FACTORS INFLUENCING THE RELIABILITY OF POWER SUPPLY SUBSTATIONS IN KENYA: A CASE OF THE ENERGY SECTOR RECOVERY PROJECT IN KABETE SUB-COUNTY, KENYA

BY

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DECLARATION

This research project report is my original work and has not been presented in any other university for any award.

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This research project report has been submitted for examination with my approval as the University Supervisor.

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DEDICATION

I dedicate this research project to my husband Mr. Samuel Gitonga for the continued support during my studies.

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ABBREVIATIONS AND ACRONYMS

EU European Union

ERA Energy Regulatory Authority

ERC Energy Regulatory Commission

ESRP Energy Sector Recovery Projects

IPPs Independent Power Producers

KEMP Kenya Electricity Modernization Project

KPLC Kenya Power and Lighting Company

NERC North American Electric Reliability Corporation

REA Rural Electrification Authority

REF Rural Electrification Funds

ABSTRACT

One of the major problems facing most counties is frequent power outages due to the poor state of electricity infrastructure, policies and lack of finances. Any power outage even for the shortest period can have adverse effects on not only the economic condition of country but also on the security, health and general wellbeing of a community. For instance, in Kenya as some areas can go without power for several days, which in many ways affects people's activities (Tortora and Rheault 2012). This study sought to investigate the factors influencing the reliability of power supply substations in Kenya in order to draw important lessons for future ventures. The scope of the study was limited to Kabete Sub-County and the Energy Sector Recovery Projects. The objectives of the research were: to establish how electricity consumption influences the reliability of power supply substations; to assess how energy sector regulations influence reliability of power supply substations; to determine how the power grid congestion influences the reliability of power supply substations and to establish the extent to which Energy Regulatory Authority's involvement influences reliability of power supply substations. Two theories namely the Agency and Fault Tree Analysis theories were reviewed. Further, a conceptual framework was drawn to show the relationship between the independent and dependent variables. The study adopted the descriptive survey research design in which targeted population was 290 energy sector personnel that are directly involved in the implementation, operation and maintenance of power supply substations from Kenya Power and Lighting Company, Energy Regulatory Authority and Energy Regulatory Commission. The sample size comprised of 165 respondents were selected by stratified random sampling method from these organizations. The primary limitations that were faced during research include issues of confidentiality of respondents. Before the actual study, a pilot study was done two weeks before the actual study whereby reliability was tested using the test-retest method and validity was tested using content validity method. Research questionnaires were used to collect data after which data analysis was done by calculating the arithmetic mean and standard deviation. The research findings were presented in tables. Study findings revealed among all the factors that were under study, Energy Regulatory Authority involvement had the most significant influence on the reliability of power supply substations with a mean of 3.90. This was closely followed by power grid congestion with a mean of 3.87, thirdly was electricity consumption with a mean of 3.83 and lastly Energy Sector Regulations with a mean of 3.78. The conclusions drawn from this research study are; reliability of power supply substations is critical for the development of Kabete Sub-County and the nation at large; there are multiple interdependent factors that directly affect reliability, some are beyond the control of policy makers (such as climatic changes and leadership) yet many factors are, in fact, actionable if a long-term and comprehensive approach is adopted. Therefore, electricity consumption, energy sector regulations, power grid congestion and Energy Regulatory Authority involvement need not be treated separately. These levers are integral to ensuring that power supply substations meet and maintain a sustainable power reliability index. Grounded on these findings it was recommended that there is need for the concerned governmental agencies in partnership with any private entities to encourage people to adopt the use of alternative sources of energy, as this is the way that overdependence on electricity can be reduced; hence, promote the reliability of power supply substations. In addition, it was recommended that it is important for the government through the concerned bodies to adopt regulations and policies that are geared towards promoting a functional energy sector and that there is need for such organizations to provide enough support towards electrification projects.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Although numerous strides have been made in reforming the power sector from the early 90's, the state of reliability of power supply substation in Kenya is still wanting because of the numerous shortages and power surges that the country experiences, which not only have affected people's quality of life but also the economic activities of most communities. Ideally, although electricity is supposed to be available to every customer who has a connection, this is not the case in most areas in Kenya as some areas can go without power for several days, which in many ways affects people's activities (Tortora and Rheault 2012). As per World Bank Enterprise research studies, power cuts in Sub-Saharan Africa have cost companies a lot of losses, Kenyan companies being one of the most affected nations. Most power cuts in Kenya are associated with problems of the power supply distribution system, poor outage management strategies, and lack of capacity by the Kenya Power and Lighting Company to handle the ever-increasing demand of electrical energy. It is worth noting that, not only are these power cuts costly to people who depend on power for subsistence, but also on utilities within Kenya Power and Lighting Company (KPLC) and Rural Electrification Authority (REA). As per research studies, an unplanned for power outage can cost over $40,000 per day (IEA, 2013).

Although in most nations reliability of power supply substation has received bad publicity, in the United States the scenario is different because of the systems in place. Unlike in most nations where the supply, distribution and managing of the power systems is left to certain organizations, which end up enjoying and misusing the monopoly of being key in this sector, in the US the scenario is different as there are numerous independent power producers, suppliers and distributors who are mandated with making sure that every American receives reliable power supply substation. The US has also been able to achieve very high reliability in power supply substation ratings due to the improved transmission and distribution systems, better transmission infrastructure, proper energy sector regulation and well-defined design, operation and maintenance practices. Further, in most states there are market-based incentives through performance-based rates (PBRs) that help to set targets, reward and penalty systems in the utility rate structure. All these compounded with adequate

governmental support has made it possible for the US to make great strides in its power production and distribution substation (Seattle Office of Emergency Management, 2011).

In Indonesia, endeavors to promote reliability of power supply substation began in 1985 with the adoption of the Electricity Law. In this law, the Indonesian government allowed some private investment in power generating as Independent Power Producers (IPPs). To ensure production of power to serve the ever-growing need of power at that time, the government signed numerous deals with IPPs such as PT Paiton Energy. Although these efforts greatly improved the level of power reliability in Indonesia, in late 1990's, most of these programs were frozen due to the Asian Financial crisis. This never lasted for long, as in 2002 the government enacted the 2002 Electricity Law, which was changed in 2005 and later changed in 2009. In addition to enacting and reviewing laws that manage the power sector, the Indonesian government has increased also invested heavily in the energy sector, in addition to increasing the amount of investment in infrastructure and partnering with other nations in ensuring that power supply substation and reliability is promoted in Indonesia. Some of the substation that have helped the Indonesian government to achieve high power reliability include the Cirebon, PT Penjaminan Infrastruktur II, the Tanjung Expansion, and the Fast Track Program II of 2010 (Fairhurs, 2016; Asian Development Bank, 2015).

To solve its reliability in power supply substation problems, the Guatemalan government liberalized its energy sector. The liberalization paved way for the expansion, growth and better management of the energy sector to meet people's demands. In addition to this, it adopted different tariff policies while maintaining incentives to facilitate cost recovery. Further, the government ensured that it strengthened the overarching regulatory body with a primary goal of making sure that there were high levels of power reliability. Guatemala has more than 10 power generating stations. On the other hand, to sustain the ever-growing power deficit hence ensure power reliability, the Guatemalan government is in the forefront in funding power supply substation for example the Xalalá project in Quiché, the Chixoy and the Barillas Dam project in Huehuetenango. Although this is the case, it is worth noting that the development of most of these projects have faced numerous obstacles including lack of enough funds and revolts from the local communities where most of them have been set as they blame the government of failing to compensate them for the lost land and human rights violations.

As of 2013, Indonesia was still struggling with serious energy crisis because of the numerous power cuts that were experienced in different neighborhoods, which were caused by inadequate end user tariffs levels and power losses during transmission. For instance, as per research reports by AES SONEL (one of the companies that were mandated by the Cameroonian government to generate, transmit and distribute electrical energy), between August 2012 to March 2013, there were more than 8000 power cuts, which translated to a very low power reliability index. To improve on the reliability index, the Cameroonian government adopted and implemented a number of substation including the use of cellphones to report any outages in order to improve and shorten the response time. Additionally, the Cameroonian government over time has received numerous grants and support towards funding power substation for instance The European Union (EU) FCfa 1.7 billion towards electrifying rural areas and the 2016 International Bank for Reconstruction and Development (IBRD) loan of $325 Million that was towards funding the Electricity Transmission and Reform Project. Although a lot has been done towards ensuring that the reliability index is improved, as of 2016 still the reliability index was very low as the country's national grid faced numerous outages (Ossono, 2014).

Just like any other developing country, Kenya is also struggling with low power reliability index as most areas still suffer from numerous power outages. To enhance and increase the power reliability index, the Kenyan government in collaboration with the International Development Association, through Kenya Power and Lighting Company initiated the Energy Sector Recovery Substation (ESRP) program. The ESRP program was an investment component in generation and distribution as well as provide a power sector recovery program targeted at improving the performance of distribution and customer service operations (ESRP EOI, 2005). In addition to this, the Kenyan government over time has implemented other substation that are geared towards improving power reliability. For instance, up to 2016, the government had completed constructing over 30 substations in the country towards ensuring power reliability. Another project that was implemented by the Kenyan government towards improving the reliability of power supply substation was the Kenya Electricity Modernization Project (KEMP). Although the Kenyan government and other international organizations have also pumped a lot of funds towards ensuring power reliability, the country still experiences numerous power outages and surges; hence, the low power reliability index. As per research studies, as of the first quarter of 2016, the number of interruptions had increased

by over 70% from the figures that were reported in the year 2015 (Institute of Economic Affairs, 2015; Kenya Power and Lighting Company, 2010).

Although Kabete Sub-County has been one of the major recipient of power supply substations, still the sub-county lags due to the increased number of blackouts it experiences. For instance, although it was one of the recipients of the ESRP project that was meant to boost power reliability, power surges and outages are the order of the day. Additionally, over time, although electricity accessibility has increased in this region, the area still suffers just like any other regions in Kenya.

1.2 Statement of the Problem

As per research studies, Kenyan homes and industries experience more than 600 hours of outages per annum compared to 120 hours or five days per year in South Africa (IEA, 2014). To limit this, the Kenyan government through KPLC has been in the forefront in ensuring that all areas receive electricity reliably. Since the 1990's, the Kenyan government has not only initiated power generating and distribution substation, but also projects that are geared towards ensuring reliability of the supplied electricity. Although this is the case, up to date the country still experiences numerous power outages; hence, at clear indication of the failing power reliability programs to achieve their objectives. Over years, Kabete Sub-County has been one of the major recipients of electricity supply substation. For instance, it was one of the sub-counties that were selected for the ESRP project whose primary goal was to promote the power reliability index. In addition to this, in the Kenya Distribution Master Plan of 2013, Kabete was one of the areas that received the 66/11 kV primary substations that were meant to improve power reliability in Nairobi North. Although these and more substation that are geared towards improving the power reliability of Kabete have been implemented, the expected power reliability index or levels are yet to be achieved due to the numerous power outages that have been experienced in this neighborhood. Some of the factors that have been blamed for the low reliability index include poor infrastructure that sometimes causes faults in the feeders, technical hitches in the main electricity line and bad weather. In addition, some research findings show that poor fiscal energy and fiscal policies have greatly contributed to this problem. On the other hand, a low power supply substation index has been blamed on poor planning and the monopoly enjoyed by KPLC as it is the only power distributor; hence, their response time is long making most customers to go without electricity for very long periods (Institute of Economic Affairs, 2015; Kenya Power and Lighting Company, 2010). It

is against this background that this study aims to investigate the factors influencing the reliability of electricity supply substations in Kenya with Kabete Sub-County as the case study.

1.3 Purpose of the Study

The purpose of this study was to establish factors influencing the reliability of power supply substations in Kenya, the case of Kabete Sub-County.

1.4 Objectives of the Study

The study sought to achieve the following objectives:

i. To establish how electricity consumption influences the reliability of power supply substations.
ii. To assess how energy sector regulations, influence reliability of power supply substations.
iii. To determine how the power grid congestion influences the reliability of power supply substations.
iv. To establish the extent to which Energy Regulatory Authority's involvement influences reliability of power supply substations.

1.5 Research Questions

The research questions of the study were:

i. How does electricity consumption influence reliability of power supply substations?
ii. How does the energy sector regulations influence the reliability of power supply substations?
iii. How does the power grid congestion influence the reliability of power supply substations?
iv. How does the Energy Regulatory Authority's involvement influence reliability of power supply substations?

1.6 Significance of the Study

This research study may be of great benefit to the implementers of any electrification projects, as well as any other stakeholders that are involved in the implementation of power supply substations. To the Energy Regulatory Commission, the study may offer information that can be of importance during the formulation of policies that are geared towards improving the power reliability index. The research findings of this study may also be of

great significance to the government and the Ministry of Energy when formulating policies towards enhancing the reliability of power supplied to all localities.

1.7 Delimitation of the Study

Although there are many factors that influence the reliability of power supply substations, the study delimited itself to the following objectives: electricity consumption, energy sector regulations, power grid congestion and the involvement of the Energy Regulatory Authority. Additionally, due to the technical nature of the study the target population of 290 was limited to energy sector personnel from KPLC, ERA and ERC. Although power supply substations have been implemented throughout Kenya, this study delimited itself to Kabete Sub-County and the Energy Sector Recovery Projects.

1.8 Limitations of the Study

One limitation that was faced by the researcher is the issue of confidentiality. This is because most organizations' information is treated as confidential hence most employees were not willing to divulge some information. To mitigate this, the researcher assured them that all the information that they provided was to be treated confidentially.

Another limitation that was the unwillingness of some respondents to participate in the research from some departments of organizations that were under study. The researcher countered this by revisiting their offices and assuring them that this research was only for academic purposes hence there is nowhere it was to be used to convict them.

1.9 Assumptions of the Study

In conducting this research on factors influencing the reliability of power supply substations in Kabete Sub-County, Kenya, the following assumptions were made:

1. That all respondents would be cooperative and give reliable responses.
2. That electricity consumption would influence reliability of power supply substations.
3. That energy sector regulations would influence reliability of power supply substations.
4. That power grid congestion would influence reliability of power supply substations.
5. That the involvement of Energy Regulatory Authority would influence reliability of power supply substations.

1.10 Organization of the Study

The first chapter provides introductory information for this research study, including background of the study, statement of the problem, research objectives, research questions, significance of the study, delimitation of study, limitation of the study, basic assumptions of the study, organization of the study, and operational definition of terms. Chapter two provides the review of the literature pertinent to the research topic "Factors influencing the reliability of power supply substations". The third chapter provides the research methodology, which will include the research design, target population, sampling technique, research instruments, data collection procedures, data analysis, and ethical considerations. Data analysis, presentation and interpretations is described in Chapter four. The data from the questionnaires is analyzed and the demographic noted. The analysis is used to answer the research questions formulated at the beginning of the study. Chapter five is dedicated to the description of the summary of findings, discussions, conclusion and recommendations.

1. 11 Definition of significant terms used in the study

Energy Regulatory Authority Involvement: This is the responsibility, authority and participation of the Energy Regulatory Authority towards ensuring reliability of power supply through monitoring, provision of funds and establishment of inter-agency collaboration policy.

Energy Sector Regulations: This is the set of government policies and regulations which guide the generation, transmission, distribution and sale of electricity. They include: existing energy laws, number of end-user tariffs and increase in liberalized organizations in electricity sub-sector.

Electricity Consumption: This refers to the increase in number of new electricity connections from what is normally planned for before generation and distribution with limited alternative sources of energy to cater for the ever-changing reserve margin trends due to increase in population migration and congestion.

Power grid congestion: This is a situation wherein the existing increase in system infrastructure and operational performance are unable to accommodate all the required electric generation and transmission demand resulting in decrease in power transmission and distribution losses and costs.

Power Supply Substation: This is an installation of a set of equipment reducing the high voltage of electrical power transmission to that which is suitable for supply to consumers.

Reliability of Power: This refers to the decrease in number of blackouts experienced per household per month, decrease in number of planned interruptions and reduction in restoration time of interrupted power supply.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the empirical and theoretical literature review that pertains to the factors influencing the reliability of power supply substations in Kenya. It will also discuss two theories and their significance to this study. Empirical literature review is presented in these four factors which include: electricity consumption, energy sector regulation, power grid congestion and the involvement of the Energy Regulatory Authority. In addition, the chapter will present the conceptual framework, which will show the independent and dependent variables relationship. On the other hand, the chapter will also present gaps arising from the previous studies.

2.2 Reliability of Power Supply Substations

North American Electric Reliability Council (NERC) defines reliability as the degree to which the performances of the elements of the electrical system result in power being delivered to consumers within accepted standards and desired amount. According to the World Bank Enterprise Survey data of 2016 found that business owners in around 30% of developing economies perceive unreliable electricity services as a major obstacle to their business activities. In Sub-Saharan Africa, economies on average suffer 690 hours of outages in 2015. The drag in economic growth caused by weak power infrastructure is estimated to be about two percent annually. The economies overall well-being is negatively influenced by unreliable power supply. Beirut residents cope with no electricity for three hours on average each day. Residents in other areas of the country as not so lucky and endure 12 hours of daily power outages. Lebanese household resort to use of generators when there is a power outage, besides which they spend 15% of their annual income to pay electric bills which amount $ 1,300. Reduction of duration and frequency of power outages is critical for all societies. Stable power production is not the sole responsibility of a distribution utility as other key players like generation, transmission are also involved (2016).

The electricity market has been in chaos recently which has led to concerns of government regulators and legislators, businesses and the public regarding reliability of their electricity supply. In the modern society, electricity plays a key role. With the advent increase of the

internet based economy, high quality and reliable electric services are a necessity. Increase in demand is due to increased dependency which puts pressure on reliability of the system. The current reliability needs are different from those of the past due to characteristics of much of the new electricity load mean. Proactive measures need to be taken now to insure system reliability and power quality, in the past, been occasional interruptions in electricity supply from extreme weather conditions, equipment failures, human error, and system inadequacy may become more frequent unless (Osborn and Kawann, 2001).

In Zambia, insufficient rainfall due to the El Niño weather phenomenon resulted in electricity shortages in 2015 with Lusaka experiencing 137 hours of outages per customer due to poorly maintained distribution lines. Electricity bills are governed by the revenues of all market players in an energy system including the generation, transmission and distribution companies. Operation of the power system costs are considered in the tariffs. Financial constraints across the power system are caused by insufficient revenue collected by distribution utilities. Maintenance spending and capital investments suffer cut backs resulting in increased production costs due to wear and tear of the existing infrastructure and power system reliability deteriorates. Electricity provision can be compromised by lack of proper attention to operational performance. Purely public, private, or mixed partnership are ownership structures of the power sector. Efficient management structure is essential and compliments the utility ownership type. An independent regulator can supervise the price of electricity and ensure consumer protection since the electricity market is often monopolistic. The role of the regulator in relation to electricity reliability is to set objectives regarding utilities' performance as well as deterrents to reduce the duration and frequency of outages. Financial deterrent can be one of the objectives set by the regulator in the case where outages surpass threshold the regulator imposes penalties or allow for customers to receive compensation. (World bank, 2016). Many countries, including Ghana, work towards deregulated competitive markets in the power sector by eliminating monopolistic structure by opening the market and allowing new market entrants to buy and sell power. The government finds it challenging to adjust tariffs to ensure full cost recovery given its impact on the consumers. As a result, tariffs lagged and in most cases, could not recover variable operating cost. In most countries, a state-owned monopoly structure, severely compromises the power supply reliability, and hinders economic development (PSEC, 2010).

2.3 Electricity Consumption and Reliability of Power Supply Substations

In the recent past, there has been an increase in the penetration of renewable energy sources in the modern power world. Although most researches have associated most renewable sources of energy such as solar with expensive installation costs, the benefits that come with such are more. As research studies show, with more investment in alternative sources of energy comes infrastructure upgrades and construction of high transmission lines at the expense of power reliability. Most alternative sources of energy provide an alternative source of energy which in most scenarios caters for the deficit more so when there are high power demands that may require an extra input into the grid. Further, as research studies show, adoption of alternative sources of energy encourages the construction of large scale storage facilities that are likely to offer the needed deficits when the demand is high (Lofthouse, Simmons and Yonk, 2015). Another survey by the Hossain showed that if the current effort to adopt the use of alternative sources of energy specifically renewable energy is adopted by global nations, then by 2050, more than 80% of the world electricity needs will be catered for by renewable sources of energy. If this happens then electricity will be very reliable as there will be practical ways of covering the power outages that have contributed to numerous loses (2015).

In a research study that was carried by Ku Leuven Energy Institute in Belgium, it was found out that as more people sought more connections, the number of blackouts increased as the available infrastructure could not support the ever-increasing number of new electricity connections (2014). In addition to the ever-increasing demand, the study also found out that quite several outages were caused by extreme weather conditions. For instance, in the U.S. between the year 2000 and 2004, more than 44 outages per month were reported. This number increased from roughly 100 outages per month between the year 2005 and 2009 to over 200 outages per month between the year 2010 and 2013. Between this years, the demand rose as more households sought connections; hence, the strain that was experienced by the existing infrastructure coupled with bad weather conditions (U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability, 2013).

In a research that was done by Xiao and Xue in India, it was out that most of the problems that are facing the Indian power system is because of congestion in some areas, more so informal settlements. The problem of congestion is closely related to unplanned migrations to areas with more economic activities. In most scenarios, in areas that are congested cause a long term over draw of power. Although overtime the Indian government has tried to come up with measures geared towards dealing with the overdraw, it is very hard for such policies to work in congested areas such as informal settlements due to numerous unregulated illegal connections. In addition to this, it was also proved that the increased number of outages was also due to poor grid infrastructure, mal-operations of protection systems and lack of proper policies and regulation on the generation, transmission and distribution of electricity. It is worth noting that most cascading failures in the electricity networks more so due to overloads that are caused by congestion is one of the biggest threats to a network's robustness even than structural inadequacies in an electrical system. This is the case because an overload that results due to overuse affect numerous components of an electrical system; hence, the need for power supply substations companies to come up with ways of generating more power to meet the ever-increasing number of new electricity connections as the world changes (2013).

It is worth noting that, in addition to increase in electricity demand as the population increases, sometimes changes in weather conditions can cause a surge in the demand for more electricity as the number of electrical appliances that are normally running during this time also increases. For instance, research studies have proved that most electrical grids in most states in the USA are normally stressed when it is very cold or hot outside; hence, the increased number of blackouts throughout these seasons. In most nations, summer is the period of peak demand as most homes run air conditions. As a result, because it is very hard to store energy efficiently in anticipation for the increased seasonal demand and the cost of constructing, running and maintaining reserve plants is very high, in most scenarios the available grid and networks suffer the brunt of the demand and when they cannot support the demand, an outage will be the result (Kelly and Grouse, 2011). A research by the North American Electric Reliability Corporation (NERC), on the trends on the power demand showed that as years keep going by, the demand for electricity also increases as more connections are made. For instance, as per the report, it is predicted that by 2018, the demand for more electricity is likely to increase to more than 15% due to the increase in the use of technological tools (2010).

2.4 Energy Sector Regulation and Reliability of Power Supply Substations

An important outcome to the regulatory sector is Kenya's independent Energy Regulatory Commission ERC), an important outcome of sector reforms. The Electricity Regulatory Board is the forerunner to the ERC was established under the Electric Power Act of 1997, but passing of the Energy Act of 2006 resulted in its disbanding and the founding of the ERC., The ERC's directive extends beyond electricity and includes natural gas (including petroleum), renewables and all other forms of energy in contrast to Electricity Regulatory Board. In addition to the existence of these bodies, in 2006 the Kenyan government enacted the Energy Act (2006) to not only boost the production but also the distribution and ensuring power reliability. Further, the adoption of the new constitution in 2010 necessitated the review of the energy sector policy and legal framework, a process that is still ongoing. Although the Kenyan government has adopted all these policies, still the problem of power outages is prevalent primarily because electricity tariffs are often very high by world standards, despite often being held below the cost of supply (International Energy Agency, 2012).

In another research that was carried out in Ghana, (Kemausuor et al., found out that over time Ghana has been able to achieve a good power reliability index due to adoption of regulations and policies that are geared towards promoting a functional energy sector (2009). In another study by Bekker et., al., (2008) in South Africa revealed that because of good fiscal, energy and monetary policy, South Africa has made numerous strides towards promoting power reliability to its people. In Kenya, the scenario is a little bit different as Kenya is one of the African countries that are struggling with low power reliability. Although the government through the Rural Electrification Funds (REF) and ERA has tried to expand electricity network in the country to promote power reliability, still the county has suffered numerous power outages clearly indicating that the adopted energy and monetary policies are not efficient (Kenya Integrated Household Budget Survey (KIHBS, 2007).

In a research that was carried out on Costa Rica, Barnes et al., found out that Costa Rica had been able to improve its power supply substations capacity and overall reliability index due to practical power supply substations policies and energy laws. In addition, in another study that was carried in Bangladesh, found that although this county was still struggling with low

power reliability standards, the government was in the forefront in formulating and implementing numerous policies that are geared towards improving Bangladesh's power reliability standards (2005). In Africa, although most nations more so in the Sub-Saharan African are struggling with low power reliability standards, some nations such as Tunisia have been able to achieve high power reliability index due to sound government policies. For instance, in Tunisia, in collaboration with all concerned stakeholders, the government could implement a well formulated and integrated electrification framework whose main role was to oversee the conversation of Tunisia into one of the countries with the best electrification network; hence, improved power reliability (Cecelski et al., 2006).

2.5 Power Grid Congestion and Reliability of Power Supply Substations

In a study that was carried by Amadi in South Africa, it was found that among other factors, severe power generation, transmission and distribution shortfalls were the primary causes of the outages that were experienced in Port Harcourt. A poor transmission network is normally associated with numerous technical problems and very high losses; hence, one of the costliest ventures for most power transmission companies. In most nations, most power systems normally run very close to their stability, a fact that most of the times causes an overload as the demand increases. With operating beyond the stability levels comes the need for expansion of such infrastructure and in cases where such expansion is not possible, then the problem of power outages is prevalent due to weak networks and voltage instability (2015). In another study that was carried out in Nigeria, Ado and Josiah found out that poor infrastructure was the primary reason why most states faced low power reliability ratings as most power outages were associated were associate with blown or failing power distribution systems. In the same study, it was found that 75% of the outages that the country faced were directly related to overused transformers, poor cable layouts and lack of the necessary upgrades that were required as there were no enough funds to support the need (2015).

In a research that was carried by Amoako-Tuffour and Esi Eshun in Ghana, it was found out that most government owned energy entities operated on high long-run marginal costs and most were unable to procure more funds for maintaining and expanding their operations. Because of these, most organizations that were mandated with the generation, transmission and distribution of electricity had inadequate investment in infrastructure. Further, due to lack

of expansion in operations most transformers and grid lines are faced with overload problems, a fact that has greatly contributed to transmission losses hence the increased number of blackouts and interruptions (2015). In another research that was carried by Zhu et al., it was found that most of the currently operational hydroelectric stations and sub-stations have very high capital and maintenance costs, something that depletes all the revenues got. As a result, most organizations lack funds to expand their generating and expansion activities to meet the increasing 'demand for power. As research studies show, expanding the energy can be one of the costliest ventures. For instance, for Ghana to expand its energy sector, it needs roughly $9 billion between 2014 and 2019, an investment which unless the government gets international financing is impossible to implement (2015).

In addition to the expensive cost of expanding the production and distribution of electricity, even developing new and renewable sources of energy is another very costly venture. For instance, among renewable sources of energy, installation of solar is more expensive than electricity. In a research that was carried out in Germany by Lofthouse, Simmons and Yonk, it was found that in 2015 alone, German taxpayers paid $23 billion for solar energy whose market value was far much less than what was paid. In another research in the US, it was found that although wind is one of the easily generated renewable source of energy, most states have been forced to make billion-dollar investments as most wind resources are in remote places that are far from where consumption takes place (2015). For example, a recent survey in Nebraska revealed that for the state to meet its wind energy goals that are aimed at reducing congestion that has led to numerous outages, it will be forced to pump over $4 billion into wind projects; hence, a costly venture. In these like scenarios, the reliability of power in the states is automatically affected because of the cost that comes with new installations and expansions of the existing power systems (Hansen, Simmons and Yonk, 2015).

For a power supply substations system to work well, there is need for proper infrastructure to be in place such the electric grids and networks that supply work to the users. If there is no proper infrastructure, then both the production and supply of electrical power can be in jeopardy more so when it comes to meeting the ever-increasing demand for electricity. For instance, when it is rainy, there is need for the available infrastructure to be able to produce enough power to serve all the power demand, otherwise absence of this can lead to wastage of inflows. Additionally, when the rains disappear for a power supply substations company to

meet all the power demands, then there must be enough thermal power plants that rely on oil and gas to run. However, because of the cost that are involved in the acquiring and running of this like plants, sometimes acquiring of new infrastructure is hard leading to a huge load pressure on the available infrastructure due to obsolete infrastructure (Chakravortya et. al., 2014). In a research that was in India, Allcott et al., found out that overuse of the power from the government grid was one of the primary reasons that had led to numerous both planned and unplanned power outages and numerous disputes. Regardless of the numerous efforts by the Indian government to upgrade its power supply substations infrastructure to meet the ever-increasing demand, there is a stunted growth of their development (2014).

As research studies show, over 19% of the global population lack electricity connections. This has made many societies to lag not only economically but also in other developmental areas as most individuals are trapped in extreme poverty due to this. Worse, although most government have tried to connect most households with electricity, still the generated power is yet to meet the demand that exists. One the primary factors that has made it hard for most governments to achieve 100% connections is lack of adequate funds. In most nations, utility companies run as natural monopolies because of the economies of scale that exist in the power generation, transmission and distribution. Due to this, as research studies show most of the nations that are involved in this face the challenge of limited capital and investment. With lack of funds comes problems of weak infrastructure and poor performance, this impacts the power reliability index negatively. (IRENA, 2012).

2.6 Energy Regulatory Authority Involvement and Reliability of Power Supply Substations

The reliability of an electricity supply system mirrors its ability to maintain service continuity. In this context, the service is to make electricity available for use to the end-user customers of the electricity supply system. When an electricity supply system fails to perform this task, there are customers that experience service interruptions, which means that these customers are de-energized. Reliability of electricity supply is primarily concerned with duration and frequency of such blackouts. Thus, reliability of supply is a customer-oriented quantity that does not consider the origin of the causes of interruptions. Considering this, it is important for the concerned authorities to always make sure that proper policies are in place to limit the instances of interruptions (Byrd and Matthewman, 2014).

In most world nations, the supply of electricity is normally regulated or managed mostly by state-owned monopoly, a case that is not different in Kenya. As such in most instances, all the funds that drive the generation, transmission and supply of electricity are given by the state through the mandated state regulated bodies. Worse is that, even in areas where the whole production and distribution channels has been restructured or deregulated, most of the control of the entire system still is devoid of state interference and funding. As it stands currently, most governments are unable to finance the degree of subsidy that is necessary to promote power reliability. In a research that was done on Nigeria, Price Waterhouse Coopers found out that due to lack of enough money, the Nigerian government has been unable to support its power sector; hence, the current Nigeria's low power reliability (2016). Worse, because of the regulations that run this sector, private investors are unlikely to fund the infrastructural needs of the sector. Therefore, the financial viability of the funding is a must for power reliability to be achieved because enough funding is required at all levels of power supply substations (Zhang and Kumar, 2011).

Power sector reforms are normally supposed to ensure that there is stability of electricity supply and increase the investment capital. To improve cost recovery and the financial health of utility systems in developing countries, there is increasing pressure to price electricity at its marginal cost and allow independent ability of the power industry in developing countries like Power Producers (IPPs) to sell power to the grid (Adoghe, Odigwe and Igbinovia, 2009). In addition to enacting of proper policies, to ensure that policies and programs are achieving their goals, it is necessary for a proper monitoring program to be put in place. Monitoring an existing electrical supply system requires the concerned to be able to monitor the energy consumption by areas and systems to determine the amount of energy that is required at a given time. Additionally, monitoring should involve the continuous checking of the production and transmission lines to ensure that they function to their optimum (Bekker et. al., 2008).

Additionally, although ERA has over time enacted and implemented numerous policies that are geared towards improving power reliability, little has been done in terms of accelerating connection rates and introducing customer friendly connection policies. This is because with good customer friendly policies it is easy for it to be able to control the number of connections more so the illegal ones, which have greatly contributed to the overloading of electrical grids. On the other hand, in areas where new connections and generation programs

are running, the Kenya Power and Lighting Company has been blamed for low reliability ratings due to the numerous power disturbances that are associated with new connections. According to the Ministry of Planning and National Development, annual progress report, one of the primary problems towards achieving the required power reliability standards is planned power interruptions as the process of reinforcement and upgrading sometimes forces power to be switched off. As such, although this is a problem that ERA should have developed proper policies of ensuring that such is minimized, still the problem is prevalent (2006).

On the other hand, monitoring includes real time ascertaining of areas that are experiencing power blackouts at a specific time to ensure that the response time to a blackout is minimized. Although such systems exist in the Kenya, the data from them is very scanty hence, most of the time most localities suffer power outages for a very long time before restoration. One of the roles of the ERA is ensuring the reliability of most power equipment and ensuring network protection and control. In addition to this, through proper monitoring policies ERA has been able to maximize the efficiency and reliability of the available electricity infrastructure. Although this is the case, ERA has failed in increasing most of its facilities uptime as it is constrained in terms of resources and monitoring and following up in scenarios of power outages more so in remote areas (Barnes et al., 2005).

Refining the reliability of electricity supply involves the formulation of policies and putting in place mechanisms of dealing with new electricity demands and power outages in case they occur. For this to be made possible in Kenya, the government established the Energy Regulatory Authority (ERA) whose primary goal is to regulate generation, transmission, distribution and supply of electricity; protect consumer, investor and other stakeholder interests; collect and maintain energy data; ensure collaboration the Kenya Bureau of Standards; license energy auditors, monitor and develop testing and certification procedures. Since its inception although numerous achievements have been made in ensuring that the county receives reliable power, still the problem of power outages is major menace in Kenya. As research show, instead of improving performance of the protection system to reduce the number of interrupted customers, most of the efforts of ERA have been directed towards expanding distribution channels; hence the low electricity supply reliability index (Roos, 2005).

2.7 Theoretical Framework

This is a review of two theories and their relevancy to this study and they include the Agency and Fault Tree Analysis theory.

2.7.1 The Agency Theory

The Agency theory is a supposition that tries to define the nature of relationships, which exist between principals who are key decision makers and the agents who are involved in the implementation of the decisions. The theory was developed by (Alchian and Demsetz 1972) in their endeavor to offer solutions to issues and problems that may occur between the agents and their bosses. As per the theory, although differences between agents and the principals may arise from time to time, it is necessary for the involved parties to work together and come up with amicable and all-inclusive solutions to the problems actions (Lan and Haracleous, 2010). Further as per the theory, in order to limit the negative effect that may result due to such conflicts, there is need for an entity to formulate and implement a solid corporate policy, which will guide all decisions in an agency or company (Fama and Jensen, 1998).

On the other hand, as per the theory, in most organizations the key decision maker always endeavors to make decisions that are geared towards maximizing utility as the expense of those who are likely to affected by such decisions. As such in most cases such decisions may ignore the need for uniform development of some areas, which the principal assume are not necessary uncertainty. This theory generally tries to understand why behavior or decisions made by different members of an entity vary. That is, it basically provides an explanation on why the differences in behaviors or goals among members who came together for a common goal may eventually vary, more so as concerns their attitude towards risk. It is worth noting that, this theory concentrates more on the incentives given to agents, the cost of the incentives and the likely outcome of behaviors and actions that result due to these incentives being put into use. In most scenarios, agency problems normally arise due to inefficiencies and incomplete information or in scenarios where is there is some degree of uncertainty (Eisenhardt, 2000).

Although this theory may be applicable in the rural electrification of household ventures as the work of the rural electrification distribution networks are normally given to agents by funders and primary stakeholders, sometimes the primary goal of such contracts may be deviated by those tasked with implementing them. This in most cases may occur due to

varying interests of the parties that may be involved in the distribution. Although this theory tries to provide an understanding on how the principal and executives' relationship may affect the success of a venture, it is limited to the nature of relationship that exist between these two parties. As a result, it fails to include other factors that may lead to the success or failure of a project actions (Lan and Haracleous, 2010).

This theory may be practical in the electrification ventures that are geared towards improving the power reliability, because the entire electrification process is done and coordinated by different principals whose decision are binding. As such when making decisions that relate to power reliability as it is a problem that affects many people, it is necessary for the concerned principals to consult all the affected stakeholders instead of monopolizing the entire process. The reliability of a product or a process is supposed to be a successful operation although the absence of failures cannot be avoided. As Eisenhardt argues, the probability of a decision to reliability problems depends on the facts that are taken into consideration in the pre-decision-making stages of that process. As such in the electrification world where reliability is a key success indicator, it is necessary to link solutions to factors that cause and affect them (2000).

2.7.2 Fault Tree Analysis Theory

In 1962 at Bell Telephone Laboratories the fault tree analysis (FTA) was introduced, relating to a safety evaluation of the launching system for the intercontinental Minuteman missile. For risk and reliability studies most commonly used techniques the Fault Tree Analysis. Reactor safety study have used with success the FTA to analysis safety systems in nuclear power stations (Vincoli, 1994). Computer programs for both qualitative and quantitative fault tree analysis were improved by the Boeing Company. The interrelationships between a potential critical event (accident) in a system and the causes for this event can be displayed in a fault tree logic diagram. The following are some of the causes of failure: environmental conditions, human errors, normal events (events that are expected to occur during the life span of the system), and specific component failures. The objectives of the fault tree analysis determine if it is qualitative or quantitative. The likelihood of a critical event occurring at a specified interval can be predicted by Fault Tree Analysis.

The FTA may show possible results, for example, be a listing of the possible combinations of environmental factors, human errors, normal events, and component failures that may result in a critical event in the system (Vesely and Stamatelatos, 2002). The identification of potential causes of system failures before the failures occur is the main objective of the Fault

Tree Analysis. It can also be used to evaluate the probability of the top event using analytical or statistical methods. These calculations involve system quantitative reliability and maintainability information, such as failure probability, failure rate and repair rate. After completing an FTA, you can focus your efforts on improving system safety and reliability (Vesely, 2002; Evans and William, 2001). One advantage that comes with the use of the FTA theory is that it offers a very organized and versatile type of analysis as it evaluates events based each event's purpose and function within a system.

Although this is the case, critics of this theory argue that it is meticulous in that as much as it attempts to offer a description of the relationship of all the events that may have acted upon a system to result in an outcome, it fails to link or consider possible causal events factors that may exist in any of these elements. Although this is the case, it is worth noting that this is one of the most widely used methods in system reliability, maintainability and safety analysis. It is a empirical procedure used to determine the various combinations of hardware and software failures and human errors that could cause undesired events (referred to as top events) at the system level (Vincoli, 1994). Therefore, this theory is most appropriate to use in finding the root cause of power failures before the failure results to power interruption to the consumer. Once applied this theory can make sure that the predictable power losses are significantly reduced.

2.8 Conceptual Framework

The conceptual framework conceptualizes the relationship between the dependent and independent variable. The framework of this study is as presented in figure 1.

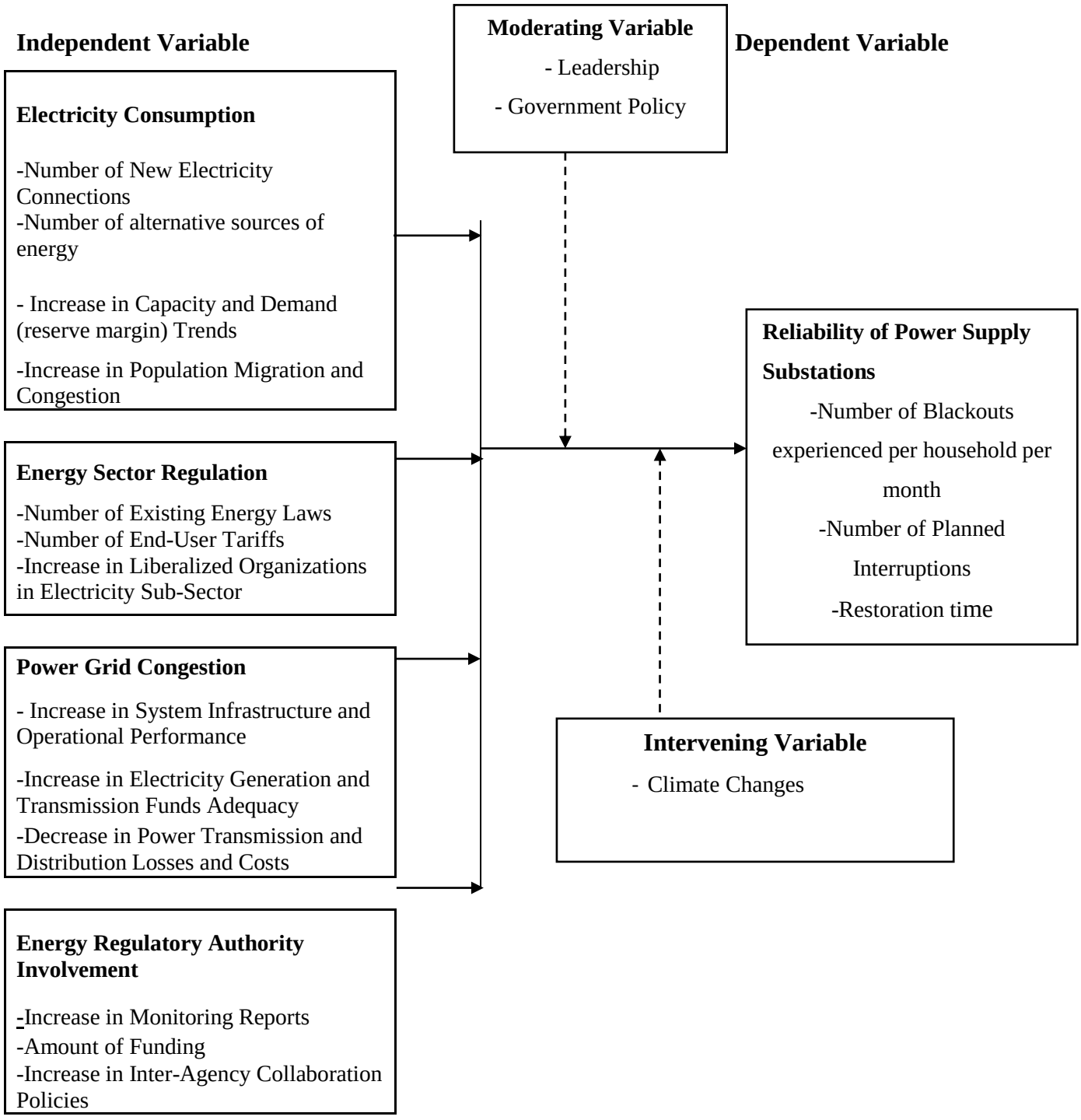

Figure 1. Conceptual Framework of Factors Influencing Reliability of Power Supply Substations

In this study, the independent variables are: electricity consumption, its indicators are number of new electricity connections, number of alternative sources of energy, capacity and demand and increase in population migration and congestion; energy sector regulation, its indicators are number of existing energy laws, number of end-user tariffs and liberalization of the electricity sub-sector; power grid congestion, its indicators are increase in system infrastructure and operational performance, adequacy of electricity generation and transmission funds and decrease in power transmission and distribution losses and costs and lastly Energy Regulatory Authority involvement, its indicators include increase in monitoring reports, amount of funding and increase in inter-agency collaboration policies. On the other hand, the dependent variable that will be under study is reliability of power supply substations, its indicators are number of blackouts experienced per household per month, number of planned interruptions and restoration time. The intervening variable is climate change while moderating variables are leadership and government policy

2.8 Research Gaps

The exhaustive review of past literature both theoretically and empirically has highlighted a few gaps which the present study will try to answer. In the literature review of this study, although most studies tried to explore factors that influence the reliability of power supply substations, most researches dwelt on only a few variables and indicators of this factors. For instance, although Carto (2014) and the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability (2013) proved that poor infrastructure is one of the primary causes of poor power reliability in most of the U.S, these researchers failed to take into consideration other factors that are closely related to poor infrastructure such as the capacity and the transmission and distribution logistics. Additionally, another research by North American Electric Reliability Corporation (NERC) failed to show how the increase in demand caused overloads; hence, the need to link how increase in number of new electricity connections affects the available power production, transmission and distribution and how these relates to power reliability.

Further, although Lofthouse, Simmons and Yonk, (2015) and Samanta (2015) extensively explored how the number of alternative sources of energy influence power reliability, they fail to connect this to other factors such as the economies of scale that are associated with these sources of energy. Additionally, in this research there is no link between how the

existing rules and regulations have contributed to low power reliability. As such this research, will endeavor to explore the obstacles that affect the reliability of power supply substations holistically and how such obstacles can be mitigated. On the other hand, although most of these studies have established some of the factors that include the power reliability of a county, some have not offered realistic measures that can help to improve power reliability rating. On the other hand, although there are numerous studies that have been done on this topic, there is no documented study that is based on the stated factors in the Kenyan context; hence, this study will try to bridge this gap to offer solutions that can work in the Kenyan context.

2.9 Summary of Literature

This chapter introduced the concept of reliability of power supply substations in Kenya and other countries. From the empirical review, it is apparent that there are many studies into the subject of power reliability in the world but in Africa very few studies have been done. It was noted that in the developed economies power reliability index is high in comparison to the developing countries like Kenya. The study also investigated the factors influencing the reliability of power supply substations, it was guided by four main independent variables as indicated in the conceptual framework (figure 1) this includes electricity consumption, energy sector regulations, power grid congestion and Energy Regulatory Authority involvement. The intervening variable seen to affect this relationship, but was beyond the control of the researcher was; climate change. Also, the moderating variables that were considered included; leadership and government policy. Finally, a conceptual framework was done depicting the interrelations of independent and dependent variables and showing the intervening and moderating variables that may have influenced their relationship. The Two theories namely the Agency and the Fault Tree Analysis were discussed in this study.

Table 2.1 Empirical Research Matrix

Variable	Author and Year	Title of study	Methodology	Findings	Research gaps
Electricity Consumption	U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability, 2013	Economic Benefits Of Increasing Electric Grid Resilience To Weather Outages	Case studies were used in this research	Increase in electricity demand caused an increased need for better infrastructure	In this research, other factors such as the capacity and demand trends were not discussed
	Ku Leuven Energy Institute (2014)	Security of Electric Power supply substations	A descriptive research design was used in this research	Inadequate generation capacity and lack of the required infrastructure is the primary cause of a low reliability index in Belgium	This research focused on how demand of electricity power leads to infrastructural deficits causing a low power reliability. As a result, other factors that influence the reliability of power supply substations were not discussed
	Kelly and Grouse, 2011	Electricity Reliability; Problems, Progress and Policy Solutions	The study was done using the exploratory and descriptive research design	Due to the seasonal fluctuations on the demand for electrical power, sometimes the available infrastructure is unable to support the demand; hence, the numerous power outages	Although this research extensively explored how electricity consumption leads to a low power reliability rating, it ignored other factors such as how a government's policy and population migration affect reliability
	North American Electric Reliability Corporation (NERC), 2010)	Reliability Considerations from the Integration of Smart Grid	The study was done using the exploratory and descriptive research design	As times keeps changing, the demand for more power supply substations increases due to change in technology	This study only focused on how demand changes because of technology hence, it failed to link to other factors that affect the reliability of power supply substations.
	Lofthouse, Simmons and Yonk, 2015	The True Cost of Wind Energy	Survey questionnaires were used in this research	Although alternative sources of energy such as wind energy offer a solution to the numerous power outages experienced in many societies, the cost of its generation is high; hence, not economical	This study only focused on the cost of production of alternative sources energy; hence, ignoring other factors which affect the reliability of power supply substations
	Hossain, 2015	Wind Energy	A qualitative	Adoption of	This study only

		2015; On the Shape of Near 100% RE Grid	approach was used in this research study using case studies	alternative sources of energy can help to enhance power reliability although the cost of installing it may be expensive	focused on the cost of production of alternative sources energy; hence, ignoring other factors which affect the reliability of power supply substations
Energy Sector Regulations	Cecelski et al., 2006	Sub-Saharan Africa: Introducing Low-cost Methods in Electricity Distribution Networks	The case study and descriptive research method was used	It was found out that although most sub-Saharan Africa countries were struggling with power reliability problems, as a result of unsound energy and financial policy, most of them were improving	In this research although the nature of existing policies and their effect on the reliability of power supply substations were explored, the study fails how this is connected to other factors such as the increased number of new electricity connections
	Kemausuor et al., 2012	GIS-Based Energy Access Project: A Review of the Trends, Policies, and Plans for Increasing Energy Access in Ghana	The case study and descriptive research method was used	Ghana has been able to achieve a good power reliability index due to adoption of regulations and policies that are geared towards promoting a functional energy sector	Although this broadly explored the significance of good policies on power reliability, it ignored other factors that contribute to a good power reliability index.
	Bekker et., al., 2008	South Africa's rapid electrification programme: Policy, institutional, planning, financing and technical innovations	The study used case studies and exploratory research study design	Good fiscal, energy and monetary policy, South Africa has made numerous strides towards promoting power reliability to its people	This study focused on only factor, the energy sector regulation and policies hence failed to connect how other related affect the reliability of power supply substations
Power Grid Congestion	Amoako-Tuffour and Esi Eshun (2015)	A Review of the Trends in Ghana's Power Sector	A descriptive research design and exploratory methods were used in this research	Most government owned energy entities operated on high long-run marginal costs and most were unable to procure more funds for maintaining and expanding their operations	In this research study, other factors that affect the reliability of power substations were not studied
	Zhu et al., (2015)	Research on Development Strategies of Distributed Generation Based on Micro Grid Technology	The case study methodology was used in this study based on recent real-life cases	Most of the currently operational hydroelectric stations and sub-stations have very high capital and maintenance costs;	In this study, other factors that influence the reliability of power substations were not discussed

				hence, hindering any expansion efforts to ensure power reliability	
	Lofthouse, Simmons and Yonk, 2015)		Case studies and descriptive research methods were used	High generation and transmission costs can make some form of energy to be uneconomical towards improving reliability	Although this study explored how cost that are related to generation and transmission affect supply substations, it failed to explore other factors that affect reliability of power substations
	Chakravortya et. Al., 2014	Does the quality of electricity matter? Evidence from rural India	An exploratory and descriptive research design were used	Power generation and transmission infrastructure is very expensive; hence, expansion becomes a problem leading to reliability problems	This research only dwelt on transition and congestion infrastructure factor hence, ignoring other factors such as the nature of the existing fiscal and energy policy
Energy Regulatory Authority Involvement	Adoghe, Odigwe and Igbinovia, 2009	Power Sector Reforms-Effects on Electric Reliability of power supply substations and Stability in Nigeria	Case studies were used in this study whereby review of real cases was done	Enough funding is necessary for the reliability of a power supply project; hence the need to encourage private investment in the power supply substations industry	This study only dwelt on funding hence ignored factors such the government's energy policy and increased electricity demand on power supply substations
	Ministry of Planning and National Development, annual progress report, 2006	Investment Programme For The Economic Recovery Strategy for Wealth and Employment Creation 2003-2007	This study used a descriptive research study	Maintenance, reinforcement and upgrading of power lines are some of the contributors to failure of most power supply substations due to numerous planned power outages.	This research dwelt on only planned interruptions, hence ignoring other factors which affect the reliability of power supply substations
	Byrd and Matthewman, 2014	Blackouts: A Sociology of Electrical Power Failure	An exploratory research design was used in this research	Poor policies are some of the main contributors to low power reliability index in most nations	This study failed to show how different factors other than poor policies which affect the reliability of power supply substations interrelate
	Barnes et al., 2005	The urban household energy transition: Social and environmental impacts in the developing	Case studies were used in this research study	Failure in increasing power facilities' uptime that are constrained in terms of resources and monitoring is one of the causes of numerous power	Although the research explored factors that relate to the involvement of power supply substations bodies on reliability of power supply substations, it ignored other factors such as

		world		outages; hence, a low reliability	how increased demand can lead to low reliability ratings
	Zhang and Kumar, 2011	Evaluating renewable-energy-based rural electrification program in western China: Emerging problems and possible scenarios	An exploratory research design in addition to a descriptive research design was used in this research	The financial viability of the funding is a must for power reliability to be achieved because enough funding is required at all levels of power supply substations	This study was limited to only two factors; hence, it failed to show how factors such as number of new electricity connections contribute to low power reliability.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research design, target population, sample size, pilot study, research instruments as well as data collection procedures and analysis techniques that were used in the study. Additionally, it focused on the sampling procedure adopted and tools for data analysis, presentation and interpretation. A justification on the choice of these methods was also be provided.

3.2 Research Design

According to Kraemer (2006), research design is the overall strategy that was used during collection and analysis of data in a way that is relevant to the research goals. This research study used the descriptive survey research design. This conforms to Mugenda and Mugenda (2003) observation that a descriptive research design gives a researcher an opportunity of presenting all the collected data from different sources to give a complete story. A descriptive research design was used in this research design as it offered the researcher an opportunity of describing findings in their present state. In addition, descriptive survey research design enabled the researcher to observe, describe and document aspects of situations as they occurred.

3.3 Target Population

According to Kombo and Tromp (2006) a population is a group of individuals, object or items from which samples are taken for measurement. The study targeted 290 energy sector personnel that are directly involved in the implementation, operation and maintenance of power supply substations. These personnel were from departments that were randomly selected from the strata's which were from the following organizations: Kenya Power and Lighting Company, Energy Regulatory Commission and Energy Regulatory Authority. According to Mugenda and Mugenda (2003), there is need to make sure that the population under study has all the characteristics of the entire population that is under study for generalization of results. Additionally, it is necessary for the population under study to meet a certain criterion that is relevant to the study for it to be included in the study (Burns and Grove (2003). The population under study was distributed as shown in Table 3.1

Table 3.1 Target Population

ORGANIZATION	TARGET POPULATION
KPLC	198
ERA	66
ERC	26
TOTAL	**290**

3.4 Sample Size and Sampling Technique

3.4.1 Sample Size

A sample of 165 respondents were picked from the departments that were represented in the three organizations namely Kenya Power and Lighting Company, Energy Regulatory Authority and Energy Regulatory Commission as a population of 290 respondents resulted in a sample size of 165 using the Krejcie and Morgan table of 1970.

3.4.2 Sampling Technique

Stratified random sampling method was used to pick the group that took part in the research because of the commonality in characteristics that are shared by departments. The departments acted as strata for this research study and each of them was sampled independently as it helped to ensure that each subject had an equal chance of being selected. This method was used in this research as it helped to ensure that there are no departments that are over or under represented. This conformed to Barreiro and Albandoz (2011) who asserts that a good sampling method must ensure that all the units that are under research are equally represented in the chosen sample by minimizing any form of sample bias. In this research, the sample selected satisfied the condition of the sampling which according Mugenda and Mugenda, (2003) must be more than 10% of the population under study. Therefore, 165 respondents formed the sample size of this study and it was calculated as shown in Table 3.2.

Table 3.2 Sampling Frame

Organization	Department	Population	Sample Size
Energy Regulatory Authority	Station Management	5	3
	Administration	12	7
	Technical Services	12	7
	ICT	9	5
	Corporate Affairs and Administration	9	5
	Quality	14	8
	IT & Telecommunications	16	9
	Supply Chain	28	16
	Network Management	29	17
Kenya Power and Lighting Company	Energy studies Research	12	7
	Regional Operations	42	24
	Engineering	31	18
	Electricity Connectivity	23	13
	Infrastructure Development	14	8
	Licensing and Market Monitoring Division	5	3
	Consumer Service Division	13	7
	Tariffs and Rates Division	7	4
Energy Regulatory Commission	Standards and Compliance Monitoring Division	4	2
	Planning and Information Service	3	1
	Markets Operations Division	2	1
Total		**290**	**165**

3.5 Research Instruments

This section presents the various instruments that were used to collect data for this research. A questionnaire was used to collect data and it was selected because of its ability to provide uniformity in the collected data due to its structure. A questionnaire can also help to promote privacy; hence, promoting the provision of true answers. On the other hand, a questionnaire is preferred for large samples because of their ability to reach a large group at once (Burns and Bush, 2009). A questionnaire was issued to the respondents who ticked appropriately on how they think the factors that were under study influenced the reliability of power supply substations. The research questionnaire was divided into two sections namely; the respondents' profile (section A) and the factors influencing the reliability of power supply substations in Kabete Sub-County, Kenya (section B).

3.5.1 Pilot Study

According to Mugenda and Mugenda (2003), it is important to do a pilot study on at least 10% of the sample that has similar characteristics in any research study. This is important before the actual research study as it helped to identify errors and challenges that may be faced during the actual study. It can also help to identify and later rectify errors in the research instruments to make sure that reliable and valid data is collected during the actual research day (Kraemer, 2006). In this regard, 17 questionnaires were distributed to the department that were under study two weeks before the actual study for assessing the feasibility of the study. During the pilot study, the respondents were explained to the purpose of the research study and assured of their confidentiality to ensure that they gave genuine information. After two weeks, the same respondents were requested to fill identical questionnaires but without any notification.

3.5.2 Validity of the Instrument

Validity is how well a research instrument measures what it is supposed to measure or how accurate a research instrument reflects the reality of a test in terms of giving stable and consistent results. It helps to ascertain if the research results meet the necessary requirements of a selected research method by evaluating the aptness, relevance and usefulness of a research study. There are two types of validity, namely content and construct validity. Content validity helps to ascertain the match between test questions and the content they are meant to address whereas construct validity refers to the extent to which test asses the theoretical construct under study (Golafshani, 2003). In this study, content validity was used to check the validity of the research instrument. To do this, a questionnaire was issued to the university supervisor for checking of the specificity and clarity of the research instrument for this research. The offered response was used to make necessary corrections in the questionnaire.

3.5.3 Reliability of the Instrument

Reliability in research is the overall consistency of an assessment tool to give consistent results every time it is used. That is, it measures the level to which the research instruments are without bias and give consistence results over time based on the same conditions and method of data collection (Carlson, 2009). In this study, reliability of research instruments

was tested using the test-retest method whereby the same questionnaire was issued twice to respondents, after which the statistical package SPSS was used to calculate the Cronbach's alpha coefficient. Cronbach's alpha coefficient was used to measure the reliability of the questionnaire. Cronbach's alpha is a reliability coefficient that indicates how items in a set are positively correlated to one another. It measures the correlations among test items, with a measure of 1 being higher in terms of internal consistency and reliability of >0.7 being acceptable (Revelle and Zinbarg, 2008). In this study, the acceptable value for alpha was 0.7 as it is considered acceptable for social science researches.

Table 3.3 SPSS Statistics Output for Cronbach's Alpha for Reliability Test

Reliability Statistics

Cronbach's Alpha	**Cronbach's Alpha base on standard questionnaire**	**Number of Questionnaires**
0.805	0.797	17

From the results shown in table 3.3, the reliability test provided a Cronbach's Alpha coefficient of 0.805 which indicates a high level of internal consistency for our Likert scale. Since the coefficient is above 0.7 the results are acceptable.

3.6 Data Collection Procedures

According to Madhu (2005), data collection procedure is the plan for activities that are involved in each study. Data for this study was collected through drop and collect system of questionnaires with a letter of transmittal from the researcher. To help in research, 10 research assistants were trained on interviewing skills and data collection techniques. Data collection took 30 days, before that clearance was sought from University of Nairobi and National Council of Science, Technology and Innovation (NCSTI) to carry out research. Permission was also sought from the county Director of Education - Kiambu County to allow the study to take place within his/her jurisdiction. Respondents were given a week to fill the questionnaires after which the research assistant helped to collect them for analysis. During the data collection period, follow up calls were made to increase the response rate. After this, coding of the questionnaire that were returned was done and prepared for analysis.

3.7 Data Analysis Techniques

Data analysis provides a way of coming up with inductive conclusions from data and differentiating the phenomenon of interest from statistical fluctuations that are in the research data. Additionally, data analysis can help a researcher to restructure findings from different sources of data collection and help to break a macro problem into micro parts that will offer meaningful insights out of a large quantity of data (Burnard et. al., 2008). Questionnaires were examined to ensure that all responses were provided as required and to ensure that there was no vagueness. Arithmetic mean of the collected data was calculated as a measure of average because it is least affected by variations of sampling and it is based on all observations, while Standard Deviation was used as a measure of dispersion as helped to limit rounding errors and together with the mean, it helped to detect skewness (Manikandan, 2011). After this descriptive analysis of the results was made and generalized to the entire population. On the other hand, data from questionnaire was coded and Statistical Package for Social Science (SPSS) Version 22 program was used to perform descriptive statistics. The data was presented in tables.

3.8 Ethical considerations

To ensure that this research presents a true picture of the factors that influence the reliability of power supply substations in Kabete Sub-county, Kenya, permission was sought from the University of Nairobi and the National Commission for Science, Technology and Innovation for research. Additionally, respondents were assured of the confidentiality of any provided information that was given.

3.9 Operationalization of the Variables

Different variables were measured using different approaches. Table 3.3 outlines the relevant measures and their corresponding operational definitions.

Table 3.5 Operationalization of the Variables

Variables	Indicators	Scale of Measurement	Research Design	Research Analysis Techniques
Electricity consumption	-Number of alternative sources of energy	Ordinal	Quantitative	Descriptive
	-Increase in capacity and demand (reserve margin) trends	Ordinal	Quantitative	Descriptive

	-Number of new electricity connections	Ordinal	Quantitative	Descriptive
	-Increase in population migration and congestion	Ordinal	Quantitative	Descriptive
Energy sector regulations	-Number of existing energy laws	Ordinal	Quantitative	Descriptive
	-Number of End-User Tariffs	Ordinal	Quantitative	Descriptive
	-Increase in liberalized organization in electricity sub-sector	Ordinal	Quantitative	Descriptive
	-Increase in electricity generation funds adequacy	Ordinal	Quantitative	Descriptive
Power grid congestion	-Increase in power system infrastructure, and operational performance	Ordinal	Quantitative	Descriptive
	-Increase in electricity generation and transmission funds adequacy	Ordinal	Quantitative	
	- Decrease in power transmission and distribution losses and costs	Ordinal	Quantitative	Descriptive
Energy Regulatory Authority's involvement	-Increase in monitoring reports	Ordinal	Quantitative	Descriptive
	-Amount of funding	Ordinal	Quantitative	Descriptive
	-Increase in inter-agency collaboration policies	Ordinal	Quantitative	Descriptive
Reliability of Power Supply Substations	-Number of Blackouts experienced per household per month	Ordinal	Quantitative	Descriptive
	-Number of Planned Interruptions	Ordinal	Quantitative	Descriptive
	-Restoration time	Ordinal	Quantitative	Descriptive

CHAPTER FOUR
DATA ANALYSIS, PRESENTATIONS AND INTERPRETATIONS

4.1 Introduction

This chapter presents the findings of the study which were in line with the objectives of the study. Some of the discussed sub-sections include the respondents' profile, electricity consumption and reliability of power supply substations, energy sector regulation and reliability of power supply substations, power grid congestion and reliability of power supply substations and Energy Regulatory Authority involvement and the reliability of power supply substations. In this chapter, the data presented was processed using Statistical Package for Social Sciences (SPSS) version 22. The analysis results were presented in tables, interpreted and findings explained. The analysis results were presented in mean and standard deviations.

4.2 Questionnaire Return Rate

This study had sample size of 165 respondents. A total of 165 questionnaires were dispatched to the randomly selected members of the sample size. Knowing the percentage of the response rate was necessary to deem if the study was adequate or not. The results on the response rate are presented in Table 4.1

Table 4.1 Return Rate

Organization	Issued Questionnaires	Returned questionnaires	Percentage
Energy Regulatory Authority	35	25	71.4
Kenya Power and Lighting Company	112	90	80.4
Energy Regulatory Commission	18	16	88.9
TOTAL	**165**	**131**	**79.39**

A total of 165 questionnaires were issued to respondents and out of those, 131 questionnaires were returned. This represented a return rate of 79.39 %. This response was very good for data analysis as it conforms to Schindler and Cooper (2005) that any return rate of 70% or above is very good.

4.3 Respondent Profile

The respondents' information that was considered in this study included the name of the organization, department of work, the length of continuous service with the organization, and the respondents' designation in their respective departments.

4.3.1 Organization of the Respondents

The respondents were asked to state the organizations they worked for and the responses are represented in Table 4.2. Knowing the respective organizations of the respondents was necessary as it helped to know how close the sample replicated the population that was under study.

Table 4.2 Respondents' Respective Organization

Organization	Response Rate	Percentage
Energy Regulatory Authority	25	19.08
Kenya Power and Lighting Company	90	68.70
Energy Regulatory Commission	16	12.21
TOTAL	**131**	**100.00**

As per the findings, 19.08 % of the respondents were from the Energy Regulatory Authority, 68.70 % were from Kenya Power and Lighting Company and 12.21 % were from the Energy Regulatory Commission. The implication is that Kenya Power and Lighting Company had the highest number of respondents since the power supply project under study was implemented by KPLC. Also, the company is the national power distributor and retailer, their feedback is critical to this research study.

4.3.2 Respondents Department of Work

To distinguish between the different sub-groups under an organization which were under study and gather significant information on their involvement in the implementation of power supply substations, respondents were requested to indicate their respective department under which they worked. The results are presented in Table 4.3

Table 4.3 Respondents' Department of Work

Organization	Department	Population	Sample Size	Returned Questionnaires	Percentage
Energy Regulatory Authority	Station Management	5	3	3	100.0
	Administration	12	7	5	71.4
	Technical Services	12	7	5	71.4
	ICT	9	5	4	80.0
	Corporate Affairs and Administration	9	5	3	60.0
	Quality	14	8	5	62.5

Kenya Power and Lighting Company	IT & Telecommunications	16	9	6	66.7
	Supply Chain	28	16	14	87.5
	Network Management	29	17	15	88.2
	Energy studies Research	12	7	5	71.4
	Regional Operations	42	24	20	83.3
	Engineering	31	18	15	83.3
	Electricity Connectivity	23	13	10	76.9
	Infrastructure Development	14	8	5	62.5
	Licensing and Market Monitoring Division	5	3	3	100.0
	Consumer Service Division	13	7	6	85.7
Energy Regulatory Commission	Tariffs and Rates Division	7	4	3	75.0
	Standards and Compliance Monitoring Division	4	2	2	100.0
	Planning and Information Service	3	1	1	100.0
	Markets Operations Division	2	1	1	100.0
Total		**290**	**165**	**131**	**79.39**

From the research findings, ERA department of Station Management had a return rate of 100%, Administration had a return rate of 71.4%, Technical Services had a return rate of 71.4%, ICT had a return rate of 80% Corporate Affairs and Administration had a return rate of 60%, Quality had a return rate of 62.5%, IT & Telecommunications had a return rate of 66.7% Supply Chain had a return rate of 87.5% and Network Management had a return rate of 88.2%. KPLC department of Energy studies Research had a return rate of 71.4%, Regional Operations had a return rate of 83.3%, Engineering had a return rate of 83.3%, Electricity Connectivity had a return rate of 76.9%, Infrastructure Development had a return rate of 62.5%, Licensing and Market Monitoring Division had a return rate of 100% and Consumer Service Division had a return rate of 85.7%. ERC departments of Tariffs and Rates Division had a return rate of 75%, Standards and Compliance Monitoring Division had a return rate of 100%, Planning and Information Service had a return rate of 100%, and Markets Operations Division had a return rate of 100%. The implication is that each department had a return rate of above 60% which shows that the respondents were well distributed and represented from each of the three organizations. It was also noted that the fewer the sample size in a department the higher the response rate. The departments with higher sample sizes had lower

response rate. This indicates that in small departments, the respondents were more motivated to fill and return questionnaires.

4.3.3 Length of Continuous Service in the Respective Organization

This section of the questionnaire sought to determine how long the respondents had been working in their respective organizations. Ascertaining this length was significant to this research as it revealed the respondents' level of experience in implementation of power supply substations. The results are presented in Table 4.4.

Table 4.4 Length of Continuous Service with the Organization

No of Years	No of Respondents	Percent	Cumulative Percent
1-3 Years	23	17.6	17.6
4-6 years	50	38.2	55.8
6 - 10 years	37	28.2	84
Over 11 years	21	16.0	100
Total	**131**	**100**	

From the results, 38.2 % of the respondents had worked in their respective organizations for a period of 4 to 6 years, 28.2 % has worked for their respective organizations for a period of between 6 to 10 years, whereas 17.6 % of the respondents had worked for their respective organizations for a period of between 1 to 3 years. Additionally, the results showed that 16 % of the respondents had worked for their respective organizations for a period of over 11 years. From the research findings, most of the respondents have worked in their respective organization for more than four years. The implication is that they are familiar with challenges faced while implementing and operating power supply substations. Their feedback would provide information that depicts the true picture of reliability of power supply substations.

4.3.4 Designation of Respondents

This section of the questionnaire sought to determine the designation of the respondents in their respective organizations. This was significant for research as it gave a clear picture of the nature of roles that is played by different respondents in the implementation of power supply substations; hence, their understanding of the factors that affect these projects. The results are presented in Table 4.5

Table 4.5 Designation of Respondents

Designation	Frequency	Percent	Cumulative Percent
Engineer	51	38.93	38.93
Administrator	18	13.74	52.67
Customer Care	16	12.21	64.88
Sales	3	2.3	67.18
Marketer	2	1.53	68.71
Regional Operators	20	15.27	83.98
Quality Manager	2	1.53	85.51
Procurement	14	10.69	96.2
Researcher	2	1.53	97.73
Marketing Manager	1	0.76	98.49
Quality Analyst	1	0.76	99.25
Quality Officer	1	0.76	100
Total	**131**	**100**	

From the results 38.93 % of the respondents were Engineers, 15.27 % of respondents were Regional Operators, 13.74 % of the respondents were Administrators, 12.21 % of the respondents were Customer Service Officers, 10.69 % of the respondents were Procurement Officers, 2.3 % of the respondents were Sales Officers, 1.53 % of the respondents were Marketers, Quality Managers, Quality Officers and Researchers additionally 0.76 % of respondents were Marketing Manager, Personal Assistant, Quality Analyst and Quality Officer. From the research findings Engineers represented the highest percentage of the respondents. The implication is that since this is a technical research, Engineers were most knowledgeable on reliability of power supply substations. The Administrators who overlook all aspects of the respondent's organizations were also able to give critical feedback from a managerial perspective. Additional Customer Care Officers who receive complaints on power outages and response time provided credible information on key indicators of reliability of power supply.

4.4 Increased Electricity Supply and Reliability of Power Supply Substations

The study sought to determine how different political factors influence the reliability of power supply substations. The factors which were under study included demand for electricity, number of alternative sources of energy, increase in capacity and demand (reserve margin) trends and increase in population migration and congestion. Table 4.6 shows how these factors influence the reliability of power supply substations.

Table 4.6: Electricity Consumption on the Reliability of Power Supply Substations

Statements	Mean	Std. Deviation
Number of new electricity connections Influences the Number of Blackouts Experienced Per Household Per Month	3.20	0.86
Number of new electricity connections Influences Number of Planned Interruptions	3.85	0.72
Number of new electricity connections Influences the Restoration Time	4.09	0.98
Capacity and Demand Trends Influence the Number of Blackouts Experienced Per Household Per Month	3.65	0.83
Capacity and Demand Trends Influence the Number of Planned Interruptions	3.81	0.81
Capacity and Demand Trends Influence the Restoration Time	4.18	0.82
Increase in population migration and congestion Influence the Number of Blackouts Experienced Per Household Per Month	3.43	0.94
Increase in population migration and congestion Influence the Number of Planned Interruptions	3.96	0.56
Increase in population migration and congestion Influence the Restoration Time	4.03	0.95
Number of alternative sources of energy Influence the Number of Blackouts Experienced Per Household Per Month	3.60	0.75
Number of alternative sources of energy Influence the Number of Planned Interruptions	3.96	0.66
Number of alternative sources of energy Influence the Restoration Time	4.22	0.82
Mean of Mean	**3.83**	**0.81**

From the findings, it was revealed that the increased consumption of electricity has a significant influence on the reliability of power supply substations (aggregate mean 3.83). Among the factors that were under study, availability of alternative energy sources had the most significant influence on the reliability of power supply substations (mean 3.93). Although this factor affects the number of blackouts that are experienced per household per month (mean 3.60), the most significant influence was on the amount of the restoration time (mean 4.22) followed by the number of planned interruption (mean 3.96). This clearly implicates that dependency on electricity due to lack of alternative sources of energy is the primary reason why some areas over years have suffered most due to power blackouts. Overdependency on electricity for all power needs can result to exhaustion of the existing system since it will be almost impossible to carry out planned interruptions for maintenance

or upgrade purposes since the economic implications of the entire area depending on electricity are too high.

Additionally, findings of the research showed that the capacity and demand trends also had a significant influence on the reliability of power reliability substations (aggregate mean 3.88). The research findings proved that there is a direct link between the increase in capacity and demand (reserve margin) trends on the number of blackouts that are experienced per household per month (mean 3.65), the number of planned interruptions (mean 3.81) and on the restoration time (mean 4.18). These findings imply that regions with high capacity and demand trends have quicker response time since the number of customers who suffer from the blackout are more and thus the financial implications on the power utility company. The number of planned interruptions to areas with high capacity and demand is more than areas of low capacity and demand trends because of the required maintenance due to wear and tear of equipment that supply's power and the constant upgrading of the existing systems to ensure reliability of power supplied.

Further, findings of this study proved that increase in population migration and congestion also had a significant influence on the reliability of power supply substations with an (aggregate mean 3.81). Among the factors that were under study in this, the population and migration trends had the most significant influence on the restoration time (mean 4.03). Although the influence on restoration time is significant, the case is a little bit different with its influence on the number of planned interruptions (mean 3.96) and the number of blackouts experienced per household per month (mean 3.43). These findings imply that areas with increase in population migration and congestion have fast restoration time due to the number of complaints provided by the consumers affected. The number of planned interruptions are also high because increase in population migration and congestion result to many illegal connections on already overdrawn transformers which result to constant blackouts and poor reliability of power.

On the other hand, results of this research study revealed that the number of new electricity connections has a significant influence on the reliability of power supply substations (aggregate mean 3.72). Among the indicators that were study under this, the number of new electricity connections has the most significant influence on the restoration time (mean 4.09) and the number of planned interruptions (mean 3.85). Although this was the case, the

findings of this study revealed that respondents were neutral on the influence of electricity consumption on the number of blackouts experienced per household (mean 3.20). Such can be attribute to the fact that, blackout in houses are caused by numerous factors some of which do not directly link to the reliability of power supply substations. From the results that show electricity consumption had a mean of mean of 3.83, all the means of the indicators below this value can be considered outliers. The outliers in this case are assumed to be caused by biased parameter estimation in the indicator number of blackouts experienced per household per month and capacity and demand trends influence the number of planned interruptions.

4.5 Energy Sector Regulation and Reliability of Power Supply Substations

Energy and Regulation factors that were under study include Number of existing energy laws, number of end-user tariffs and increase in liberalized organizations in electricity sub-sector. The results are presented in Table 4.7

Table 4.7: Energy Sector Regulation on Reliability of Power Supply Substations

Statements	Mean	Std. Deviation
Number of existing energy laws influence the number of blackouts experienced per household per month	3.55	0.74
Number of existing energy laws influence the number of planned interruptions	3.69	0.86
Number of existing energy laws influence the restoration time	4.13	0.79
Number of End-User Tariffs influences the number of blackouts experienced per household per month	3.48	0.83
Number of End-User Tariffs influences the number of planned interruptions	3.83	0.77
Number of End-User Tariffs influences the restoration time	4.07	0.90
Increase in liberalized organizations in electricity sub-sector influence the number of blackouts experienced per household per month	3.49	0.80
Increase in liberalized organizations in electricity sub-sector influence the number of planned interruptions	3.83	0.66
Increase in liberalized organizations in electricity sub-sector influence the restoration time	3.92	0.99
Mean of Mean	**3.78**	**0.82**

From the findings, it was revealed that energy sector regulation had influence on the reliability of power supply substations (mean 3.78). Respondents agreed that Number of existing energy laws, number of end-user tariffs and increase in liberalized organizations in electricity sub-sector significantly influence the reliability of power supply substations. Among factor that were under energy sector regulation, research findings proved that number of existing energy laws (mean 3.79) and number of end-user tariffs (mean 3.79) had the most significant influence on the reliability of power supply substations. Liberalization of the electricity sub-sector (mean 3.75) was third. The implication is that without proper energy policies, laws and tariff strategies then the probability of poor reliability is high and this will automatically lead to not only an increased number of blackouts per household, but also the restoration time is likely to be poor. Emphasis must be placed in unbundling of the electricity sub-sector since it will improve reliability, monopolization in the sector will be eliminated and efficiency improved by each utility since the workloads will be manageable.

From the findings, number of existing energy laws influences the number of blackouts experienced per household per month (mean 3.55); nature of existing laws influences the number of planned interruptions (mean 3.69) and nature of existing laws influences the restoration time (mean 4.13). These findings imply that the existing laws affect most the restoration time. The existing laws have hindrances to how power utility personnel respond to power outages hence restoration takes longer. When customers go for long periods without power, poor reliability index is noted. In additional findings increase in liberalized organizations in electricity sub-sector influence on the restoration time (mean of 3.92), increase in liberalized organizations in electricity sub-sector influences number of planned power interruptions (mean of 3.83) and increase in liberalized organizations in electricity sub-sector influences number of blackouts experienced per household per month (mean of 3.49). These findings imply that liberalization of the energy sub-sector had most significant influence on restoration time since liberalization of the sub-sector created several individually run utilities whose duties and responsibilities were separate but overall mission similar, due to the red tape involved while carrying out activities that require more than one utility, the response time becomes longer.

The findings on number of end-user tariffs influence on number of blackouts experienced per household per month (mean of 3.48), number of end-user tariffs influence on number of

planned interruptions (mean of 3.83) and number of end-user tariffs influence on the restoration time (mean 4.07) imply that restoration time was influenced most by number of end-user tariffs, this was because number of end-user tariffs cater for the power generation, transmission, distribution and operation cost. If number of end-user tariffs don't cover these costs, it will be difficult to maintain and restore power since the cost of these operations will not be catered for. From the results that show energy sector regulations had a mean of mean of 3.78, all the means of the indicators below this value can be considered outliers. The outliers in this case are assumed to be caused by biased parameter estimation in the indicator number of blackouts experienced per household per month and number of existing energy laws influence on number of planned interruptions.

4.6 Power Grid Congestion and Reliability of Power Supply Substations

To establish how power grid congestion influences the reliability of power supply substations, respondents were asked how different factors that were under study influence the reliability. Power grid congestion factors that were under study included increase in system infrastructure and operational performance, increase in electricity generation and transmission funds adequacy and decrease in power transmission and distribution losses and costs. Table 4.8 shows how different power grid congestion factors influence the reliability of power supply substations.

Table 4.8 Power Grid Congestion on the Reliability of Power Supply Substations

Statement	Mean	Std. Deviation
System infrastructure and operational performance influence the number of blackouts experienced per household per month	3.48	0.78
System infrastructure and operational performance policy influence the number of planned interruptions	3.88	0.77
System infrastructure and operational performance influence the restoration time	4.02	1.02
Increase in electricity generation and transmission funds adequacy influence the number of blackouts experienced per household per month	3.65	0.93
Increase in electricity generation and transmission funds adequacy influence the number of planned interruptions	3.93	0.79
Increase in electricity generation and transmission funds adequacy influence the restoration time	4.06	0.95
Decrease in power transmission and distribution losses and costs influence the number of blackouts experienced per household per month	3.65	0.85

Decrease in power transmission and distribution losses and costs influence the number of planned interruptions	3.84	0.75
Decrease in power transmission and distribution losses and costs influence the restoration time	4.31	0.79
Mean of Mean	**3.87**	**0.85**

Research findings of this research revealed that power grid congestion significantly influences the reliability of power supply substations (mean 3.87). Among the factors which were under study, decrease in power transmission and distribution losses and costs had the most significant influence on the reliability of power supply substations (mean 3.93), followed by increase in electricity generation and transmission funds adequacy (mean 3.88), and finally increase in increase in system infrastructure and operational performance (mean 3.79). Further, the results also proved that had a significant influence on the restoration time (mean 4.02), increase in electricity generation and transmission funds adequacy also has a significant influence on the restoration time (mean 4.06) and Decrease in power transmission and distribution losses and costs influences restoration time (mean 4.31).

On the other hand, from the results, it was revealed that increase in electricity generation and transmission funds adequacy had an influence on the number of planed interruptions (mean 3.93), increase in system infrastructure and operational performance influences number of planned interruptions (mean 3.88) and decrease in power transmission and distribution losses and costs influences number of planned interruptions (mean 3.84). Additional results show increase in system infrastructure and operational performance influences number of blackouts experienced per household per month (mean 3.48), increase in electricity generation and transmission funds adequacy influences number of blackouts experienced per household per month (mean 3.65) and Decrease in power transmission and distribution losses and costs influences number of blackouts experienced per household per month (mean 3.65).

The research findings implications are that power transmission and distribution losses had the most significance influence on the restoration time (mean of 4.31). This implies that when transmission breakdowns that take place in inaccessible areas, it takes a lot of time for the emergence repair team to access such places. Additionally, increase in electricity generation and transmission funds adequacy influences number of planned interruptions (mean of 3.93) implies that if there are adequate funds for electricity generation and transmission the number of planned interruptions would decrease and thus increase reliability of power supply

substations. Lastly increase in electricity generation and transmission funds adequacy influences number of blackouts experienced per household per month (mean of 3.65) and decrease in power transmission and distribution losses and costs influences number of blackouts experienced per household per month (mean of 3.65) implies that number of blackouts are influenced equally by increase in electricity generation and transmission funds and decrease in power transmission and distribution losses and costs. The economic implications that these two indicators have due to the blackouts that occur is high. Lack of electricity generation and transmission funds result to deficiency in power supplied while demand continues to be on the rise, the existing grid is overburdened and results to rampant blackouts hence influence the reliability of power supply substations poorly.

Power transmission and distribution losses are very costly since only a portion of the generated power is supplied to the customer. The losses of power during transmission and distribution result to an unrecoverable cost for the power utility companies. These losses in turn result to increased operation cost which affect reliability of power supply substations poorly. From the results that show power grid congestion had a mean of mean of 3.87, all the means of the indicators below this value can be considered outliers. The outliers in this case are assumed to be caused by biased parameter estimation in the indicator number of blackouts experienced per household per month and decrease in power transmission and distribution losses and costs influence in number of planned interruptions.

4.7 Energy Regulatory Authority Involvement and Reliability of Power Supply Substations.

To establish how operations of ERA directly influences the reliability of power supply substations, respondents were asked how different factors that relate to ERA influenced the reliability of power supply substations. The results are presented in Table 4.9

Table 4.9 Energy Regulatory Authority Involvement on the Reliability of Power Supply Substations

Statements	Mean	Std. Deviation
Increase in monitoring reports influence the number of blackouts experienced per household per month	3.51	0.68
Increase in monitoring reports influence the number of planned interruptions	3.64	0.79
Increase in monitoring reports influence the restoration time	4.29	0.77

Amount of funding influence the number of blackouts experienced per household per month	3.63	0.77
Amount of funding influence the number of planned interruptions	3.88	0.75
Amount of funding influence the restoration time	4.22	0.85
Increase in inter-agency collaboration policies influence the number of blackouts experienced per household per month	3.75	0.90
Increase in inter-agency collaboration policies influence the number of planned interruptions	3.90	0.69
Increase in inter-agency collaboration policies influence the restoration time	4.24	0.80
Mean of Mean	**3.90**	**0.78**

In response to the influence of ERA's involvement on the reliability of power supply substations (aggregated mean 3.90), respondents strongly agreed that increase in inter-agency collaboration policies had a significant influence on the reliability of power supply substations (mean 3.96). Secondly was amount of funds (mean 3.91) and lastly was increase in monitoring reports (mean 3.81). The implication of these findings is that inter-agency collaboration is very critical in improving reliability of power supply substations. Several agencies are involved in project implementation, operation and maintenance, provision and application of collaboration policy can prevent many disputes that occur due to misunderstandings. Misunderstandings are caused by application of different policies by different agencies simultaneously.

In addition to this, findings of this research also proved that increase in monitoring reports has a significant influence on the restoration time (mean 4.29), followed by the number of planned interruptions (mean 3.64), and finally on the number of blackouts experienced per household per month (mean 3.51). The implication of these findings is that monitoring reports influenced the restoration time of power since ERA doesn't have in place increase in monitoring reports schedules of power interruptions, the power utility company takes its time to restore power to the customer. By providing timely and continuous monitoring, restoration time can be improved hence reliability on power supply substations is improved also.

On the other hand, the results revealed that the amount of funding had a significant influence on the restoration time (mean 4.22), followed by the number planned interruptions (mean 3.88) and finally on the number of blackouts experienced per household per month (mean 3.63). These findings imply that if the power utility company is well funded for maintenance and repair works, restoration time would be reduced and subsequently reliability is improved.

The findings on inter-agency collaboration influence on number of blackouts experienced per household per month (mean 3.75), inter-agency collaboration influence on number planned interruptions (mean 3.90) and inter-agency collaboration influence on restoration time (mean 4.24). These findings imply that increase in inter-agency collaboration policies would go a long way in eliminating the red tape associated with government agencies, this would enhance collaboration for the improvement of services offered. Delays that result from excessive paper work between agencies would be reduced and maintenance procedures simplified hence restoration time would be reduced and permits for planned interruptions provided timely. From the results that show Energy Regulatory Authority involvement had a mean of mean of 3.90, all the means of the indicators below this value can be considered outliers. The outliers in this case are assumed to be caused by biased parameter estimation in the indicator number of blackouts experienced per household per month and increase in monitoring reports influence on number of planned interruptions.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, discussion, conclusions drawn and recommendations derived from the study, as well as areas for further research.

5.2 Summary of Findings

The study sought to find out the factors influencing the reliability of power supply substations in Kenya. A case of the Energy Sector Recovery Project in Kabete Sub-County. The questionnaires response rate was 79.39%. The response rate of the Kenya Power and Lighting Company was 80.4 %, that of Energy Regulatory Authority was 71.4 % and that of the Energy Regulatory Commission was 88.9 %. Respondents of this research were members of the energy sector, specifically those that are involved in the implementation, operation and maintenance of power supply substations in Kabete Sub-County. On designation of respondents; 38.93 % of the respondents were Engineers, 15.27 % of respondents were Regional Operators, 13.74 % of the respondents were Administrators, 12.21 % of the respondents were Customer Service Officers, 10.69 % of the respondents were Procurement Officers, 2.3 % of the respondents were Sales Officers, 1.53 % of the respondents were Marketers, Quality Managers, Quality Officers and Researchers additionally 0.76 % of respondents were Marketing Manager, Personal Assistant, Quality Analyst and Quality Officer. On length of service; 38.17 % of the respondents had worked in their respective organizations for a period of 4 to 6 years, 28.24 % has worked for their respective organizations for a period of between 6 to 10 years, whereas 17.56 % of the respondents had worked for their respective organizations for a period of between 1 to 3 years and additionally 16 % of the respondents had worked for their respective organizations for a period of over 11 years. Data analysis and interpretation of responses from respondents revealed the following major findings:

5.2.1 Electricity Consumption and Reliability of Power Supply Project

It was revealed that the increased consumption of electricity has a significant influence on the reliability of power supply substations (aggregate mean 3.83). Among the factors that were under study, availability of alternative energy sources had the most significant influence on the reliability of power supply substations (mean 3.93). Although this factor affects the number of blackouts that are experienced per household per month (mean 3.60), the most significant influence was on the amount of the restoration time (mean 4.22) followed by the number of planned interruption (mean 3.96). Additionally, findings of the research showed that the capacity and demand trends also had a significant influence on the reliability of power reliability substations (aggregate mean 3.88). The research findings proved that there is a direct link between the increase in capacity and demand (reserve margin) trends on the number of blackouts that are experienced per household per month (mean 3.65), the number of planned interruptions (mean 3.81) and on the restoration time (mean 4.18). Further, findings of this study proved that increase in population migration and congestion also had a significant influence on the reliability of power supply substations with an (aggregate mean 3.81). Among the factors that were under study in this, the population and migration trends had the most significant influence on the restoration time (mean 4.03). Although the influence on restoration time is significant, the case is a little bit different with its influence on the number of planned interruptions (mean 3.96) and the number of blackouts experienced per household per month (mean 3.43).

5.2.2 Energy Sector Regulations and Reliability of Power Supply Substations

From the findings, it was revealed that energy sector regulation had influence on the reliability of power supply substations (mean 3.78). Respondents agreed that Number of existing energy laws, number of end-user tariffs and increase in liberalized organizations in electricity sub-sector significantly influence the reliability of power supply substations. Among factor that were under energy sector regulation, research findings proved that Number of existing energy laws (mean 3.79) and number of end-user tariffs (mean 3.79) had the most significant influence on the reliability of power supply substations. Liberalization of the electricity sub-sector (mean 3.75) was third. Number of existing energy laws influences the number of blackouts experienced per household per month (mean 3.55); nature of existing laws influences the number of planned interruptions (mean 3.69) and nature of existing laws influences the restoration time (mean 4.13).

In additional findings, increase in liberalized organizations in electricity sub-sector influence on the restoration time (mean of 3.92), increase in liberalized organizations in electricity sub-sector influences number of planned power interruptions (mean of 3.83) and increase in liberalized organizations in electricity sub-sector influences number of blackouts experienced per household per month (mean of 3.49). The findings on number of end-user tariffs influences on number of blackouts experienced per household per month (mean of 3.48), number of end-user tariffs influences on number of planned interruptions (mean of 3.83) and number of end-user tariffs influences on the restoration time (mean 4.07). Additionally, finding of this research study revealed that on average all the factors that were under study have a significant influence on the reliability of power supply substations. However, it is worth noting that, the number of the existing laws and the government's energy policy had the most significant influence on the reliability of power supply substations.

5.2.3 Power Grid Congestion and Reliability of Power Supply Substations

Research findings of this research revealed that power grid congestion significantly influences the reliability of power supply substations (mean 3.87). Among the factors which were under study, decrease in power transmission and distribution losses and costs had the most significant influence on the reliability of power supply substations (mean 3.93), followed by increase in electricity generation and transmission funds adequacy (mean 3.88), and finally increase in system infrastructure and operational performance (mean 3.79). Further, the results also proved that increase in system infrastructure and operational performance had a significant influence on the restoration time (mean 4.02), increase in electricity generation and transmission funds adequacy also has a significant influence on the restoration time (mean 4.06) and decrease in power transmission and distribution losses and costs influences restoration time (mean 4.31). On the other hand, from the results, it was revealed that increase in electricity generation and transmission funds adequacy had an influence on the number of planed interruptions (mean 3.93), increase in system infrastructure and operational performance influences number of planned interruptions (mean 3.88) and Decrease in power transmission and distribution losses and costs influences number of planned interruptions (mean 3.84). Additional results show increase in system infrastructure and operational performance influences number of blackouts experienced per household per month (mean 3.48), increase in electricity generation and transmission funds adequacy influences number of blackouts experienced per household per month (mean 3.65) and decrease in power transmission and distribution losses and costs influences number of

blackouts experienced per household per month (mean 3.65). Further, from the studies, it was revealed that the decrease in power transmission and distribution losses and costs significantly influenced the reliability of power supply substations. This was followed by the increase in adequacy of electricity generation and transmission funds and increase in system infrastructure and operational performance.

5.2.4 Energy Regulatory Authority Involvement and Reliability of Power Supply Substations

In response to the influence of ERA's involvement on the reliability of power supply substations (aggregated mean 3.90), respondents strongly agreed that increase in inter-agency collaboration policies had a significant influence on the reliability of power supply substations (mean 3.96). Secondly was amount of funds (mean 3.91) and lastly was increase in monitoring reports (mean 3.81). In addition to this, findings of this research also proved that increase in monitoring reports has a significant influence on the restoration time (mean 4.29), followed by the number of planned interruptions (mean 3.64), and finally on the number of blackouts experienced per household per month (mean 3.51). On the other hand, the results revealed that the amount of funding had a significant influence on the restoration time (mean 4.22), followed by the number planned interruptions (mean 3.88) and finally on the number of blackouts experienced per household per month (mean 3.63). The findings on inter-agency collaboration influence on number of blackouts experienced per household per month (mean 3.75), inter-agency collaboration influence on number planned interruptions (mean 3.90) and inter-agency collaboration influence on restoration time (mean 4.24). The findings on inter-agency collaboration influence on number of blackouts experienced per household per month (mean 3.75), inter-agency collaboration influence on number planned interruptions (mean 3.90) and inter-agency collaboration influence on restoration time (mean 4.24). Although respondents agreed that ERA's involvement has a significant influence on the reliability of power supply substations, research findings revealed that the level to which different factors influenced the reliability of power supply substations varies. Among the factors that were under study, increase in inter-agency collaboration policies had the most significant influence on the reliability of power supply substations and increase in monitoring reports had the least influence.

Table 5.1 Summary of Key Findings

Research Objective	Indicator	Mean	Average Mean	Composite Standard Deviation
To establish the influence of electricity consumption on the reliability of power supply substations.	-Number of alternative sources of energy	3.93	3.83	0.81
	-Increase in capacity and demand (reserve margin) trends	3.88		
	Number of new electricity connections	3.71		
	-Increase in population migration and congestion	3.81		
To assess the influence of energy sector regulations on the reliability of power supply substations.	-Number of existing energy laws	3.79	3.78	0.78
	-Number of end-user tariffs	3.79		
	-Increase in liberalized organizations in electricity sub-sector	3.74		
To determine the influence of power grid congestion on the reliability of power supply substations.	-Increased power system infrastructure, utility financial and operational performance	3.79	3.87	0.85
	-Increase in electricity generation and transmission funds adequacy	3.88		
	-Decrease in power transmission and distribution losses and costs	3.93		
To establish the influence of the Energy Regulatory Authority's involvement on the reliability of power supply substations	-Increase in monitoring reports	3.81	3.9	0.78
	-Amount of funding	3.91		
	-Increase in inter-agency collaboration policies	3.96		

5.3 Discussion

This section of the report discusses the findings and compares them with literature reviewed in chapter two.

5.3.1 Electricity Consumption and the Reliability of Power Supply Substations

From the research findings, it was proved that the electricity consumption has a significant influence on the reliability of power supply substations. Among the factors that were under study, it was proved that the number of alternative sources of energy had the most significant

influence. This can be attributed to the fact that although the supply of electricity is a complex system that integrates the economic, technical, social and financial institutions, the number of alternative sources of energy can have a great effect on the reliability of power supply more so when electricity is the primary source of energy in a home. It is worth noting the dynamics may be different in home that do not depend on electricity as their primary source of energy, because even during periods of blackouts such homes cannot feel the pinch of a blackout as they will already have an alternative source of energy. Additionally, the probability of less power blackouts occurring in areas where electricity is not the primary source of energy is less, as the likelihood of transformer overloads and power surges is low; hence, such areas are likely to have an above average power reliability index.

Further, findings of these study proved that increase in capacity and demand (reserve margin) trends and population and migration trends have also a significant influence on the reliability of power supply substations. This is very practical in most localities, because with congestion comes a higher number of new electricity connections and if that demand cannot be supported by the available infrastructure, then the probability of such areas having a low reliability index due to power outages are is high. Findings of this research were in agreement with a research that was conducted by Ku Leuven Energy Institute (2014) in Belgium where it was proved that as more people sought more connections, the number of blackouts increased as the available infrastructure could not support the ever-increasing number of new electricity connections. Findings of this research also concurred with Xiao and Xue (2013) research findings which proved that most of the problems that are facing the Indian power system is because of congestion in some areas, more so informal settlements.

On the other hand, this research agreed with another research that was conducted by the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability, 2013 which proved that as the weather pattern changes, there is an increase in the number of new electricity connections and this causes an increase in power outages; hence a low reliability index. Research findings of this research were also in agreement with Hossain (2015) research findings that if the current effort to adopt the use of alternative sources of energy specifically renewable energy is adopted by global nations, then by 2050, more than 80% of the world electricity needs will be catered for by renewable sources of energy, leading to a high-power reliability index.

5.3.2 Energy Sector Regulation and Reliability of Power Supply Substations

Findings of this research revealed that the nature of existing energy, number of end-user tariffs have a significant influence on the reliability of power supply substations. Since the adoption of the Energy Act in 2006, there has been numerous development in the energy sector as this has significantly boosted the expansion and adoption of not only clean sources of energy but also new sources of energy. Further, the adoption of the new constitution in 2010 that necessitated the review of the energy sector policy and legal framework boosted the expansion of the energy production, transmission and distribution. Although this is the case, it is worth noting that adoption of these policies has not significantly promoted the reliability of power supply substations as most are geared towards expanding the energy sector. As a result, there is need for the government to enact and implement policies that are specifically geared towards improving the reliability of power supply in Kenya.

Findings of this research agree with Barnes et al., (2005) research in Costa Rica which found that Costa Rica had been able to improve its power supply substations capacity and overall reliability index due to practical power supply substations policies and energy laws. Findings of this research study were also in agreement with Cecelski et al., (2006) research in Bangladesh where is was proved that although this county was still struggling with low power reliability standards, the implementation of policies that were specifically targeting improving of the power reliability index has greatly improved the growth of the energy sector. Additionally, findings of this research agreed with Kemausuor et al., (2009) in Ghana which proved that that over time Ghana has been able to achieve a good power reliability index due to adoption of regulations and policies that are geared towards promoting a functional energy sector. On the other hand, findings of this research study agreed with Bekker et., al., (2008) research in South Africa, which proved that because of good fiscal, energy and monetary policy, South Africa has made numerous strides towards promoting power reliability to its people.

5.3.3 Power Grid Congestion and Reliability of Power Supply Substations

From the research findings, it was revealed decrease in power transmission and distribution losses and costs is one of the factors that significantly influences the reliability of power supply substations. Further, it was revealed that electricity generation and transmission funds and power system infrastructure, utility financial and operational performance also

significantly influence the reliability of such substations. As a result, unless decrease in power transmission and distribution losses and costs are tamed, then the probability of any power project having a god reliability index is low. This is likely to be the case, because such losses can be very closely more so when more power is generated but very little reach the designated destination. Lack of funds can also significantly hinder the improvement of the reliability index as the expansion of a distribution network can be a very costly venture. The expansion of production and distribution networks require not only purchase of high-voltage lines, secondary distribution transformers, single and three-phase low-voltage lines, and drop-down lines for last-mile connections, but also other numerous costs that are sometimes lack of funds, leading to power congestion and eventually a low reliability index.

Findings of this research agreed with Amoako-Tuffour and Esi Eshun (2015) research in Ghana which proved that most government owned energy entities operated on high long-run marginal costs and most were unable to procure more funds for maintaining and expanding their operations. Because of these, most organizations that were mandated with the generation, transmission and distribution of electricity had inadequate investment in infrastructure; hence, the low power reliability index that was experienced in some localities in this nation. In addition, findings of this research agreed with Zhu et al., (2015) research findings that most of the currently operational hydroelectric stations and sub-stations have very high capital and maintenance costs, something that depletes all the revenues got. Because of this, most organizations lack funds to expand their generating and expansion activities to meet the increasing ‘demand for power leading to low power supply reliability in most localities.

Further, findings of this research agreed with Alcott et al., (2014) research in India where it was found that overuse of the power from the government grid that was caused by lack of funds to expand electricity lines was one of the primary reasons that had led to numerous both planned and unplanned power outages and numerous disputes. On the other hand, findings of this research also agreed with Amadi (2015) in South Africa where it was proved that among other factors, severe power generation, transmission and distribution shortfalls were the primary causes of the outages that were experienced in Port Harcourt; hence, the low power reliability index experienced in this region.

5.3.4 Energy Regulatory Authority Involvement and Reliability of Power Supply Substations

From the research findings, it was revealed increase in inter-agency collaboration policies on power production, transmission and distribution has the most significant influence on the reliability of power supply substations. Additionally, it was proved that the amount of funding and increase in monitoring reports of power supply substations can also have a significant influence on the reliability of these substations. Since the inception of the Energy Regulatory Authority in 2000 to regulate, license, distribute, monitor and sale electricity, there has been numerous advancements in the energy sector, more so in the production, supply and distribution of electricity. Although this is the case, still the problem of power outages that has led to a low power reliability is a menace. This has been the case, because as research show most efforts of ERA have been directed towards expanding distribution channels rather than both production and distribution. This should be the case because power sector reforms are normally supposed to ensure that there is stability of electricity production, transmission and supply.

Findings of this research agreed with Ministry of Planning and National Development research findings in 2006 which proved that the inadequacy of inter-agency collaboration policies on reinforcing and upgrading electricity supply systems is one of the primary factors that have hindered the achievement of the required power reliability index. Findings of this research were also in agreement with Nigeria, Price Waterhouse Coopers (2016) research findings that proved that lack of enough money to expand the energy supply lines was one of the primary causes of the low power reliability index. Further, findings of this research agreed with Zhang and Kumar (2011) research where it was found that the financial viability of the funding is a must for power reliability to be achieved because enough funding is required at all levels of power supply substations.

5.4 Conclusions

The first objective of this research study sought to establish how electricity consumption influences the reliability of power supply substations in Kabete Sub-County. It was found that among the factors that were under study under the electricity consumption (aggregated mean 3.83), the number of alternative sources of energy had the most significant influence (mean 3.93) followed by increase in capacity and demand (reserve margin) trends (mean 3.88) and

finally the number of new electricity connections (mean 3.71). It is therefore concluded that the electricity consumption has a significant influence on the reliability of power supply substations.

The second objective of the study was to assess how energy sector regulations influence reliability of power supply substations. From this it was found that Number of existing energy laws had a significant influence on the reliability of power supply substations (aggregate mean 3.78). Among the factors that were under study under the energy sector regulation the existing energy laws and number of end-user tariffs had the most significant influence on the reliability of power supply substations, closely followed by liberalization of the electricity sub-sector. It is therefore concluded that the energy sector regulations have significant influence on the reliability of power supply substations.

The third objective of this study was to determine the influence of power grid congestion on the reliability of power supply substations. The research findings revealed that decrease in power transmission and distribution losses and costs significantly influences the reliability of power supply substations (mean 3.93), followed by electricity generation and transmission funds (mean 3.88), and finally power system infrastructure, utility financial and operational performance (mean 3.79). Therefore, with an (aggregate mean 3.87), it can be concluded that power grid congestion has a significant influence on the reliability of power supply substations.

The fourth objective sought to establish the extent to which Energy Regulatory Authority's involvement influences reliability of power supply substations. From the findings, it was proved that the involvement of the Energy Regulatory Authority has a significant influence on the reliability of power supply substations. Among the factors that were under study, increase in inter-agency collaboration policies showed to have the most significant influence (mean 3.96), followed by the amount of funding (mean 3.91) and finally ERA's increase in monitoring reports (mean 3.81). Thus, with an (aggregate mean 3.90), it can be concluded that the involvement of ERA has a significant influence on the reliability of power supply substations.

5.5 Recommendations

1. From the electricity consumption influences the reliability of power supply substations in Kabete Sub-County, with aggregate mean of 3.83, respondents agreed that the

number of new electricity connections, number of alternative sources of energy, capacity and demand (reserve margin) trend and increase in population migration and congestion had a significant influence on the reliability of power supply substations. It is therefore recommended that there is need for the government through the concerned bodies to make sure that there are ways of improving the current quantity of electricity that is generated and supplied to meet the ever-increasing demand. Additionally, there is need for the concerned governmental agencies in partnership with any private entities to encourage people to adopt the use of alternative sources of energy, as this is the way that overdependence on electricity can be reduced; hence, promote the reliability of power supply substations. For areas with large populations, it is important for proper apportioning of electricity to be done to these areas, to limit overloads that can lead to power outages.

2. The influence of the energy sector regulation on the reliability of power supply substations. From the research findings, it was revealed that with an aggregate mean of 3.78, respondents agreed that the energy sector regulation significantly influences the reliability of power supply substations. Considering this, it is important for the government through the concerned bodies to adopt regulations and policies that are geared towards promoting a functional energy sector. This involves the formulation and implementation of number of end-user tariffs and energy laws which will promote the adoption of proper practices in the production, transmission, funding and usage of the available electricity.

3. From the influence of the power grid congestion on the reliability of power supply substations, it was found that increase in system infrastructure and operational performance, increase in electricity generation and transmission funds adequacy and power transmission and distribution loses and costs significantly influences the reliability of power supply substations. Due to this, it is therefore recommended that to ensure that the reliability of power supply substations is improved hence less power outages, there is need for Kenya Power and Lighting Company to ensure that the required systems and infrastructure in place to ensure that all the generated power reaches its designated destinations. With this in place, power transmission losses and costs will be minimized; hence, a good power reliability index. Additionally, to ensure that all this happens, it is important for the government to allocate enough

funds to ERA and KPLC because in special cases the process of generating, transmitting and distributing electricity is a very costly venture due to the remoteness of some areas that are inaccessible.

4. The influence of the Energy Regulatory Authority involvement on the reliability of power supply substations. It was found that increase in monitoring reports (mean 3.81), amount of funding (mean 3.91), and increase in inter-agency collaboration policies (mean 3.96) have a significant influence on the reliability of power reliability substations. It is therefore recommended that there is need for both governmental and non-governmental bodies that are involved in the electrification substations to try and empower societies by giving incentives and subsidies to communities in an endeavor to promote the use of clean sources of energy and lessen the overdependence on electricity through proper policies. Additionally, there is need for such organizations to provide enough support towards electrification substations, because without this the likelihood of most substations stalling is high; this can cause congestion and burdening of the available infrastructure hence a low power reliability index. Promoting increase in inter-agency collaboration policies would go a long way in eliminating the red tape associated with government agencies, this would enhance collaboration thus improvement in services offered.

5.6 Suggestions for Further Research

1. The scope of this study was limited to Kabete Sub-County. To get the true picture of the situation in the country, there is need for similar studies to be extended to other localities for concrete conclusions to be made.

2. From this research study, it was found that decrease in power transmission and distribution losses and costs influences restoration time hence the reliability of power supply substations. As a result, to get the true picture of how this factors generally affects the reliability of power supply substations, there is need for a study to be done to ascertain the influence of decrease in power transmission and distribution losses and costs on the reliability of power supply substations.

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APPENDICES

Appendix 1: Introductory Letter

Teresia Wanjiru
P.O Box 33944-00600,
Nairobi, Kenya
Mobile: 0725272546
Email: terryshe@rocketmail.com

To whom it may concern,

Ref: Data Collection

I am a student at the University of Nairobi taking a degree in Master of Arts in Project Planning and Management. As part of the requirements of the course, I am required to carry out an independent research; hence, I am currently undertaking a research study on "Factors influencing the reliability of power supply substations: A case of the Energy Sector Recovery Project in Kabete Sub-County, Kenya''. The study seeks to examine factors influencing the reliability of power supply substations in Kenya; namely electricity consumption, energy sector regulation, power grid congestion, and Energy Regulatory Authority involvement.

To enable me to successfully carry out the study, a questionnaire is provided to facilitate data collection, which will be the major basis of findings of this research. Your participation in this exercise will be very helpful to the researcher in carrying out the study to its successful conclusion. The study aims to shed more light on this area of research by contributing to the already existing knowledge on factors influencing the reliability of power supply substations.

Thank you in advance for your contribution.

Yours faithfully,
Teresia Wanjiru.

Appendix 2: Research Questionnaire

This questionnaire is divided into two sections. Section A will be used to obtain general information about the respondent. Section B will be used to generate information on factors influencing the reliability of power supply substations in Kenya.

NB: The information obtained will be strictly treated in confidence and nothing you say will be used against you. Your assistance in completing this questionnaire will be highly appreciated.

Kindly respond to the following questions by ticking on the appropriate box [√] or filling in the answer in the blank spaces.

SECTION A: RESPONDENT'S PROFILE

Please indicate our name and name of your organization below:

1. Name (Optional)……
2. Organization……

3. Which department do you work in?.....

[Please tick appropriately]

4. How long have you been with the organization?
    a) Less than 1 year [ ]
    b) 1-3 Years [ ]
    c) 4-6 years [ ]
    d) 6 - 10 years [ ]
    e) Over 11 years [ ]
5. What is your designation in the department?. …….

SECTION B: FACTORS INFLUENCING RELIABILITY OF POWER SUPPLY SUBSTATIONS IN KENYA

Various factors such as electricity consumption, energy sector regulation, power grid congestion and Energy Regulatory Authority's involvement are reported to influence the reliability of power supply substations in Kenya.

On a scale of 1-5, where 1 represents (Strongly Disagree), 2 (Disagree), 3 (Neutral), 4 (Agree) and 5 (Strongly Agree)

Please indicate by ticking appropriately how the following factors influence the reliability of power supply substations in Kenya

	Variables	**Scale**				
6.0	**Electricity consumption**	**1 SD**	**2 D**	**3 N**	**4 A**	**5 SA**
6.1	Number of new electricity connections influences the number of blackouts experienced per household per month					
6.2	Number of new electricity connections influences the number of planned interruptions					
6.3	Number of new electricity connections influences the restoration time					
6.4	Increase in capacity and demand trends influences the number of blackouts experienced per household per month					
6.5	Increase in capacity and demand influences the number of planned interruptions					
6.6	Increase in capacity and demand trends influences the restoration time					
6.7	Increase in population migration and congestion influences the number of blackouts experienced per household per month					
6.8	Increase in population migration and congestion influences the number of planned interruptions					
6.9	Increase in population migration and congestion influences the restoration time					
6.10	Number of alternative sources of energy influences the number of blackouts experienced per household per month					
6.11	Number of alternative sources of energy influences the					

	number of planned interruptions					
6.12	Number of alternative sources of energy influences the restoration time					
7.0	**Energy Sector Regulation**	**1 SD**	**2 D**	**3 N**	**4 A**	**5 SA**
7.1	Number of existing energy laws influence the number of blackouts experienced per household per month					
7.2	Number of existing energy laws influences the number of planned interruptions					
7.3	Number of existing energy laws influences the restoration time					
7.4	Number of end-user tariffs influences the number of blackouts experienced per household per month					
7.5	Number of end-user tariffs influences the number of planned interruptions					
7.6	Number of end-user tariffs influences the restoration time					
7.7	Increase in liberalized organizations in electricity sub-sector influences the number of blackouts experienced per household per month					
7.8	Increase in liberalized organizations in electricity sub-sector influences the number of planned interruptions					
7.9	Increase in liberalized organizations in electricity sub-sector influences the restoration time					
8.0	**Power grid congestion**	**1 SD**	**2 D**	**3 N**	**4 A**	**5 SA**
8.1	Increased system infrastructure and operational performance influences the number of blackouts experienced per household per month					
8.2	Increased system infrastructure and operational performance influences the number of planned interruptions					
8.3	Increased system infrastructure and operational performance influences the restoration time					
8.4	Increase in electricity generation and transmission funds adequacy influences the number of blackouts experienced per household per month					
8.5	Increase in electricity generation and transmission funds adequacy influences the number of planned interruptions					
8.6	Increase in electricity generation and transmission funds adequacy influences the restoration time					
8.7	Decrease in power transmission and distribution losses and costs influences the number of blackouts experienced per household per month					

8.8	Decrease in power transmission and distribution losses and costs influences the number of planned interruptions					
8.9	Decrease in power transmission and distribution losses and costs influences the restoration time					
9.0	**Energy Regulatory Authority involvement**	**1 SD**	**2 D**	**3 N**	**4 A**	**5 SA**
9.1	Increase in monitoring reports influences the number of blackouts experienced per household per month					
9.2	Increase in monitoring reports influences the number of planned interruptions					
9.3	Increase in monitoring reports influences the restoration time					
9.4	Amount of funding influences the number of blackouts experienced per household per month					
9.5	Amount of funding influences the number of planned interruptions					
9.6	Amount of funding influences the restoration time					
9.7	Increase in inter-agency collaboration policies influence the number of blackouts experienced per household per month					
9.8	Increase in inter-agency collaboration policies influence the number of planned interruptions					
9.9	Increase in inter-agency collaboration policies influence the restoration time					

Appendix 3: Krejcie and Morgan Table of 1970

Table 3.1

Table for Determining Sample Size of a Known Population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*

Appendix 4: Letter of Authorization from the University of Nairobi

UNIVERSITY OF NAIROBI
COLLEGE OF EDUCATION AND EXTERNAL STUDIES
SCHOOL OF CONTINUING AND DISTANCE EDUCATION
DEPARTMENT OF EXTRA-MURAL STUDIES
NAIROBI EXTRA-MURAL CENTRE

Your Ref:

Our Ref:

Telephone: 318262 Ext. 120

Main Campus
Gandhi Wing, Ground Floor
P.O. Box 30197
N A I R O B I

11th April, 2017

REF: UON/CEES/NEMC/25/370

TO WHOM IT MAY CONCERN

RE: TERESIA WANJIRU THUKU - REG NO L50/78091/2015

This is to confirm that the above named is a student at the University of Nairobi College of Education and External Studies, School of Continuing and Distance Education, Department of Extra- Mural Studies pursuing Masters of Art in Project Planning and Management.

She is proceeding for research entitled **"factors influencing the reliability of power supply projects in Kenya."** A Case of the Energy Sector Recovery Projects in Kabete Sub- County, Kenya.

Any assistance given to her will be highly appreciated.

UNIVERSITY OF NAIROBI CEES P.O. Box 30197 12 APR 2017 NAIROBI NAIROBI EXTRA MURAL CENTRE

CAREN AWILLY
CENTRE ORGANIZER
NAIROBI EXTRA-MURAL CENTRE

Appendix 5: Research Permit from NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349,3310571,2219420
Fax: +254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/17/35684/16805**

Date: **8th May, 2017**

Teresia Wanjiru Thuku
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Factors influencing the reliability of power supply projects in Kenya: A case of the energy sector recovery project in Kabete Sub-County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Kiambu County** for the period ending **5th May, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Kiambu County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kiambu County.

The County Director of Education
Kiambu County.

THIS IS TO CERTIFY THAT:
MISS. TERESIA WANJIRU THUKU
of UNIVERSITY OF NAIROBI, 0-600
nairobi,has been permitted to conduct
research in *Kiambu County*

on the topic: *FACTORS INFLUENCING THE RELIABILITY OF POWER SUPPLY PROJECTS IN KENYA: A CASE OF THE ENERGY SECTOR RECOVERY PROJECT IN KABETE SUB-COUNTY, KENYA*

for the period ending:
5th May,2018

Permit No : NACOSTI/P/17/35684/16805
Date Of Issue : 8th May,2017
Fee Recieved :Ksh 1000

.....
Applicant's Signature

.....
Director General
National Commission for Science, Technology & Innovation