y_{4(it)}}$	Kwh per capita	130.64	60.64	50.44	290.08
$\mathbf{GDP_{it}}$	Current US$	715.89	390.38	157.06	1707.99
$\mathbf{IC_{it}}$	Kilowatts	795.17	487.02	177	2269.5
$\mathbf{PolityIV_{it}}$	Score (-10 to +10)	1.57	4.79	-5	9
$\mathbf{Reg_{it}}$**,**	Dummy variable (0,1)	.65	.48	0	1
$\mathbf{Restr_{it}}$	Dummy variable (0,1)	.38	.49	0	1
$\mathbf{C_{it}}$	Dummy variable (0,1)	.36	.48	0	1
$\mathbf{PSP_{it}}$	Dummy variable (0,1)	.69	.46	0	1
$\mathbf{Leg_{it}}$**,**	Dummy variable (0,1)	.46	.5	0	1

Source: Author's computations.

This table provides summary characteristics of the variables before any transformation.The national access to electricity averaged 25.23% for the four countries. It was lowest in the early 1990's, the period before the reforms. The average access to electricity in rural areas is 13.29%, as in the national access, this was very low in the 1990's(minimum of 0.184) but has risen to highs of 71.68% in 2018.the mean access in urban areas is above 50%. Compared to the national and access in rural areas the minimum and maximum access level in urban areas are quite high.

Installed capacity has also increased from a minimum of 177 Kilowatts in Uganda in 1993 and a maximum in 2017 of 2269.5Kilowatts in Kenya. PolityIV score ranges from -5(anocracy) to 9(democracy). Electricity generated in the four countries average is 13.64 Kwh per capita.The reform measures are captured as dummy variables with minimum of zero and maximum of one.

3.3.2 Diagnostic test results

Several diagnostic tests were conducted in this study to facilitate formulation of the ideal model for our study. To choose between fixed effect model and random effects model in the panel data analysis we used Hausman test. The findings are presented in appendix 1-4.The results from this test indicates that in all our four regressions, the fixed effects model is the most appropriate.

Findings from other post estimation tests are presented in the table below.

Table 3.4 Model specification test results

Test	**Variables**	**Statistics**	**P-Value**	**Findings**
Heteroskedasticity: Modified Wald test for group-wise heteroskedasticity	National electrification rate	25.16	0.0000	Presenceof heteroskedasticity
	Rural electrification rate	9.30	0.0000	Presenceof heteroskedasticity
	Urban	29.31	0.0000	Presence of

	electrification rate			heteroskedasticity
	Electricity generation capacity per capita	6.61	(0.1580)	No heteroskedasticity
Serial correlation (Wooldridge test)	Access/National Level.	76.1	(0.0032)	serial correlation present
	Access rural	32.44	(0. 01)	serial correlation present
	Access Urban	12.36	(0.039)	serial correlation present
	Electricity generation capacity per capita	0.544	(0.514)	no serial correlation
Cross-section dependence: BREAUSCH-Pagan LM Test of independence	Access/National Level.	-1.956	(0.0505) -	no cross-section dependence
	Access rural	-1.024	(0.3058)	no cross-sectional dependence
	Access Urban	-2.68	(0.0074)	cross-sectional dependence present
	Electricity generation capacity per capita	0.1925	(0.9264)	no cross-sectional dependence
Unit root test(Levin – Chu unit-root test	Access/National Level.	-2.37	(0.009)	no unit-root
	Access rural	-2.000	(0.02)	no unit-root
	Access Urban	-1.72	(0.04)	no unit root
	Electricity generation capacity per capita	-0.464	(0.3213)	Presence of unit root

Source: Author's computations.

The four models tested positive for heteroskedasticity. Apart from electricity generation model, the other three models also tested positive for the presence of serial correlation.The study used robust standard errors to correct the identified heteroskedasticity and serial correlation in the models.

When using panel data, it is possible to have errors showing cross-sectional dependence. This may be as a result of interdependence between countries, for example,in economic transactions.We therefore tested for cross-sectional dependence using Breausch-Pagan Lm test of independence. Our findings indicate absence of cross-sectional dependence in national access to electricity model, rural access to electricity model and also in electricity consumption model. However, the urban access to electricity model exhibited presence of cross-sectional dependence. To test for unit-root, we used Levin – Chu unit-root test. Regarding the variables found to exhibit a unit root, this study followed the discussion by Kao(1999),Pesaran and Smith(1995) and (Smith2001). The three studies argue that, unlike in time series analysis where data is averaged over time, in pooled estimations, data is averagedin groups, this reduces the noise allowing us to get a consistent estimator. We can therefore prevent the issue of spurious regression even when variables contain a unit root and also obtain efficient estimators by using pooled data.

3.3.3Regression results

The regression results Equation 3.4 are presented in the following tables with adjustments incases whereheteroskedasticity, autocorrelationand cross-sectional dependence have been identified in the diagnostic stage

3.3.4 Reforms and nationalaccess to electricity.

Fixed effect model gave the following results;

Table 3.5 Fixed effect estimates of the impact of reforms on national access to electricity.

variables	Model 1	Model 2	Model 3	Model 4
GDP	9.4402(6.974)	12.0458(7.816)	9.976(7.824)	11.268(8.432)
IC	12.669**(6.426)	114.649**(6.563)	12.548**(5.532)	15.254**(4.996)
Polity IV	4.928**(1.958)	5.038(2.385)	5.027**(2.018)	2.634**(2.332)
Restr	-6.818(5.371)	-6778(5.400)	-6.792(5.468)	-6.694**(2.301)
PSP		-.822(35.87)	-.818(3.741)	1.635(1.872)
Reg			.251(3.982)	-5.814(1.931)

C				**18.196*** (1.930)**
Constant	**-136.28*** (21.179)**	**-128.775*** (.1189)**	**-147.723*** (21.984)**	**-151.127*** (34.383)**
R squared	**.6786**	**.6800**	**.6787**	**.7718**

Notes: Standard errors in the parenthesis,* $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Source: Author's computations.

In model 1, 2 and 3 national electricity access variable is regressed on the control variables and on reform variables which are introduced in the model in the order in which they were adopted. In model 1 restructuring which was the first reform measure to be introduced in 1997 is a dependent variable together with the control variables. Model 2 adds private sector participation which was launched in 1997 with the introduction of two independent power producers. In model3 regulation which represents the establishment of Electricity Regulation Board in Kenya in 1998 is added to the model. Model 4 is the overall which encompasses all reform variable and the control variables. From model 4 we conclude that competition on the supply has contributed positively to accelerated electrification in the country.Restructuring has had a negative impact while Regulation and private sector participation have had no effect. Zhang, Parker, and KirkPatrick reported similar findings in their study.

3.3.5Reforms and rural electrification.

A regression of the fixed effect model on the rate of rural electrification gave the following result;

Table 3.6 Fixed effects estimates.

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
GDP	3.139(6.300)	3.960(9.514)	4.231(8.817)	3.459(7.708)
IC	16.978***(5.460)	16.974***(5.643)	20.287***(6.631)	18.174***(6.089)
Polity IV	1.945(2.983)	4.100(3.443)	4.223(2.877)	1.678(1.289)
Restr	-11.123 (7.668)	-11.094(7.672)	-11.052(7.649)	-8.873**(4.378)
PSP		-.9933(5.427)	-.994**(5.570)	1.690(3.472)

Reg			-0.753(6.77)	-7.780**(3.807)
C				20.821***(4.94)
Constant	-115.892***(42.5956	-110.995(-1.84)	-103.514**(36.386)	-130.321***(28.037)
R squared	.5381	.5185	.5200	0.6461

Notes: Stderrors in the parenthesis $* p < 0.1$, $** p < 0.05$and $*** p < 0.01$.

Source: Author's computation.

Model 4 which is the overall model incorporating the four reform variables and the three control variables indicates again that competition has a positive and significant impact on rural areas access to electricity. Regulation and restructuring negatively impacts on rural areas electrification while private sector participation has no impact. Zhang, Parker, and Kirkpatrick (2002) reached same conclusion regarding competition, but their research found regulation and privatization to have no significant impact on rural electrification.

3.3.6Reforms and urban electrification.

The same fixed effect models were regressed as before with urban areas electrification rate as the dependent variable. The following results were obtained;

Table 3.7 Fixed effects estimates.

variables	Model 1	Model 2	Model 3	Model 4
GDP	17.849(13.234)	18.495(14.475)	15.378(14.375)	17.526(13.726)
IC	8.179*(4.889)	8.174(5.162)	6.736(4.722)	7.562(4.875)
Polity IV	3.849***(1.287)	4.023**(1.749)	3.659**(1.487)	2.870**(2.45)
Restr	-8.4128(2.781)	-8.381***(2.738)	-8.412*** (2.811)	-7.871***(1.754)
PSP		-1.014(2.528)	-1.035 (1.457)	0.218(1.812)
Reg			3.552*(2.134)	0.498(1.561)
C				9.558***(0.783)

Constant	**-120.210*** **(58.490)**	**-124.492*** **(61.111)**	**-98.497*** **(57.167)**	**-117.141** **(66.861)**
R squared	.8056	.8047	.8145	.9505

Notes: Stderrors in the parenthesis * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

*Source: Author's*computation

As in the case of national electrification and rural electrification analyzed above, competition appears again as the key reform that impacts positively and significantly to urban electrification. Restructuring again appears to negatively impact the rate of electrification in urban areas while private sector participation and regulation have no impact.

3.3.7Impact of reforms on household electricity supply.

In this section, equation 3.4 was estimated with electricity generated as the dependent variable. GDP, installed capacity and polity were used as control variables while electricity sector reforms were introduced in each successive model.

Table 3.8 Fixed effects estimate.

variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
GDP	.4655 (.3023)	.4356 (.2760)	.4156 (.2616)	.415* (.2554)
Installed Capacity	.2358 (.1778)	.2368 (.1689)	.0292 (.0175)	.2055 (.1800)
Polity IV	.0432** (.0175)	.0369 (.0262)	.0292* (.0175)	.0342* (.0202)
Restructuring/Unbundling	-.1938*** (.0475)	.1948*** (.0558)	-.1952*** (.0464)	-.01991*** (.0316)
Private sector participation		.0408 (.1043)	.0407 (.0880)	.0320 (.0887)
Regulation			.0624 (.0589)	.0839 (.0684)
Competition				-.0677 (.0465)
Constant	.16501 (.9966)	.3374 (.7873)	.0604 (.7438)	.6584 (.7119)

R squared	.8512	.8534	.8592	.8626

Notes: Stderrors in the parenthesis * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Source: Author's computation.

The coefficient of PolityIV is consistently significant in three models. This suggests that the strength of institutions is key in facilitating adequate supply of electricity. GDP is positive and significant in the fourth model where all reform variables are incorporated.Restructuring is seen to significantly and negatively impact on electricity supply. From our analysis private sector participation, regulation and competition do not lead to obvious improvement in electricity supply.

3.4 Conclusion

The findings of this study highlight the critical role played by competition in accelerating electrification both nationally and across rural and urban areas and also in enhancing power supply. By opening the market share to multiple players, competition creates an enabling environment for fostering efficiency, better service delivery, innovation and infrastructure expansion to underserved population. This suggests that policies aimed at enabling competitive power sector can more effectively promote widespread electrification.

The study on the other hand indicates a negative relationship between restructuring and electrification progress. Restructuring is often implemented to improve operational efficiency and governance. However, in the short run it can disrupt implementation of ongoing electrification policies. Restructuring process involve reallocation of resources, reorganizing power sectors, developing new institutional frameworks and so on. All this may create short term instability that may slow down electrification pace. These findings therefore suggest that, while restructuring may be beneficial in the long term, the process require proper management in the short run to avoid negating electrification process.

The study finds no significant impact of regulation and private sector participation. This suggests that, while these two reforms are key in ensuring proper oversight, fair competition and consumer protection, on their own they may not be sufficient. Without competition private sector participation on its own may not yield the desired outcomes.

Overall, this chapter shows that competition is clearly a key driver in enhancing access to power and improving power supply. Other reforms such as restructuring, private sector participation and regulation though necessary must be carefully managed and aligned to the sector's electrification strategies to minimize possible negative impact. Policies makers must therefore strike a balance between promoting competition and minimizing negative impacts of other measures in the short run to facilitate achievement of electrification for all.

CHAPTER 4: IMPACT OF ELECTRIFICATION ON HOUSEHOLD WELFARE IN KENYA

4.0Introduction

Access to electricity is widely recognized as a key driver of socio-economic development, directly influencing household welfare. Electricity enables access to modern necessities, improves living standards, and creates opportunities for income generation and education. This chapter explores the impact of electricity access on household welfare, focusing on how electrification enhances household's well-being, including income, education and household's labour dynamics. By analyzing empirical evidence from various contexts, we examine the extent to which electrification can reduce poverty, increase productivity, and foster long-term development. This analysis also highlights the disparities in the benefits of electricity access across urban and rural areas.

In Kenya the agenda of combating poverty has been there since independence. Several government policies have been developed to tackle this problem. Kenya Vision 2030 which aspires to transform the country into a middle-income is one example of policy document which aims at combating poverty in Kenya. The policy document is anchored on among other things infrastructure development and enhancement of energy. This development blue print highlights the need to address poor infrastructure and high cost of energy for the vision to be realized.

Investment in physical infrastructure is generally associated with long term economic growth. Coupled with sound macroeconomic policies, good governance and strong institution, sustainable economic growth which is socially inclusive can be achieved. The linkage between physical infrastructure and poverty reduction has been debated alot in the literature (Khandker et al 2012, Khandker et al 2009, Bensch et al 2011, Chakravorty et al 2013). This has given rise to two schools of thought. One school of thought finds no contribution from physical infrastructure in alleviating poverty. This school argues that, social infrastructure such as health and education is what drives poverty down. The second school in support of the physical infrastructure argues that, with proper macroeconomic policies, political willingness and good institution it is likely that physical infrastructure will contribute to poverty alleviation. However, the general consensus is that there is a positive linkage between good infrastructure and poverty alleviation.

Povertyand access to electricity in Kenya.

Although the Kenyan economy has been growing overtime, a huge part of its population is still very poor. In 2015 the percentage of Kenyan's living below the poverty line i.e. population whose consumption expenditure was below Kshs. 3,252per person per month in rural areas and below Kshs 5,995per person per month in urban areas was 36%. 32% of the population was "food poor" i.e. food expenditure per person per month was below Kshs. 1,954 in rural areas and Kshs.2,551 in urban areas.The table below shows poverty levels for the year 2005/2006 and year 2015/2016.

Table 4.1 Poverty rates in Kenya, 2005/2006 and 2015/2016

Year	**Indicator**	**Overall Poverty rate%**	**Food poverty rate%**	**Population living in poverty(Million)**
2005/2006	Rural	49.7	47.2	14.1
	Urban	34.4	40.4	2.5
	National	46.6	45.8	16.6
2015/2016	Rural	40.1	35.8	11.7
	Urban	29.4	24.4	3.8
	National	36.1	36.1	16.4

Source: Kenya National Bureau of Statistics

Overall population living in poverty has declined marginally except that in the urban areas.Though studies have been done on the role of physical infrastructure on poverty reduction, little is known about the Kenyan case.In this study we look at how electricity connections by households impacts on some indicators of welfare.

4.0.1 Statement of the problem.

The ultimate goal of any energy sector policy goes beyond provision of clean and affordable energy to its people. Electrification is mainly pursued as an effort to improve people's way of life. Kenya vision 2030 highlights provision of reliable energy as one of the key support strategies to "attaining sustainable economic growth through: increased productivity in all sectors, poverty alleviation through equitable distribution of resources, creation of employment and enhanced access to basic needs" (GoK,2008).

A section of empirical literature asserts that electrification contributes immensely to welfare growth through various channels(Khandker 1996, Dinkelman, 2008) as discussed above.The claim is, however, not universal. Bernard, 2010 for example expresses skepticism on the assumed benefits of electrification. He argues that the available evidence is not adequate to support the claimed benefits.

With Kenya's extensive energy sector reforms coupled with a very high rate of electrification, Kenya presents an ideal case particularly for developing countries for a study on the benefits accrued from households' electrification. Using a rich data set from2015/16 Kenya Integrated Household Budget Surveys (KIHBS), this essay attempted to respond to the following specific issues:

i. What is the impact of electrification on per capita household expenditure in Kenya?
ii. What is the impact ofelectrification on education enrollment ratein Kenya?
iii. What is the impact of electricity connection on time spent at work?

4.0.2Objectives of the study

Specifically, the study assesses:

i. The impact of electrification on per capita household expenditure in Kenya
ii. The impact of electrification onaverage school enrollmentrate in Kenya.

iii. The impact of electrification on average time spent at work in Kenyan households

4.0.3Justification of the study

In an attempt to foster economic development, governments worldwide allocate a lot of resources in infrastructure development. The expected result from this development is ultimately higher standards of living of the citizens. Available empirical literature confirms that infrastructure development do indeed improve household welfare (Dinkelman 2010, Grogan 2013, Lipscomb et al 2013). Consumption of electricity, water,roads and telecommunications by households is seen to improve the quality of life.

Despite the observed benefits arising from infrastructure development, empirical literature also shows that low- and middle-income countries are lagging far behind or face dire need in this aspect. This is mainly attributed to both technical and financial constraints common in developing countries. Nevertheless, governments appreciate the important role played by infrastructure in raising the household’s welfare. As a result of these realization reforms in infrastructure sectors (Water, roads, electricity, and telecommunication) have been ongoing since 1990’s globally. Empirical literature affirms that quite a lot of progress has been achieved so far, though there is still a lot that needs to be done.

We specifically focus on the impact that electrification has had on household’s income and expenditure, education and on household’s labour dynamics. We carry out this bearing in mind the difficulties raised in the literature of teasing out the impacts that can be directly attributed to grid connection.

4.1 Literature Review

4.1.1 Theoretical Literature

Household connection to electricity is seen to alter the activities of the household and how the activities are carried out. At the national level, it is widely accepted that energy drives economic growth which leads to improved household welfare (Shahidu et al, 2010). Causality runs from either energy consumption to economic growth or vice versa(Erol and Yu,1987) in Japan, others unidirectional causality either from energy consumption to economic growth (Gozgoer et al ,2018) or vice versa (Onuonga, 2012) and still others have found no causality (Stern,1993).

At the household level electrification may result in a wide range of social-economic benefits to the household among them higher income, better education, increased labour force participation and higher expenditures (Shahidu et al, 2010).

Electrification can affect household's incomes in many ways. It may change the way time is allocated to different activities. As a result of the increase in light hours, household chores may be allocated to evening hours thus freeing day time hours to other activities(Grogan,2013). This will lead to increase in available labour in the market. This may increase household's income. By reducing time spent by women carrying out home activities electrification enables them to participate more in other income generating activities (Dinkelman 2010).Time saved from firewood collection, cooking using more time consuming traditional energy sources can be used for other more productive economic activities which would not have been possible without electricity (Grogan 2013). However excess labor supply may also lead to a decline in the wage levels which may also lead to decline in wages if the additional labour results in over supply of labour in the market

Modern energy is directly linked to fostering entrepreneurial activities and thus poverty alleviation by increasing productivity and thus putting more income in the households (IEA,2002).Households with electricity connection have a higher likelihood of engaging in entrepreneurial activities compared to those without (Khandker, 2013). Electrification could encourage entrepreneurial activities which otherwise would be non-existent in an area. Activities such as welding, electricity appliances shops, hair salons, retail shops could spring up more easily in an electrified area than in non-electrified towns. Businesses are also likely to open for longer hours which translate to higher income for the household.Income generating activities appear to thrive more in electrified town centers. Small scale business enterprises such as restaurants, grain millers, bakeries, workshops which thrive in the presence of reliable electricity become a reality in rural areas connected to the grid. Besides creating more job opportunities households get more opportunities for income generation (IEA,2014).

Electrification of household may impact on how labor is engaged. It may change the amount of work, the type of jobs, a person can do and how the work is done. First, by increasing the number of light hours, everyone can work for more hours during the day and at night. Second, it can increase labour productivity through introduction of technology in both households and firms. Third, it could encourage start of new enterprises that require use of electrical appliances. Fourth, It can impact on labour by facilitating access to information, markets and jobs, and finally it could also increase time spent on recreation activities such as watching television(Dinkelman,2011).Work opportunities tend to increase in rural areas connected with electricity. Low cost of labour and land may motivate investors to set up industries in electrified areas therefore creating more job opportunities.Access to electricity may also result in introduction of technology which will improve labor productivity say in the small-scale agricultural activities predominant in rural areas. This will directly contribute to increased household income.

Modern infrastructure allows households to adopt technology in home production. With the use of more efficient technology household chores are done with lesser time and are done more efficiently. Technological shock arising from the availability of electricity when applied in home production where formally only human labor was available, leads to increased productivity for example in agricultural activities.

It is generally accepted that electrification contributes to better education outcomes. Increased lighting hours and improved lighting which allows kids more time to study at home than their counter parts in non- electrified household (Libscomb, 2013).Increased school enrollment rates and more years of schooling are also seen as immediate benefits observed in connected households. Besides this, illiteracy rates also decrease in areas connected to electricity.

The positive link between electricity and education cannot therefore be overemphasized (UNDESA,2014). Lighting can increase the teacher student contact hours. Modern media tools such as primary school laptop project in Kenya can only be done where there is access to electricity. Electrified school are seen to perform better on key educational indicators than their non-electrified counterparts (UNDESA,2014).

4.1.2 Empirical Literature review

Household connection to electricity has been seen to change the way of doing things in households. These changes may lead to welfare gains such as higher income and expenditures, improved education outcomes and more labour force participation

Reviewed empirical literature attempting to test this theory has looked at possible welfare impacts from various fronts. In most cases empirical literature has focused on assessing income outcomes, labour outcomes, education outcomes and health outcomes among others. In this paper we focus on income, labour and education outcomes which may have resulted from massive electrification in Kenya.

Evidence of income gains from electrification has shown mixed results. A study in India done by Charkravorty (2014) finds that high quality electricity (more hours of supply and fewer power outages) in rural household's increase incomesby 28%. The increase in income from non-agricultural activities attributed to grid connection by around 9% for the period 1994-2005. Using electricity for lighting increases available time for women which allow them to earn money outside home in Nicaragua (Grogan,2013). In another study by Van de Walle (2013), electricityconnection increases consumption of both food and non-food items for both the electrified households and for those households found in electrified villages. This rise in expenditure is attributed to the increase in farm and non-farm incomes and wages attributed to grid connection. Khandker(2013) finds the increase in household income to be 28% and expenditure to rise by 23%due to electrification.

The assertion of the positive income results arising from grid connection is not supported by all. For example,Dinkelman(2011) finds no impact on female earnings and a 16% increase in male earnings. Bensch(2011) also finds no evidence of any impact of gird connection on income in Rwanda. Households hardly use electricity for income generating activities. Connected households in Rwanda also spends more on energy than their counterparts who have no electricityLipscomb (2013) finds large and positive gains in income resulting from electrification in Brazil.

Labour outcomes perceived to result from access to electricity have been analyzed in several studies. The theoretical argument that electrification frees up time spent collecting firewood and other biomass and also makes home production fast and efficient have found support in several studies. Grogan

(2013), finds in Nicaragua positive correlation between having access to electricity and women working outside home for a salary but no impact in case of men. Women are 23 % likely to work outside home as a result of electrification. He also finds a negative association between grid connection and time spent by families in agricultural activities. Dinkelman (2011) also supports this argument in case of South Africa, here electrification is seen to free women from home activities and engage in micro-enterprises.

The use of electric appliances is seen in some studies as the main factor that eases time to allow women to work outside home.Dinkelman(2011), Grogan and Sadamand (2012) find use of electric stoves in South Africa for example and other time saving electrical appliances as contributing to time saving. In other studies,households in rural areas are seen to use electricity first of all for lighting. Besides increasing the quality of lighting over that of traditional lighting it affords more time for home production and also facilitates reallocation of time.

Studies on how education outcomes are impacted on by household electrification have resulted in mixed findings. For example,Bensch (2011) finds very small impact on children studying at home. Van de Walle (2013), Khandker (2013), Lipscomb(2013) and Kanagawa(2008) finds positive and significant education outcomes. Lipscomb attributes an increase of 72% in years of schooling and in Brazil to electrification. Gender issue also arise here, InIndia for example Van de Walle(2013) finds the effects on schooling significant only with girls. Lighting allows girls to reallocate time to facilitate schooling. Boys' school attendance seems not to be impacted on by electrification. In Vietnam Khandker (2013),electrification impact on both boys and girls positively. School enrollment, attendance and years of schooling improve for both boys and girls in electrified households. In Brazil electrification reduced illiteracy rate by 8%, increased schooling years by 72% factors that Lipscomb (2013) attributed to the overall increase in labour productivity.

The direction of causality is difficult to ascertain. High income levels create the demand and affordability of electricity connection. The same case applies to education levels which can foster a household's ability to be connected to the grid.

4.2 Methodology

4.2.1Theoretical framework

We employ the neo-classical growth model attributed to Solow, 1956 to predict how economic growth arising from investment in infrastructure (electricity provision) impacts on poverty. The Solow's model is represented as:

$$Y_t = F(\ K_{t,} L_{t\ ,} A_t)$$

Where: Y_t is output, K_t is capital , L_t is labour and A_t is total factor productivity . The model makes the following assumptions:

$$F_K = \delta F \frac{(\ K_{t,} A_t, L_t)}{\delta K} > 0$$

$$F_{KK} = \delta^2 F \frac{(\ K_{t,} A_t, L_t)}{\delta K^2} < 0$$

And

$$F_L = \delta F \frac{(\ K_{t,} A_t, L_t)}{\delta K} > 0$$

$$F_{LL} = \delta^2 F \frac{(\ K_{t,} A_t, L_t)}{\delta L^2} < 0$$

The argument is that, investment increases capital accumulation which increase capital and labour productivity resulting in increased incomes for all in the economy. An upward shift in total productivity raises the marginal products of both labour and income thereby increasing their incomes.The assumption of diminishing marginal returns implies that investment in infrastructure by poor countries will lead to a faster rate of growth than for the rich countries. The policy implication of Solow’s model is that policies should focus on improving incentives for economies to grow and thus reduce poverty incidence.

In analyzing the benefits of electrification to household welfare a number of issues arise. The endogeneity problem stands out as one of the issues researchers in this area face. Electrification is likely to be correlated with the outcome variables such as income levels, education outcomes and also labour productivity. Another issue highlighted in the literature is the fact that electrification is rarely randomly done, in manycases; it is likely to be placed in the most economically viable areas, politically correct regions or regions with high populations. This makes it difficult to choose the controls to include in the models. The other issue is how to deal with the spillover effects. Electrification of a village or a household is likely to also benefit the neighbors even though they may not be connected to the grid. Isolating the impacts that are exclusively as a result of grid connection is therefore a challenge.

Dinkelman (2011) regressesfemale/male employment rate on community land gradient, which indicates the presence of electricity in a community, community control variables such as household density, households living below the poverty line, distance to the grid among others.Dinkelman uses the land gradient as the instrument for electrification program. Land gradient is seen to determine the cost and ease of electrifying a community and does not directly influence the employment outcome(Dinkelman, 2011).

Several of the reviewed studies also use fixed effect instrumental variable (FE-IV) methodology. Lipscomb et al (2013) for example examines long term effects of electrification in Brazil. They estimate 2SLS model with time and county fixed effects to correct for endogeneity.

Van de Walle et al (2013) employs panel data and fixed effect method in-order to take care of possible endogeneity of access to electricity and other household characteristics. Van de Walle et al (2013) compare the outcome of electricity using difference-in difference method comparing the households' position in 1982 and in 1999. They also use proximity to power generating plans as instrumental variable.

Using panel data Khandker et al (2013) takes care of possible endogeneity by assuming that unobserved heterogeneity of household and villages remain fixed over time. The study uses fixed effect (FE) regression to sweep away any observed effect. In doing this they estimate the following equation;

$$\Delta Y_{ij} = \beta\Delta X_{ij} + \gamma\Delta Vj + \delta\Delta E_{Hij} + \delta\Delta E_{Vj} + \alpha X_{ij0} + \alpha_v V_{j0} + \chi\Delta T + \Delta\varepsilon_{ij}$$

where Y is the outcome(i.e. income, expenditure,school enrollment, completed schooling years) variable,X is a set of household characteristics, V is a set of community characteristics,E_H is household electrification status,E_V is community electrification status, T capture the time effect, X_{ij0} &V_{j0} are the initial conditions of household and community characteristics respectively.

Other methodologies used include difference-in-difference with instrumental variable (Rud 2012, Dinkelman,2011),Propensity score matching methodology (Peters et al 2011, Bensch et al. 2013) and Random control trial (RCT) (Bernard and Torero 2013, Barron and Torero 2013)

In this study we assume that household electrification impacts positively on welfare. We assume that electrification avails more income earning opportunities for the household. The growth in income is likely to lead to consumption of more both food and non-food items particularly household items that require electricity to operate. Consumption of these items may be reflection of household welfare improvement. Reporting of household incomes in some cases may be biased; to confirm the impact on income we also consider total household expenditure which is likely to be a better reflection of household welfare.

Electrification is expected to influence education in several ways. In this study we postulate that the influence on enrollment is positive. By increasing households' light hours electrification reduces the opportunity cost of enrolling children to school on the consideration that household chores can be re-allocated to evenings Schultz (1993). This is also expected to ultimately increase the schooling years.Finally,household labour supply for both male and females is likely to be positively impacted on by electrification (Dinkelman,2011).

Given the recent government endeavor to electrify public institutions in both rural and urban areas we, investigated the importance of electricity access as an input for education and its effect on educationenrollmentof children between the ages of 5 to 18 who are likely to be studying in the households. Previous literature on whether electricity accessplays a part to better educational outcomeshasmixed results.

The roll-out of rural electrification in Kenya provides us with an opportunity to evaluate whether the perceived benefits of increase in labour force participation following electrification of an area holds true for Kenya. We assess the impact of household electrification on male and female labour force participation in Kenya.

4.2.2 Analytical framework

The study's aim was to estimate the effect of availability of electricity in a household on a number of selected welfare outcomes, namely: per capita household expenditure, average household education enrollment rate and average household labour participation.

We use 2SLS(IV)method to estimate our model. This method was chosen based on the possibility of encountering endogeneity in our analysis.Household electrification is likely to be correlated with either the outcome variables mentioned above or with other control variables. We therefore use proportion of households in a cluster that are connected with electricity as an instrument. Relevance and exogeneity tests were conducted to confirm the validity of the instrument.

In the first stage we regress the outcome variable on the instrument and control variable which in this care are household's characteristics.

$E=\alpha_0 + \alpha_1 P + \alpha_2 X_i + \varepsilon_i$……………………………………………………………………4.1

Where;

E is the electrification status of the household

P is the instrument/ Proportion of households in a cluster connected with electricity

X control variables

ε_i is the error term

In the second stage we use the fitted values from the first stage model to estimate the causal effect on the outcome variables

$Yi = \beta_0 + \beta_1 E + \beta_2 X + \mu_i$..4.2

Where Y is the outcome variable/ household welfare indicator

E is the predicted household electrification status from the first stage regression

X control variables

β_1 is the causal effect of household electrification on household welfare indicator.

and μ_i is the error term of the second stage regression.

4.2.3 Data Sources

This study used for analysis 2015/16 Kenya Integrated Household Budget Surveys (KIHBS). The data has observations on household social-economic indicators in Kenya. The survey is stratified into rural and urban areas. Only Nairobi and Mombasa counties are exclusively urban.

Thesurvey collected data on household characteristics, housing situation,labour force participationwater and sanitation, education, general health characteristics, household income,information communication technology, energy use and agriculture among others. The energy use module covered questions on energy sources, energy use, energy cost among others.

Table4.2 Variable description, measurement and source.

Variable	**Description**
Independent variables	
Household size	Total persons in a household
Residence	Rural or Urban
Age of the household head	Number of years
Sex of the household head	Gender of the household head
Education of the household head (years)	Highest education level of household head in years
Marital status	Married or not married
Employment status	Employed or not employed
Highest education among household males (years)	Highest education level of household males in years
Highest education among household females (years)	Highest education level of household females in years
Expenditure on energy	Total cost of energy used in a household per year
Wall material of the dwelling unit	Predominant wall material of the main dwelling unit
Electricity	Connected with electricity or not

Proportion of household in a cluster connected with electricity	Total number of households in a cluster connected with electricity / Total number of households in a cluster
Dependent variables	
Proportion of kids enrolled in school	Number of school aged kids attending school out of the total number in a household
Proportion of girls enrolled in school	Number of school aged girls attending school out of the total number in a household
Proportion of boys enrolled in school	Number of school aged boys attending school out of the total number in a household
Log of expenditure on education	Household expenditure on education per year in Ksh.
Hours worked per day	Time spent in income generating activity
Hours worked by men per day	Time spent in income generating activity by men
Hours worked by women per day	Time spent in income generating activity by women
Household's total wages& salaries	Household's total wages& salaries in Kshs.
Female total wages &salaries	Household's females total wages& salaries in Kshs
Male households total wages &salaries	Household's males total wages& salaries in Kshs
padqfcons	Monthly per adult equivalent food expenditure
padqexp	Monthly per adult equivalent total consumption expenditure
padqnfitems	Monthly per adult equivalent non-food items consumption expenditure

Source: Author

4.3Results and discussion

4.3.1 Household characteristics

TheKIHBS 2015/2016 covered all the 47 counties and was stratified into rural/urban/peri-urban areas. It covered 23,880 households. The sample contains 43.4percent households with electricity connection and 56.6 percent without electricity connection. Of the 43.4 percent electricity users 11.26 percent are in the rural areas and 32.14percent in urban.As at the period of the survey 2015-2016 the national electricity connectivity was 47 percent (KPLC Annual Report 2015). This position has changed significantly thereafter following adoption of various strategies aimed at achieving 70 per centconnectivity by 2017, target that was set by the government. KPLC reported a 70 percent national connectivity in 2017 and 73 percent as at June 2018 ((KPLC Annual Report 2017,KPLC Annual Report 2018).

Table 4.3 Summary statistics of variables used in estimations

Variable	**Household with electricity**				**Households without electricity**			
Independent variables	**Mean**	**Std. Deviation**	**Min**	**Max**	**Mean**	**Std. deviation**	**Min**	**Max**
Household size	4.10	2.51	1	28	4.88	2.72	1	29
Age of the household head	42.16	14.89	13	95	46.19	16.21	12	95
Sex of the household head	1.29	0.45	0	1	0.35	0.477	0	1
Education of the household head (years)	9.81	3.96	0	18	6.14	4.59	0	18
Highest education among household males (years)	9.53	3.10	0	18	9.44	2.33	0	18
Highest education among household females (years)	9.21	2.79	0	18	9.06	2.07	0	18
Log of expenditure on energy	5.88	1.00	-0.69	10.89	4.71	1.24	-.92	11.45
Wall material of the dwelling unit	0.67	0.47	0	1	0.23	0.42	0	1
Dependent variables								
Proportion of kids enrolled in school	0.99	0.09	0	1	0.97	0.13	0	1
Proportion of girls enrolled in school	0.99	0.11	0	1	0.97	0.15	0	1
Proportion of boys enrolled in school	0.99	0.10	0	1	0.97	0.14	0	1
Log of expenditure on education	5.89	1.53	-1.28	10.94	4.21	1.66	-2.82	9.99
Hours worked per day	6.99	2.66	0	24	6.47	2.66	0	24
Hours worked by men per day	7.33	2.87	0	24	7.06	2.92	0	24
Hours worked by women per day	6.27	2.77	0	24	5.74	2.64	0	18
Log of household's total wages& salaries	9.30	1.21	1.79	13.82	8.35	1.08	1.39	12.08
Log of female total wages &salaries	8.76	1.14	4.61	12.89	7.91	1.06	2.30	10.76

Log of malehouseholds total wages &salaries	9.46	1.15	1.79	13.82	8.42	1.04	1.39	12.08
Log of monthly per adult equivalent food expenditure(padqfcons)	8.10	0.68	-2.75	13.02	7.43	0.79	-2.06	13.22
Log of monthly per adult equivalent total consumption expenditure(padqexp)	8.79	0.68	4.80	13.04	7.86	0.78	2.24	13.22
Log of monthly per adult equivalent non-food items consumption expenditure(padqnfitems)	7.24	1.09	1.76	11.77	5.95	1.23	-1.44	11.47

Source: Author's computation.

The statistics compare households with electricity to those without electricity. For households with electricity, household sizes are smaller, household heads are younger males with higher education levels as one would expect. Levels of education are higher for both males and females in households with electricity than those without. Electrified houses are most likely to have a permanent wall as opposed to non-electrified houses. Wall material in this study was used to reflect the levels of wealth which indicates the ease at which a household can afford electricity.From the summary statistics households which are electrified are wealthier than the non-electrified households.

Implications of electrification on energy expenditure have been discussed in literature with mixed claims. In rural India for example Mathur &Mathur(2005) claims that electrification results in savings on expenditure on energy. Van De Walle (2013) conversely argues that expenditure on energy may increase due to electrification in a way that is welfare improving. Survey data used in this study shows a high expenditure on energy and on non-food items for household with electricity.

Summary statistics on education outcome show consistency with theory. The expenditure on education is high for electrified households compared to that of non-electrified households. More boys and girls aged between 5 and 18 years from households with electricity are enrolled in schools than those from households with no electricity.

Electrification affects the labour market through reduced time for household chores. Use of more efficient technologies for cooking and lighting makes household more productive and also increases the length of their effective hours (Dinkelman,2010). Electrification therefore increases hours of work for both males and females. In this study both males and females in electrified households provide more employment hours than those in households without electricity.

Electrification can raise income through increased productivity Khandker (2013) and Barnes et al (2003) Households examined in this study showed that those with electricity have on average higher income levels, higher total expenditure and also higher expenditures on food and on non-food items.

Diagnostic test

When using 2SLS (IV) several diagnostic tests are necessary. We first test for the strength of the instrument chosen in other words we test whether the instrument is sufficiently correlated with the endogenous regressor. A first stage F-test gave an F- statistic greater than 10 an indication that our instrument is not weak.

First stage regression summary stat

Variable	R-sq	Adjusted R-sq	Partial R-sq	F(1,98830	Prob>F
Electrification status	0.54	0.5393	0.1588	1865.36	0.0000

We also carried out an endogeneity test to test whether electrification status is actually endogenous hence the justifications of using 2SLS approach. The results from Durbin-WU-Hausman test indicate the presence of endogeneity thus justifying the use of 2SLS as opposed to OLS.

Test for endogeneity

Ho: Variables exogenous

Durbin(score) chi2(1) = 25.0972 (p=0.0000)

Wu-Hausman F(1,9882) =25.1153(P=0.0000)

The study used one instrument therefore there was no need to test for overidentification.

Test for heteroskedasticity

This was also done and in cases where heteroskedasticity was present robust standard errors were used.

Table 4.4 Model specification test results

(Modified Wald test for group-wise heteroskedasticity test)

Indicator	**Variables**	**Statistics**	**P-Value**	**Findings**
Education	School enrollment rate	10513.83	0.0000	presence heteroskedasticity
	Girls enrollment rate	6539.87	0.0000	presence heteroskedasticity
	Boys enrollment rate	7677.85	0.0000	presence heteroskedasticity
	Expenditure on education	14.59	(0.1580)	Presence heteroskedasticity
Labour	Adult working hours	499.63	0.0000	Presence heteroskedasticity
	Males working hours	850.72	0.0000	Presence heteroskedasticity
	Females working hours	261.30	0.0000	Presence heteroskedasticity
	Household wages/salariesincome	0.21	0.6497	No heteroskedasticity
	Females wages/salariesincome	0.95	0.3289	No heteroskedasticity
	Males wages/salariesincome	0.30	0.5819	No heteroskedasticity
Household expenditure	Total consumption expenditure	11.03	0.0009	Presence heteroskedasticity
	Food consumption expenditure	18.62	0.0000	Presence heteroskedasticity
	Non-food items consumption expenditure	111.97	0.0000	Presence heteroskedasticity

Source: Authors computation from Kenya Integrated Household Budget Surveys 200/2006 and 2015/16 data.

4.3.2 The impact of electrification onselected householdwelfare indicators.

Impactof electrification on householdexpenditure

Household income flow from different sources. In the 2015-2016 household survey the aggregate income is the earnings from all household members. This includes income from employment, agricultural produce, rent, household enterprises, pension income and income from other investments. The aggregate income does not include household incomes from household transfers either in cash or in kind that a household receives without working for it.

Once a household is connected with electricity, there is a tendency for households to increase total expenditure on both food and non-food items that require electricity to function. These include;electric lights, radios, television, fridges and other small household appliances. These contribute to welfare improvement, for instance households will be able to access more information and knowledge that would have been difficult to obtain, and the items will also serve as a form of entertainment. We therefore look at how electrification impacts on expenditure on food, non-food itemsand overall household expenditure which may have a bearing on household wellbeing.

Table 4.5 2SLS (IV) estimate of the impact of household electrification on household expenditure

Variable	**Total household expenditure.**	**Expenditure on food.**	**Expenditure on non-food items.**
Electricity connection	0.3804*** (0.000)	0.2911***(0.000)	0.3000***(0.000)
Residence	0.1506***(0.000)	0.0861***(0.0000	0.0354***(0.426)
Household size	-0.0813***(0.000)	-0.0920***(0.000)	-0.1031***(0.000)
Sex of household head	-0.0555*** (0.006)	-0.1382***(0.000)	-0.0315(0.385)
Age of household head	-0.0004***(0.003)	-0.0006*** (0.002)	-0.0012***(0.002)
Marital status	0.0040(0.87)	0.0085 (0.750)	-0.0788**(0.084)
Head education level	0.0687***(0.000)	0.0665***(0.000)	0.1381***(0.0000
Head employment status	0.0394*** (0.000)	0.0498***(0.000)	0.0194***(0.000)
Wall of the dwelling unit	0.2104***(0.000)	0.179*** (0 .000)	0.2432***(0.002)

Highest education among the males	0.1361***(0.000)	-0.0095***(0.005)	0.0050(0.414)
Highest education among the females	0.0324***(0.000)	0.0077***(0.003)	0.0589***(0.000)
Electricity#permanent_wall	-.2430(0.000)	-0.2371***(0.000)	-.0332(0.763)
Electricity#resid	-.0379(0.298)	-0.0870***(0 .023)	0.1675***(0 .015)
constant	5.813***(0.064)	8.0889*** (0.000)	6.2359***(0 .000)

*Source: Authors computation from Kenya Integrated Household Budget Survey2015/2016 data Notes 1: *** indicates significance at 1% level; ** at 5% level; * at 10% level. The standard errors are in parenthesis. Note 2;Total expenditure excludes expenditure on energy.*

The results of the estimated regression model on the impact of electricity on household expenditure are presented on table 4.5.Theestimated coefficients gave the predicted signs and were consistent with economic theorythat electrification improves household's purchasing power through increased income. Results suggested thathousehold electrification increased total expenditure by 38%, food expenditure by 29% and expenditure on non-food items by 30%.Van de Walle (2013) reported the similar findings for the case of India where connection increased consumption of both food and non-food items for both the electrified households and for those households found in electrified villages. The rise in expenditure is attributed to the increase in farm and non-farm incomes and wages resulting from grid connection(Barkat et al., 2002).

Additional control variables in this model were all found to be significant and had the expected signs:Urban residents have higher expenditures than their counterparts in rural areas.The more the number of household members the lower the expenditure per adult equivalent. Female headed households had also lower per adult equivalent expenditure than those headed by males. The older the head of the household head the lower the level of expenditure. Marital status was found not to significantly influence household expenditure. Inhouseholds where the head of the household is employed, the expenditure is also high. High education levels for both males and females were found to be associated with higher expenditure on all items.

To explore heterogeneous impacts of electrification across different household characteristics, we interacted the household electrification status with place of residence (urban or rural) and on wealth status of the household represented in this case by the nature of the main dwelling house(permanent or temporary). The two interaction terms were found to be negative implying that the positive effect of household electrification is smaller in urban and wealthy households than in rural and poor households. The only exception is on expenditure on nonfood items where the residence interaction term was found to be positive indicating that the positive effect of electrification is higher in urban areas expenditure on nonfood items than in the rural areas.

Impact of electrification on school enrollment rate and expenditure on education.

The focus of rural electrification during 2013/14, 2014/15 and 2015/16 financial years was on electrification of public primary schools and other public facilities. The programme was intended to improve education standards and also to act as a backbone for connecting households across the country. The programme was still ongoing at the time of this study.

Table 4.6 2SLS (IV) estimates of the impact of household connection to electricity on school enrollment and expenditure on education

Variable	**School enrollment rate**	**School enrollment rate for girls.**	**School enrollment rate for boys.**	**Expenditure on education**
Electricity connection	0.0121***(0.004)	0.0109(0.173)	0.0147***(0.024)	0.4386***(0.000)
Residence	-0.0006(0.861)	-0.0049(0.402)	-0.0021(0.751)	0.4139***(0.000)
Household size	-0.0033***(0.000)	-0.0031***(0.000)	-0.0033***(0.000)	0.0466***(0.000)
Sex of household head	-0.0002(0.924)	-0.0023 (0.942)	0.0001(0.979)	0.3568***(0 .000)
Age of household head	0.0002***(0.007)	0.0002*(0.096)	0.0003***(0.003)	0.0093***(0 .000)
Household head education level	-0.0005(0.584)	-0.0012(0.293)	0.0005 (0.659)	-0.0721***(0.001)

Marital status	0.0027 (0.285)	-0.0001(0.981)	0.0049(0.241)	0.1367*(0.068)
Household head employment status	0.0035***(0.0006)	0.0051(0.024)	0.0030(0.203)	0-0.0986***(0.001)
Highest education among the males	0.0005 (0.310)	0.0007(0.164)	0.0005(0.537)	0.1516***(0.000)
Highest education among the females	0.0008*(0.060)	0.008 (0.253)	0.0003(0.626)	0.1095***(0 .000)
Wall of the dwelling unit	0.0001***(0.000)	0.0001*** (0.008)	0.0002***(0.007)	0.289**(0 .027)
Average distance to school	-0.0005(0.409)	0.0001(0.898)	-0.0013(0.252)	-0.0063(0.6280
Electricity#permanent_wall	-0.0170***(0.003)	-0.0234**- (0.016)	-0.0174**(0.053)	-0.7531***(0.000)
Electricity#resid	-0.0056(0.280)	-0.0021 (0.815)	-0.0043(0.621)	-0.2773***(0.010)
constant	0.9806**(0 .024)	0.9836*** (0.000)	0.9736***(0.000)	1.0535***(0 .000)

*Source: Author's computation from Kenya Integrated Household Budget Survey2015/16 data. Notes: *** indicates significance at 1% level; ** at 5% level; * at 10% level. The standard errors are in parenthesis*

Results of the estimated regression equations on the impact of household electrification on selected education outcomes are presented on table 4.6 above. The findings showsignificant impact on school enrollment for all children together. When we separated school enrollment for boys and girls 2SLS estimate suggested that the positive impact is positive for boys school enrollment and no effect for girls. The effect is 1.2%for all children put together and 1.47%for boys.Findings by others for example Khandker et al (2009) are that in Vietnam boy's school enrollment increased by 11 percent following household connection to electricity.In India on the other hand Van de Walle (2013) observes positive impact on school enrollment for girls but not for boys. In Brazil also Lipscomb (2013) recorded an improvement in school enrollment in electrified households. Results also suggested that electrification impacts significantly on expenditure on education. From the regression results above, electrification increases expenditure on education by 44%. Electrification of public schools in Kenya is a very recent development;therefore the benefits are likely to be realized in future.

Other control variables that reported expected signs. Households in rural areas are less likely to enroll their kids to school than their urban counterparts although the effect was found to be insignificant; For the household size, the larger the household the less likely the chance that children will be enrolled in school. This variable was found to be significant,the main contributing factor could be affordability. The average size of households surveyed was 4 persons. Male headed household were observed to have a higher probability of children enrollment to school and also to spend more resources on education. The average age of heads of household in our data was 42 years for electrified households and 46 for non- electrified households. Results indicated that the older the household head the higher the chances of school enrollment for the children. As expected in households where the head is employed, household income is high and the distance to school is short, children are more likely to join school.

The interaction terms between household electrification status and wealth status and also interaction with place of residence reported negative coefficients indicating that the positive effect is more in poor households and in rural areas than in wealthy urban households.

Impact of electrification on household employment.

By increasing light hours, electricity creates opportunities for household members to substitute activities for others. Leisure activities can be switched to night time to allow more labour supply in paid employment. More light hours allow women to substitute household chores done during the day for income earning jobs. This study's findings are as shown on the table below.

Table 4.7 2SLS (IV) estimate of the impact of household connection to electricity on labour.

Variable	**Hours spent on income-earning work.**	**Hours spent by men on income-earning jobs.**	**Hours spent by women on income-earning jobs.**	**Total household income from wages and salaries.**	**Income earned by womenfrom wages and salaries.**	**Incomeearned by men from wages and salaries.**
Electricity connection	0.6062*** (0.000)	0.4472*** (0.019)	0.6683*** (0.000)	0.9513*** (0 .000)	0.6139*** (0.000)	1.0532*** (0.000)
Residence	0.4022*** (0 .000)	0.2438** (0.071)	0.3669*** (0.003)	0.3219*** (0.001)	0.1071 (0.180	0.4067*** (0.000)
Household size	-0.0969*** (0.000)	-0.0872*** (0.000)	-0.097*** (0.000)	0.0307*** (0.005)	0.0242** (0.072)	0.0162*** (0.234)

Sex of household head	-0.159 (0.102)	-0.5009*** (0.000)	0.3482*** (0.002)	-0.2290*** (0.059)	0.1568 (0.220)	0.0939*** (0.661)
Age of household head	-0.0017 (0 .190)	-0.0028** (0.081)	-0.0017 (0.144)	-0.0005 (0.457)	0.0009** (0.034)	-0.0008** (0.732)
Marital status	-0.2509*** (0.040)	-0.1928 (0.256)	-0.3605*** (0.007)	0.0024 (0.986)	0.0451 (0.750)	-0.3299 (0.136)
Head education level	-0.1014*** (0.001)	-.0611 (0.120)	-.0804** (0.290	0.1709*** (0.000)	0.1281*** (0.0010	0.2363*** (0.000)
Head employment status	-0.3983*** (0.000)	-0.5677*** (0.000)	-.1515*** (0.009)	-0.1032*** (0.023)	0.0451 (0.418)	0.0384 (0.478)
Wall of the dwelling unit	0.3925*** (0 .073)	0.3141 (0.238)	0..4804** (0.067)	0.5148*** (0.001)	0.4971*** (0.009)	0.3387*** (0.080)
Highest education among the males	-0.006(0.672)	-0.0817*** (0 .000)	.0474*** (0.006)	-0.0012*** (0.937)	0.0142*** (0 .440)	-0.0255 (0.243)
Highest education among the females	0.0341*** (0.002)	0.0414*** (0.002)	0.0412*** (0.002)	0.0317*** (0.015)	0.0589*** (0.000)	0.0406*** (0.008)
Electricity#permanent_wall	-.2393 (0.420)	-0.2428 (0.497)	-0.3695 (0.288)	-0.7033*** (0.003)	-0.7039*** (0.010)	-0.1942 (0.495)
Electricity#resid	-0.0050*** (0 .977)	0.0691 (0 .747)	-0.0292 (0.881)	0.6405*** (0.000)	-0.2289*** (0.230)	0.3960 (0.297)
constant	7.8775*** (0 .052)	9.7593*** (0.000)	5.5588*** (0.000)	7.9956*** (0.000)	6.729*** (0.000)	7.7924*** (0.000)

*Source: Author's computation from Kenya Integrated Household Budget Survey 2015/16 data Notes: *** indicates significance at 1% level; ** at 5% level; * at 10% level. The standard errors are in parenthesis.*

2SLS estimate indicated that household electrification increased significantly hours worked in income generating activities for both men and women. Overall these increased by 8.1%, for men hours increased by 4.4% while for women hours increased by 6.7%. These findings are consistent with other studies such as Dinkelman (2010),Grogan and Sadanand (2013) and Lipscomb et al (2013), that household electrification releases women from domestic chores thereby raising employment hours.

Household electrification was also found to have high significant impact on wages and salaries for men and women. Pooled OLS estimated a 45% impact on income from salaries and wages. The findings were similar to that of Khandker et al (2013) who found an impact on income ranging between 25- 50% in Vietnam.Lipscomb et al (2013) reported a 45% positive impact of electrification on household income. Others with similar findings include Bensch et al (2011) in a study in Rwanda, Chatravorty et al (2014) in a study in India.

Other control variables showed the following; Household size impacts negatively on hours spent at work, and positively on income for both men and women. Householdsheaded by malesspend less time at work outside home as opposed to female headed households. Total wages and salaries are also less in female headed household than male headed households. The older the head of a household the lesser the hours spent at paid work and the lower the income level. High education level among men appears to reduce the hours spent at work unlike in the case of women where more years in education leads to an increase in hours spent at work. Coefficients of well to do households from the estimation reflect an increase in hours spent at work and income earned from wages and salaries.

To explore heterogeneous impacts of electrification across different household characteristics, we interacted the household electrification status with place of residence (urban or rural) and on wealth status of the household represented in this case by the nature of the main dwelling house (permanent or temporary). The two interaction terms were found to be negative implying that the positive effect of household electrification is smaller in urban and wealthy households than in rural and poor households. The only exception is on expenditure on nonfood items where the residence interaction term was found to be positive indicating that the positive effect of electrification is higher in urban areas expenditure on nonfood items than in the rural areas.

Interaction terms of household electrification status and wealth indicator andhousehold electrification status and place of residence were all negative, implying that positive effect of household electrification on hours spent at work and the amount of salary and wages earned by both men and women have a little effect in both urban and well to do households. Rural households and low income households tend to benefit more from electrification.

4.4Conclusion and policy recommendations

This study sought to find out the impact of household electrification on the welfare of Kenyan households during the reform period. The study focused on three household welfare indicators namely: household expenditure, education and labour.

The study used Household survey data collected by KIHBS in2015/2016. Electrification was found to have strong positive and significant effects on household expenditure on both food and non-food items. This is an indication of an increase in households' income arising from electrification. The positive impact was found to be higher for poor rural households.Hours worked by both men and women were found to increase significantly upon household electrification. Wages and salaries for both men and women were also found to have been impacted positively by electrification. Again these impacts were more pronounced inpoor rural households. Government should therefore enhance policies geared toward expansion of electrification to further stimulate economic growth and development especially in rural and peri-urban areas. Even though the study did not delve into the source of increased income, it is assumed that this could have emanated from SMEs and therefore policies to support this sector would be beneficial to the economy at large.

Findings show significant impact on school enrollment for all children. The impact is however higher for boys than for girls. The study also concluded that households connected to the grid spend more income on education than their counterparts. The overall positive effect on the selected education outcomes was found to be higher in poor households and in rural areas than in wealthy urban households.

In conclusion public investments in household electrification were found to have had positive impact on the assessed welfare indicators. Government should therefore continue electrifying public institutions and facilitating electricityconnection to all household to enable all to leap the full benefits.Deliberate effort should be made to facilitate electrification of rural poor household as they appear to reap more benefits from electrification.Further research could be done on the impact of electricity other welfare indicators such as health.

CHAPTER 5 Conclusion

5.1 Summary, conclusion and policy implications

This study set out to investigate the impact of electricity sector reforms on three key areas: Power sector efficiency, electrification and power supply, and household welfare. The reforms undertaken globally over the past few decades aimed to improve sector performance, accelerate access to electricity, and enhance the household's welfare through better services. The study applied different methodologies to evaluate these effects. The study highlights important insights into how various reform have impacted on several outcomes in the electricity sector.

The first essay focused on the impact of electricity sector reforms on efficiency, using both Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The results indicated that, overall, the efficiency of the sector has improved during the reform period. Countries that have implemented more reforms tend to be more efficient. These findings confirm the need for comprehensive reform, as these are likely to facilitate more optimal resource allocation. The reforms also need to be carefully designed bearing in mind the circumstances of each country to maximize efficiency benefits

The second essay examined the relationship between electricity sector reforms and electrification rates, as well as power supply outcomes, using a fixed effects model with panel data spanning 1998 to 2018. The main finding in this chapter is that competition plays a central role in accelerating electrification and improving power supply. The introduction of competition encourages innovation and efficiency, thereby increasing the rate of electrification to both rural and urban areas. However, the results also revealed that restructuring has a negative impact on both electrification and power supply, this is likely due to short run disruptions caused by reorganization and reallocation of resources. Interestingly, neither regulation nor private sector participation showed any significant effect on electrification, suggesting that these aspects on their own are not drive expansion without the presence of competition.

Applying a two-stage least squares (2SLS) instrumental variable (IV) method to address issues of endogeneity, the third essay investigated the impact of electrification on household welfare,. The analysis found a positive and significant relationship between household electrification and welfare indicators. Electrification contributes to higher household incomes, likely due to improved opportunities for income-generating activities as a result of access to electricity. Moreover, electrification has a positive effect on school enrollment and the number of hours spent on income-generating activities, illustrating how access to electricity can open up opportunities for education and economic participation. These findings highlight the broader socio-economic benefits of electrification.

In summary, this study demonstrates that electricity sector reforms can lead to substantial improvements in efficiency and household welfare, with competition emerging as a key factor for success. However, not all reform components have positive effects. Restructuring, for example, appears to introduce difficulties that can slow down electrification progress. Moreover, the absence of significant impacts from regulation and private sector participation suggests that these elements need to be carefully integrated within a competitive framework to realize their potential benefits. Taken together, the essays suggest that a well-structured approach to reform, which emphasizes competition and mitigates the negative effects of restructuring, is essential for maximizing the benefits of electricity sector reforms. Policymakers should therefore aim for a balanced, holistic approach that not only improves efficiency but also expands access, supply and improves household welfare.

5.2 Contribution to knowledge

By pursuing the research objectives of the three essays, this study contributes to economic literature and knowledge by assessing how donor driven reforms in electricity sector have impacted on sector's outcomes and welfare of Kenyans. Contribution has been made by in putting reform measures into the assessment of sector's efficiency level. Contribution has also been made in evaluating how the extent of reforms have impacted on key government policies of accelerating electrification and expanding electricity generation capacity. The other contribution of this study is on how the welfare of the Kenyan people has been impacted by these reforms. These areas to the best of our knowledge have not been empirically investigated for the case of Kenya before

5.3 Limitations of the study

The research work presented in this thesis has a number of limitations that we acknowledge. These limitations have contributed to the low level of research work in this area particularly in African countries. The limitations however do not undermine the analysis of this study.

One of the shortcomings of this study emanates from our dataset. In the first essay the study is limited by the fact that progressive data on the extent of reforms in Africa is generally unavailable. The study has resulted to using two data points one before the donor driven reform in 1987 and two when data on the extent of reforms is available in 2015. The study would have been greatly enriched by more data points particularly on the extent of adoption of the reform measures.

The data challenge extends also to the second essay. Due to the unavailability of the extent to which reforms have been undertaken the second essay uses dummy variable to indicate the period before and after a particular reform. The limitation of using dummy variables in this case is that we may not get much insight on how reforms have impacted on access and supply of electricity as we would have had if the extent of the reform was known.

The third essay employs data from 2015/2016 Kenya Integrated Household Budget Surveys. The study would have benefited from a more recent survey. However this study will act as a baseline for future studies in this area. Measurement errors common in surveys that require respondent to recall information were also observed. These were however corrected by dropping the inconsistent observations and outliers.

5.4 Areas for further research

This research work has triggered the need for further research on the reforms. One, there is need for research on the efficiency in transmission and distribution aspect of the electricity sector In the second essay the quality of electricity supply also need to be looked into and how it can be enhanced. Following the investigations in the third essay it's clear that more studies focusing on other welfare issues would of benefit policy makers. Research on how to enhance competition in this sector is required to guide policy.

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APPENDIX

Hausman tests results for model selection.

Table 1: Hausman test results for national access to Electricity model

	(b)	(b)	(b-B)	sqrt(diag(V_b-V_B))
	fe	fe	Difference	S.E.
Regulation	-1.96562	5.537657	-7.50328	.
Restructur~g	-0.0978938	-12.72293	12.62503	.
Competition	7.929486	6.346921	1.582565	.
Privatesec~n	2.278885	3.943903	-1.66502	.
Legislatio~y	-3.052408	-5.19043	2.138022	.
Powersyste~a	0.0237168	-0.0032821	0.026999	0.0025547
GDP1	0.018859	0.0618337	-0.04297	0.0049418

chi2(8) = 150.91 Prob>chi2 = 0.0000

Table 2: Hausman test results for Rural access to Electricity model

	---- Coefficients ----	---- Coefficients ----		
	(b)	(b)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
Regulation	-3.381093	0.8262957	-4.207389	0.1242107
Restructur~g	-2.532624	-9.78095	7.248327	1.84963
Competition	10.01691	10.97405	-0.9571413	2.423987
Privatesec~n	0.816625	1.962892	-1.146267	.
Legislatio~y	4.648101	-4.406287	-0.2418133	1.241081

chi2(8) = 22.33 Prob>chi2 = 0.0043

Table 3: Hausman test results for urban access to Electricity model

	---- Coefficients ----	---- Coefficients ----		
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
Regulation	2.926859	7.4849	-4.55804	.
Restructur~g	-2.597001	-7.712258	5.115257	.
Competition	1.058103	5.340373	-4.282269	.
Privatesec~n	2.622982	1.51682	1.106162	.
Legislatio~y	0.8378869	-6.164595	7.002482	.
Powersyste~a	0.0189808	-0.0090946	0.0280754	0.0006975

chi2(8) = 694.93 Prob>chi2 = 0.0000 Fixed effect model is the most appropriate.

Table 4: Hausman test results for Electricity consumption model

----	Coefficients	----		
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
Regulation	5.117759	4.106801	1.010958	.
Restructur~g	-18.20332	-11.40025	-6.803074	2.306056
Competition	-14.98589	-1.587443	-13.39845	4.367874
Privatesec~n	4.545717	-2.213665	6.759382	.
Legislatio~y	15.05224	-4.406969	19.45921	0.8433523
Powersyste~a	0.0285002	-0.0078971	0.0363973	0.0084717
GDP1	0.0716393	0.1972016	-0.1255623	0.0178328

chi2(8) = 48.39 Prob>chi2 = 0.0000