THE UNIVERSITY OF NAIROBI

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

ASSESSMENT OF THE ENERGY EFFICIENCY PROGRAMMES WITHIN THE INTERNAL OPERATIONS OF NAIROBI CITY COUNTY GOVERNMENT ,A CASE STUDY OF CBD REGION.

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A Project Report Submitted, in Partial Fulfillment for the Award of Degree of Master of Science in Energy Management at the Department of Mechanical and Manufacturing Engineering,

The University of Nairobi.

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I declare that this work has not been previously submitted, and approved for the award of degree by this or any other University. To the best of my knowledge and belief, this research report has no material previously written or published by another person, except where due reference is made in this report.

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ABSTRACT

Name : Audrey Obwanda

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Topic: Assessment of The Energy Efficiency Programmes Within The Internal Operations of Nairobi City County Governemt ,a Case Study of CBD Region.

This study carried out an assessment of the Energy Efficiency programs within the internal operations of Nairobi City County Government (NCCG) .In carrying out this determination, this research conducted an energy audit of the specified internal operations, identified the Energy Efficiency programs that are in place within the operations of the NCCG, assessed the success rate of these Energy Efficiency programs, and finally developed an implementation model for Energy Efficiency programs for the internal operations of Nairobi County Government . These facets constituted the objectives of the study. This research was informed by the need for improved energy sustainability within the public sector as envisioned in the national government's energy policy that seeks to optimize energy use and explore alternative energy sources that are sustainable. To achieve the research objectives, this study adopted a mixed-method research design in which qualitative and quantitative data analysis was employed. A case study approach was used to focus this research on street lighting, traffic lighting, and building facility services within the Nairobi CBD region. The results of this study indicated that there have been EEPs that that have been instituted by NCCG and that these measures have led to a 32% decrees in energy consumption in city hall complex between the years of 2016 and 2018 with the EEPs including replacement of luminaires with more energy efficient options.For the streetlighting,184 lamps have been replaced with LED options translating to 4% conversion rate with some not operational due to faults and vandalism.Finally traffic lighting has a 65% LED conversion rate with incandescent lamps being 14,833 in 2016 and down to 9,754.The economic analysis shows that the EEPs implemented are able to derive economic value to the NCCG within a medium term plan.Various Barriers to implementation has also been highlighted which should be put into consideration during EEPs planning inorder to mitigate future bottlenecks .The business model developed allows departments to follow a standardised process in setting energy targets, implementing energy efficiency measures and tracking financial, environmental and energy savings.

Keywords:Assessement,Energy Efficiency,Sustainability,Energy Audit , Programmes, Internal Operations,Nairobi City County Goverment.

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LIST OF ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank
CEIC	Census and Economic Centre
EE	Energy Efficiency
EEP	Energy Efficiency Programme
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KAM	Kenya Association of Manufacturers
KPLC	Kenya Power and Lighting Company
NCCG	Nairobi City County Government
NCCRC	National Climate Change Resource Centre
SPSS	Statistical Package for the Social Sciences
UNDP	United Nations Development Programme

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CHAPTER ONE

INTRODUCTION

1.1 Background

Energy is broadly defined as the ability to cause physiological change, while power is the rate at which energy is transferred. Energy is a time measure. Energy exists in many forms in which it can be transformed from one form to another. Examples of these forms are kinetic (motion), potential, chemical, electrical (charge), mechanical and thermal. Therefore there exists a mired of sources of energy (Koronen, Åhman & Nilsson, 2020).

Classical Science theorizes that energy cannot be created or destroyed and that it can only undergo conversion or the transformation to different forms by an equipment or an appliance. In such a conversion, there are some aspects of the energy that are transferred to a useful form by the device, such as bulbs transferring energy to light, while others are wasted in the process, such as the heat that is generated by the light bulb (Kosky et al., 2013). How prudent energy is utilized is referred to as efficiency. Efficiency is considered in two parts:

1.1.1 Power Efficiency

Power efficiency determines how well power transfer occurs between input points and output points of a power system. This metric considers measurements at instants of the power system and is mathematically formulated as shown (Barron & Torero, 2017)

$$\eta_P = \frac{P_{output}}{P_{Input}} * 100\% \tag{1.1}$$

1.1.2 Energy Efficiency (EE)

Energy Efficiency is computed over a period of time. It is viewed as the ratio between useful input and output of the energy conversion process. It can be presented as a percentage or as a decimal (Barron & Torero, 2017).

This is mathematically expressed as follows. (Alcot et al., 2016)

$$\eta_E = \frac{P_{output}*t}{P_{Input}*t} * 100\% = \frac{E_{output}}{E_{Input}} * 100\% \quad (1.2)$$

Where *t* is a time expression

In practical terms, EE refers to the use of less energy in the production of a similar level of useful output or service (Cassidy, 2014). EE is applied in various aspects as an indication of energy-saving efforts such as reduction in the consumption of energy by using low energy services such as heating less so that energy is saved for future use. The two concepts are ocassionaly used together since efficient use of energy leads to energy conservation (Gadonneix et al., 2010; Chung et al., 2006; Mastelic et al., 2014). Thus, EE leads to energy conservation.

For example, EE is achieved through appliance change such as having energy efficient versions of the appliances such as fridges or having the traditional incandescent bulbs replaced by the Light Emitting Diode (LED), among others that use less energy (Goswami & Kreith, 2007). Furthermore, EE measures like the installation of double glazing, loft spaces, and insulating cavity walls have been found to enhance the efficiency of the heating process by lowering the energy required for heating purposes (Cassidy, 2014). This implies that, the EE-based appliances have been designed to ensure little energy consumption hence reduction in energy waste.

EE is viewed as important for reliable, safe, sustainable, and affordable energy use for the future. It is also considered as one of the ways that are less costly and quick when handling energy security, economic and environmental challenges (IEA, 2014a). EE is key within the modern society.EE attracts strong interest because of its role in the global economy, sustainable environment, and improving personal finance.

Globally, there are challenges that are faced by the governments in the management of climate change and the associated impacts. The realization of sustainable climate by most countries is based on the application of efficient energy uses, and this is due to the application of safe, clean, and affordable energy that is offered to the people. Energy Efficiency is based on the availability of energy in a secure manner and at the same time ensuring effective climate change (Nations & Griggs, 2015).

Cities that are found within the developing states are facing rapid urbanization. According to the United Nations, by 2050, the urbanization rate within Africa will rise by about 21% and 52% rise within Asia. Currently, nearly 50% of the global population is found within urban areas, this has contributed immensely to 75% of the greenhouse gas emission that is linked to the consumption of energy (Nations & Griggs, 2015).

In other words, cities are key players to the national government's target of meeting the energy needs that a country has and also through coming up with measures that aim to attain Energy Efficiency goals. Energy Efficiency is therefore a decentralized activity, requiring cities and the governments that oversee them to devise methods, laws, and measures that are critical in ensuring that citizens and other stakeholders within the city make optimal use of energy (Mahomed, 2016).

1.1.3 Global Perspectives

There are various terms linked to EE that requires definition. EE has been defined as the input energy ratio required and the service output produced (Proskuryakova & Kovalev, 2015). The definition has been supported by various scholars like Pérez-lombard et al. (2013) and Oikonomou et al. (2009). On the other hand, the World Energy Council (2008) has defined EE as a reduction in energy input for a needed output energy required to complete a task,thus,the current study is based on the energy definition that has been developed by World Energy Council (2008) as it accurately captures the definition of EE .

Energy intensity is a terminology that is used within EE. It means a reduction in the input energy required to deliver a single unit of GDP (Fleiter et al., 2012). Energy saving has been defined as the achieved reduced energy consumption (Pérez-lombard et al., 2013). Energy conservation has been defined as the usage of required energy in line with the work needed, and in some cases, it has been referred to as Energy Efficiency (Oikonomou et al., 2009). Energy performance is considered as the system's functioning quality in relation to energy use (Pérez-Lombard et al., 2013). Green procurement, on the other hand, is defined as the type of procurement aimed at maximizing benefits with minimal environmental harzads thus enhancing the sustainability of the environment through its application within the procurement process (Testa, Annunziata, Iraldo & Frey, 2016).

Global concerns about energy security and climate change have indicated that there is need to have specified interventions in relation to the future climate and energy needs. EE is among the interventions. EE can be implemented quickly, and it is effective through reducing carbon emission and energy use and also environmental improvement (IPCC, 2015).

Energy Efficiency improvements are key within utilities and countries in terms of improving performance without increasing their energy use. The reduced energy use is critical in making sure that there is constant investment within the electricity sector, which would have been expensive more so within developing countries, which would have affected the overall growth (Sebitosi, 2008). The World Energy Council (2013) stresses that the public sector, and more so when it comes to local authorities, have been able to support the adoption of EE through the establishment of Energy Services Companies (ESCO's).

Additionally, the local authorities have been able to enhance the marketing of efficient services and goods based on the procurement process and the purchasing power that they have. (World Energy Council, 2013).

Studies that have been done by World Energy Council (2013), International Energy Agency (2014), and Intergovernmental Panel on Climate Change (2015) regarding policy framework have not been able to illustrate or explain the reasons why there is need for institutional framework to be adopted by the local governments to make sure that EEs as well as policies touching on renewable energy exist. Voigt et al. (2014), in their study in forty countries regarding energy intensity, noted that technology is critical in catalysing growth and more so within the energy sector thus making EE dependent on technological innovations. Additionally, energy intensity globally has been realized through the innovations that have been done using technology (IEA, 2013; Voigt et al., 2014). One major challenge of the study is that it did not explain the reason why many countries are keen on enhancing EE through the adoption of technology. Also, the study did not explain why governments have policies towards EE in terms of the structural change and how it would create better energy intensity outputs (Voigt et al., 2014).

Boza-Kiss et al. (2013) conducted a study that focused on EE within buildings. The study identified various global policy trends that could be employed within the global arena to enhance EE within buildings. The study findings confirmed and concurred with the findings of Scholmann et al. (2012) and WEC (2008) that indicated that the regulatory policies are key factors to EE realization within buildings. Boza-Kiss et al. (2013) also emphasized the need for communication adoption in making sure that users are informed regarding their level of consumption. In the study, the authors have indicated that one shortcoming is the absence of a cost-comparative study done globally regarding EE policies that are crucial for countries to assessing and comparing factors (Boza-kiss et al., 2013).

1.1.4 Energy Efficiency Programs (EEPs)

Energy Efficiency is a means of reducing energy use by utilizing less energy to achieve the same objective of useful output (DiFranco & Jorizzo, 2019).There is a great potential of having economic, safer, secure, and cleaner energy. This is easily achievable by adopting EE programmes that optimize and conserve the use of energy as well as adopting renewable energy options in the supply availabilities (Offinger, 2017). As a result, developing countries can move beyond traditional sources without jeopardizing the environment.

In many settings, there are various externalities, imperfect information and transaction costs that are a significant influence in determining how energy is produced and how efficient the programs that have been adopted to achieve Energy Efficiency are (Allcott & Greenstone, 2017). Energy Efficiency policy is regarded as one of the natural issues that are regarded as an externality. The first aspect is that use of energy is linked to the emergence of negative environmental effects, and thus there is need to ensure that regulations are put in place to control such activities.

Secondly, there are instances whereby imperfect information, behavioural biases, and credit constraints make people not consider the use of private and beneficial Energy Efficiency measures and applications. For instance, within the United States, if they adopt cost-effective methods of energy use, then the country will be able to save about $700 billion annually, and this is mainly from private consumption of energy within cities. Thus, indicating the importance of Energy Efficiency measures in cities (Allcott & Greenstone, 2017).

1.1.5 Success Rate of Implementation of EEPs

In most countries, putting energy-saving potential into practice is one of the greatest objectives. It has made many countries come up with policies aimed at the regulation of the fuels and other energy sources to ensure efficiency in the models of using energy and more so when it comes to the major global cities such as New York. In most countries, success that have been realized from Energy Efficiency programs have been based on the adoption of better policies and ensuring that sufficient education is done to people to embrace better ways of energy usage (Borisova, Borisov & Dushko, 2017).

Nehler, Parra, and Thollander (2018), in their analysis, categorized some of the barriers that have been found to hinder success rate of implementation of energy-efficient programs. Some of the barriers that they have noted include both internal and external barriers within the energy management and city's management, thus creating challenges in most cities across the globe.

Furthermore, Nehler, Parra, and Thollander (2018), in their study noted that there are various barriers to Energy Efficiency that have been studied in countries like Sweden, which includes the cost as well as the risk of production, challenges in obtaining information about energy use and other priorities that most of the cities in Sweden have. Such barriers leads to lack of efficiency within the cities regarding the application of efficient energy management methods.

1.1.6 Sustainable EEP Implementation Model

Song, Li, Duan, Yu, and Wang (2017) did a study on sustainable energy-efficient city: a case study of Macau. The findings of the study indicated that climate disruption is caused by the huge dependency that cities have on energy .As a result, cities must take comprehensive efforts to ensure that the energy sources they employ are both sustainable and efficient.. The study also noted that for cities to achieve a high Energy Efficiency, there is need for energy-saving publicity and policies that are key in ensuring that effective energy-saving measures and activities are adopted.

Beccali et al. (2015), in their study, noted that the existence of the street lights in cities are in most cases poor due to the presence of inappropriate obsolescence light sources that are characterized with poor on and off dimming strategies that are employed and thus creating challenges for sustainable Energy Efficiency measures. However, they note that there are measures that can be used to improve the Energy Efficiency of street lighting systems within cities across the globe. One of the key measures that can be used is adoption of the Public Administration in developing a Sustainable Energy Action Plan in the framework of the "Covenant of Majors" activities. The plan is key to enhancing Energy Efficiency within cities as it captures all the possible solutions that cities can employ in the management of their energy consumption in regards to street lighting.

1.1.7 Nairobi City County Government EEPs

EE programs' implementation in Kenya was stimulated by grant funding and government subsidies through the Ministry of Energy to support Nairobi City County Government Energy Efficiency programs in 2016. According to the Kenya national Energy Efficiency strategy (2020), this support by the government was to enable the Nairobi county government to transition to more energy-efficient facilities to better support the national strategy of flattening the demand curve during peak hours to utilize the energy generation installations better and subsequently lower the cost of energy occasioned by having a large supply capacity unutilized for longer hours in a day. Additionally, it was to help the Nairobi County government manage their energy bills and hence enable wider rollout of energy access across the county. However, in the Energy policy paper of the GOK (2020), these grants and subsidies are only guaranteed until the end of the financial year 2029/2030. There is no much information on continued support from the government after the year 2030. It is thus crucial to examine the uncertainty associated with funding regarding EE within counties and the need to come up with business models that are capable of enhancing and sustaining future EE programs.Nairobi faces various challenges, one of the major challenges is lack of complete data on Energy Efficiency and also lack of awareness amongst the people inform of measures that can ensure Energy Efficiency within the city. According to NCCG's representative, there is no need for artificial heating for public buildings. However, such buildings are often characterized by high energy costs, and this is due to the use of gadgets, running lifts, security lighting, and pumping water for storage. Thus, creating a serious challenge regarding EE within Nairobi City County (Ndirangu & Maitho, 2020).

1.2 Problem Statement

Nairobi City County Government accounts for about 45% of all electrical energy produced in Kenya. Presently Kenya has 2130MW installed capacity connected to the national grid. MOE strategy paper on national Energy Efficiency and Conservation (2020) identifies the need for energy conservation measures that need to be implemented to guarantee effective demand-side management and consequently align with the global goals to reduce carbon footprints. To achieve these aspirations of the strategy paper, MOE and the energy retailer KPLC have rolled out a cooperation framework with county governments and KAM on developing Energy Efficiency programs within their general and individual operations. These Energy Efficiency programs involve newer technology adoption, capital injection for long-term savings, and optimal operational variations (Mburugu & Gikonyo, 2019). This guarantees energy bill savings to KAM and county governments.

In line with the National Sessional paper no.4 of 2004 on energy and its subsequent adaptation into the Energy Policy of 2018, the Nairobi City County Government domesticated the national strategy on renewable energy and Energy Efficiency within its department of environment, energy, water, and sanitation. The responsibility of this department is, among others, to come up with measures that ensure that the city government is energy efficient and that accrued liabilities due to utility costs are kept to an optimal minimum (Yatich, 2018). The department of environment, energy, water, and sanitation developed an implementation framework of various Energy Efficiency programs that it identified would bolster the objectives of the county government in the energy operations working paper of 2015. Reports of the progress of these programs remain unavailable as the complete rollout of these programs is still ongoing with the assistance of the Nairobi Metropolitan Service, an agency of the national government formed in 2018 to assist in the management of the county.

To this end, the Nairobi County Government has received grants in excess of Kshs. 2B, from the AfDB, UNDP, and World Bank, to assist in implementing these programs as part of the better cities program. Some of the financed programs include street lighting, distributed energy access to slum areas, development of renewable energy sources, and county government building services lighting and ventilation modernization.

However, the Nairobi County Government, as of FY 2020/2021, had accrued pending utility bill of Kshs.1B owed to KPLC, a 20% increment from the previous financial year (NCCG, 2021). This has on several occasions led to operational clash with the utility company and hampered the operation of the county government due to withdrawal of service by KPLC. This is indicative of non-performance.

This Proposed study, therefore, seeked to assess the Implementation of Energy Efficiency programs of the Department of Energy in NCCG with the aim of determining the barriers to program implementation and developing a sustainable program implementation model.

1.3 Objectives of the Study

1.3.1 General Objective

The overall aim of this study was to asses the Energy Efficiency Programmes within the internal operations of Nairobi City County Government.

1.3.2 Specific Objectives

(i) To carry out an energy audit of the operations of NCCG within the facets of administrative buildings,street lights and traffic light.

(ii) To determine the Energy Efficiency programs within the facets above.

(iii) To assess the success rate of implementing Energy Efficiency programs of the facets above in Nairobi County Goverment.

(iv) To formulate a sustainable Energy Efficiency program implementation model for NCCG.

1.4 Research Questions

(i) What are the energy consumption rates and conservation opportunities within the operations of NCCG's administrative buildings,street lights and traffic lights?

(ii) What Energy Efficiency programs are within Nairobi City County Government?

(iii) What is the success rate of implementation of Energy Efficiency programs in Nairobi City County Government ?

(iv) What sustainable Energy Efficiency program implementation model can be formulated for Nairobi City County Government?

1.5 Justification of the Study

Energy is a crucial aspect in urban areas' development and sustainability, as well as improving the livelihoods and social environments. However, energy largely remains a limited resource, and as such prudent use is key in ensuring that its production is sustainable and with as little carbon footprint. Cities and urban centres consume most of the energy produced globally. While considering electricity, Nairobi takes 56% of the total produced power in Kenya (Mbaka et al., 2019).

To meet the objectives of energy conservation so that investment in energy production does not result in excess idle capacities that remain unused most times, the government of Kenya developed the Energy policy of 2018. This policy has a special focus on energy conservation measures and encourages investments in Energy Efficiency programs by both public and private organizations. In line with this national policy on energy, NCCG ratified the policy to integrate with its energy strategies within its energy department.

This study is important in determining the extent to which the energy programs developed by the department of energy of NCCG have been implemented and the hindering factors that influence the rollout of these programs. As a result, the findings of this research will be important to the NCCG energy department, and the programme teams tasked with implementing these projects in mitigating against bottlenecks associated with programme implementation. This study will also assist the NCCG energy department in identifying the best financing model that will guarantee high success rates while ensuring programme sustainability.(Alain & Catherine ,2019)

The findings of this research will also be important to both national and county policy makers in developing Energy Efficiency programs that are responsive to the dynamic nature of energy utilization in a way that provides a balance between energy and performance in the operations of public institutions. It will also provide a framework upon which policy makers can better align energy conservation policies to sustainable financing. This will ensure that the associated energy costs of both the national and county governments are optimized and manageable. This study will also help guide policy makers in creating tax regimes that ensure affordability of energy-efficient equipment in order to meet general efficiency targets (Osiema,2012).

Additionally, this study will go a long way in enhancing the understanding of energy management within public institutions. It will contribute to the Energy Efficiency body of knowledge with its findings on how Energy Efficiency programs are run and the potential challenges these programs are likely to face. This study will address the research gaps that exist in the area of management of government energy consumption in its day-to-day activities in order to achieve Energy Efficiency. (Shirrime & Trubaev,2017).

Energy managers will also be beneficiaries of this study as the outcome will guide them in carrying out energy audits in public institutions and their operations. According to Kenya Association of Manufactures report on energy services of 2016,Energy audits have still not been widely adopted in most government institutions or agencies and as such, energy audits are not carried out in order to improve the Energy Efficiency of these government organizations. The study will contribute to the development of guidelines on public energy audits as a step to better manage energy use in the public sector. (Munene et al,2019)

1.6 Scope of the Study

This research focuses on the assessment of Electrical Energy Efficiency programmes within internal operations of Nairobi City County Government. The study will be based on the operations of the County within Nairobi CBD and will involve street lighting, traffic lighting, and building services resident within the city hall and city hall annex. These power loads for the county are supplied under the Commercial tariff by the Utility company KPLC. The study will rely on programs approved by the county assembly under its short-term county development plans of 2017-2022.This is because this period exists within a single policy regime .

The research will focus on the county department of environment, energy, water, and sanitation. It will involve technical staff within the department with a focus on energy. These staff will be the energy officers, departmental accountants, county electrical engineers, and chief officers. Data for this research will be obtained from the county nominal inventory and records. Additionally, data will be obtained from the power utility company.

The variable scope of this research will include an energy audit of NCCG, determining the EE programs within NCCG, assessing the success rate of implementation of EE programmes and to formulate a sustainable EE programme implementation model.

1.6.1 Justification of scope

Nairobi city county government is organised into six administrative areas refered to as sub-county namely central business district ,western ,eastern,lower northern ,upper northern and southern . Each sub-county is set up with its own administrative units that manage operations of the county resident within the sub-county. The operations within these sub-counties include streetlighting,building management survices for county installations ,health services,general administration and social services. These services are therefore replicated across each of the subcounties and each subcounty is mandated to keep its own records of its operations.The study therefore settled on the Nairobi CBD subcounty as a unit of study to be representative of the other subcounties to carry out the investigation into the EEPs of NCCG internal operations.

The study also settled on electrical energy utilised by the county as the unit of analysis because records of consumption are easily replicable across all the subcounties of the NCCG. This allowed a test consumption monitoring of the electrical use by the subcounty within the billing period. This research therefore carried out a consumption monitoring for one month of the billing period . The county government operations of Bulding services ,traffic lights and street lighting the only functions of NCCG operations considered because they were common uniformely across all the sub county administration units. This scope was therefore representative of the the whole NCCG operations.

1.7 Project Report Organization

This project report is organized into five chapters. Chapter One is the introduction to the study. It captures the background to the study, the statement of the problem, the objectives, research questions, justification of the study, and the scope of the study. Chapter Two captures the literature review. The basic concepts,theoretical framework, review of previous works, the research gap, problem formulation, and the chapter conclusion are analyzed. The methodology of this study is covered under Chapter Three and entails a review of the previous methods that have been employed to carry out studies of a similar nature, proposed method that was employed in conducting this study, expected results, the conceptual framework, and the chapter summary. Chapter four presents the results of the study and subsequently the discussion of the results. This chapter is segmented into two sections with section one covering the assessment of EEPs implemented by the NCCG and section two analysing the proposed NCCG business models for EEPs.Summary of EEPs ,validation of this study and chapter conclusion are also covered in this chapter.Result presentations are done using tables and graphics.The final chapter is concerned with Conclusion and Recommendations,in this chapter, key findings are highlighted,reccommendations for further work has been proposed,limitations of this study highlighted and Main contribution of the study outlined.

CHAPTER TWO

LITERATURE REVIEW

2.1Basic Concepts

2.1.1 Introduction

This chapter examines various concepts and theories related to this study .Research gap from past studies have also been highlighted .

2.1.2 The Efficiency Concept

Modern efficiency measures began with Farrell's (1957) work, which drew significantly on earlier research by Koopmans (1951) and Debreu (1951) in order to produce a basic measure of company efficiency that could encompass multiple inputs.Diagrammatic representation of input-oriented efficiency as proposed by Farrell (1957) is shown in Figure 2.1.

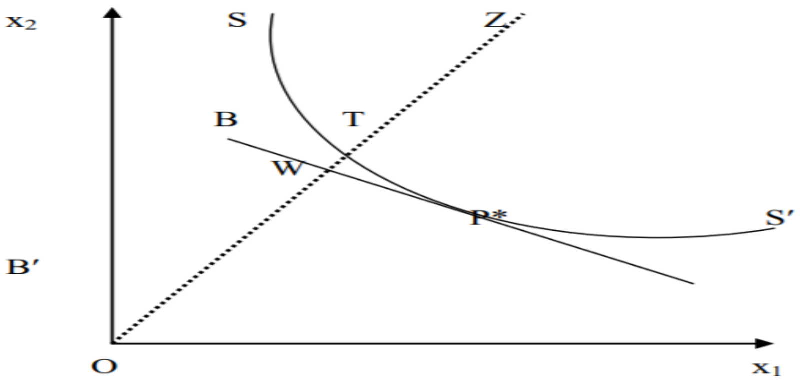

Figure 2.1;Input –Oriented Efficiency (Farrell (1957))

From figure 2.1, the curve SS′ is the isoquant of an efficient firm while the slope of the line BB′ is also the price ratio of inputs, x1 and x2. Points W, T, P*, and Z represent hypothetical production.

$$\text{Technical Efficiency} = \frac{OT}{OZ} \quad (2.1)$$

$$\text{Price Efficiency} = \frac{OW}{OT} \quad (2.2)$$

$$\text{Overall (Economic) Efficiency} = \frac{OW}{OZ} \quad (2.3)$$

Energy Efficiency (EE) has become a serious issue within the policy-making initiatives in developing countries. EE is important because of the energy security, commercial, competitiveness and industrial, benefits that have been associated with it, such as the reduction in the amounts of CO_2. Despite the efforts that have been placed in developing various policies, there are still no concrete efforts in the definition of EE (Ndirangu & Maitho, 2020).

In terms of renewable energy, EE is a must and is based on the fundamental aspect of determining the scope that is applied in the development of the needed capacity to have a well-functioning EE system. Additionally, other challenges that have been noted include issues like science and technology and also the presence of strategies that is capable of making EE adoption a success. There is increased interest in application of various alternative energy renewable methods to ensure EE is achieved within various industries globally. Thus, there is need for policy change in most of the countries to ensure that effective measures are adopted that are capable of making sure that EE goals are attained (Ahuja&Tatsutani,2009) .

In Kenya, EE has been found to be a key player in the realization of the climate management objectives in keeping up with the Paris Agreement on climate change. EE is crucial in the achievement of vision 2030 by the country with the aim of making sure that the country achieves its middle-income goals by the same year. Despite the importance that EE has in Kenya, available data indicates that about 66% of the EE potential within the country will remain unrealized by the year 2035, and this is due to the undervalue that is placed on EE (Maitho, 2020).

In Kenya, the attitude that the public has in terms of EE is not well explored, and this is despite the fact that the country consumes more energy based on the well-developed industries that are there. There is need to ensure that local stakeholders and civil society organizations (CSOs) are involved in the process of coming up with effective EE policy and strategies (Maitho, 2020).

2.1.3 Theoretical Framework

2.1.3.1 Theory of the Firm

Neoclassical economics have indicated that a firm is a monolithic actor that is keen on having costs reduced and sometimes enhancing its profit margin, and also improve their corporate performance. The behaviour of the firm is dictated by the forces that are found within the market, such as the present opportunities. Loasby (1976) points out that a firm cannot exist as a research unit on its own. Thus, research studies have looked at the prices and other market factors such as barriers to entry, monopolies, and products that can act as complements or substitutes.

The recent definitions that have been given to firms have been able to offer the inner aspects of the firm, and this is based on the understanding that is shared regarding the firms. For instance, one can make an argument that a firm is an organisation that exists beyond the price mechanisms that are involved. Cease (1937) had noted that the firm in some of the instances, act as the alternative to the relationship that is there between buying and selling within the market. The organizational part of the firm is used whenever there is low cost involved in the process.

In recent decades, there have been other concepts that have been promoted in relation to firms. For instance, firms can be regarded as collection of resources (Penrose, 1959). It is a definition that has been able to create various discussions in terms of the role that the firm has regarding management, organizing, diversing, and mobilization of the needed resources.

The application of resource-based strategy is key in making sure that a conceptual explanation is given in terms of the firms and the adoption of technologies that are EE and the opportunities that are generated in the process (Collis &Montgomery, 1997; Mahoney & Pandian, 1992).

There are about four categories of resources that are needed by the firms, and they are the human capital, physical capital, reputation, and the organizational capital. Such resources have the ability to influence the rate of EE adoption by a firm. The physical capital-related resources include factors such as location, equipment, raw materials. The human capital includes; experience, training, judgment, values, individual employees, and intelligence (Jensen&Meckline,1976) .

The organizational capital needed by the firm includes; planning process, formal structures, system control and coordination, and informal relationships. On the other hand, reputation includes factors like the general perception that the general public and the investors have, among others. Additionally, the core capability of the firm is based on the combination of all the resources that are needed by the firm in order to undertake its functions (Teece et al., 1997).

2.1.3.2 Habit theory

According to Verplanken and Aarts (1999), habit is mainly formed due to the regular performance of a certain action thus making it become an automated behaviour. Habits tend to occur unplanned and involuntarily in some cases. Habits tend to come about through the application of associative learning between the actions that one and the environment have. Additionally, mental and mind-set that one has can also influence the habit-forming process. When there is a strong habit, there is tendency for one to have a weak behaviour relationship which indicates that intention has a little effect (Verplanken & Aarts, 1999).

Verplanke and Aarts (1999) have indicated that there are other forms of habit that are based on counter-intentions, and this is where habits are based on the short-term goals that have a stronger influence than goals that are long-term. Counter-intentional habits are based on behaviours that are immediate or urgent, and they are stringer based on the reoccurrence of the situations that promote them. Stimulus is key when it comes to habits. Any change that takes place within the environment can change the stimulus hence affecting the habit that is being formed and making intention to be a greater influence.

Habit is based on four features, and that is limited control, absence of awareness, goals, and increased mental efficiency.According to Zhang et al (2021) Effects of habitual behaviour have been hard to restrain, and this is because of the need to ensure that a specific function is met. Thus, the premise indicates that there are chances of having a habit manipulated in order to have a desired behavioural change.

The success in terms of changing the habits and behaviours of the people is based on the link between the strategies and the practices that are there. Habits are routine processes as much as they are recurring actions. Cohn and Lynch (2017) noted that long interventions have been successful, and they can be adopted. The success of the intervention is linked to sustainability, the new practice that is being promoted, and this through behaviour and mental changes that take place in the process.

2.1.4 Energy Use

Access and sustained clean energy consumption are crucial in a country's socio-economic development and the improvement of human welfare. Clean energy use by the people is linked to various economic benefits and also the provision of the required basic needs critical to the sustainability of human life, such as food, health services, housing, and clothing. Therefore, to have socio-economic development, there is need to ensure that households are effectively linked to the preferred energy intensity. Globally, it is indicated that about 2 billion people are using solid biomass in domestic needs, which has been linked to 3.5 million death on an annual basis due to pollution that takes place indoors.(Gielen et al,2019).

2.2 Review of Previous Works

2.2.1 Rate of Energy Use

In an effort to determine the extent of energy conservation within the hospitality industry in Kenya, Kariuki & Odhiambo (2021) carried out a study that assessed EE implementation measures, barriers, and saving that are involved in the process. In this study, firms that provide hotel services formed the scope of the study. The study found that the annual energy use within the hospitality industry had risen considerably over a ten-year period and that the energy loss over that duration revealed variations in an upward trend. This study, however, failed to determine the challenges that hinder the implementation of Energy EE programs within the hospitality industry.

Another study that seeks an understanding of behavioural characteristics in the implementation of EE programs was carried by Munene et al. (2019). The study examined Energy Efficiency in Kenya by considering aspects of public awareness, strategies, challenges, and opportunities for EE programs. The target population of this research involved households within Nairobi, Kenya. This study found that the current energy use is not energy efficient and that the motivating force for energy use are primarily socio-economic which influences the choice of energy source, Munene et al. (2019) recommend that the ongoing EE initiatives by the national government in liaison with the local government should be amplified and reinforced in order to achieve the objectives of the demand in Kenya.

The manufacturing sector is also a key energy driver within the Nairobi city county as the county is home to a substantial number of manufacturing factories. Ndegwa (2016), in her study, examines EE in Kenya's cement industry with a specific case study of the Nairobi area. The study sought to quantify the Energy Efficiency in the cement manufacturing subsector by finding out the different factors that describe the variations across diriment cement manufacturing installations. The study identified potential for energy conservation opportunities in the various firms and identified factors such as quality of labour force as having significant effects on Energy Efficiency score. Ndegwa (2016), however, falls short of doing a comprehensive analysis of the energy position of these cement manufacturing firms. Additionally, the study does not identify the specific Energy Efficiency interventions undertaken by these firms. This raises the question of the research validity.

In order to formulate and implement an operation strategy for energy street lighting, Wambugu (2014) carried out a case study of Nairobi City County. Among the findings of this study was that the biggest drawback to the implementation of EE programs on street lighting was vandalism and a lack of financial support towards EE initiatives on street lighting. The study proceeds to recommend that national energy policy be adopted into the County operations strategy formulation and a replacement of all street lighting with LED lamps of lower wattage. This study did not determine the energy position of the NCCG in its findings.

Mohamud (2016) focuses on the outcomes obtained and provides a business model to aid in the continuance of Energy Efficiency programs beyond the guarantee period of financing in his study of the city of Cape Town's Energy Efficiency programs within its internal operations. Mohamud (2016), in his findings, states that the traffic signal department and specialized technical departments have all adopted Energy Efficiency measures and that there is need by the electrical services department to update their store stock items to energy-efficient options.

Wang, Wang, and Srinivasan (2018) have indicated that there are two ways of categorizing the use of energy by buildings, and that is through the use of Artificial Intelligence (AI) and engineering. Engineering is applied in terms of the calculations and equations that are involved in the process, while on the other hand, AI is applied in terms of the historical data that can predict the future. Engineering can be applied in the simulation of energy use, but it cannot be able to handle the simulation of the building's effective use of energy.

China has been undergoing a major industrialization phase as well as urbanization since 1978. Energy consumption within the country has been an issue of major concern, and this is in terms of the sources of energy that are being used. Demand for energy within China will continue to increase with time as the country continues to grow its industrial sector. There will be need for the country to adopt use of energy mix, and this includes application of all energy firms that are efficient and thus the adoption of the EE (Fan & Xia, 2012).

A study regarding the effectiveness of metropolitan when it comes to EE policies within the urban areas was done by Takagi, Sprigings, Nishida, Graham, and Horie Lawrence (2015). The study was based on the various policies that have been adopted by different metropolitans in terms of making sure that there is EE. The study indicated that there is need to ensure effective adoption of effective building policies within the urban areas in order to change the habits of people from less effective energy-related appliances.

Also, Poulsen and Sornn-Friese (2015) conducted a study that looked at EE and operations within ships. The study was keen on finding out the models that are applied and the effectiveness of the model that is used in the process. The study indicated that there are measures that have been used to enhance EE and thus cutting the cost of fuel used by the ship. There is active monitoring of energy use within ships and thus creating an avenue for information to be gathered on areas that are highly consuming fuel and energy.

2.2.2 Energy Efficiency Programs

Safarzadeh, Rasti-Barzoki, and Hejazi (2020) reviewed the optimal energy programs involving EE policies based on the policies of the government. The use of Industrial energy-efficiency programs (IEEPs) have been found to be popular within governments, and this is based on their efficiency to sectors that are deemed as being energy-intensive. Additionally, it has been disclosed that in countries such as the USA, China, and Sweden, the use of IEEPs is high, and this is based on the effective policies that have been adopted in the process. The policies have come up with various incentives that are used to make industries adopt EE practices. One of the incentives that have been adopted in the countries is low costs of power to those firms that have adopted use of IEEPs.

Yushchenko and Patel (2017) have indicated that EE programs are key in making sure that there are economic and social benefits within a country, such as increasing the GDP and also increasing employment opportunities. There are negative effects of EE that have been reported despite the positive effects that it has. EE has the potential to increase energy tariffs. Thus, necessitating the need to ensure improved cost-effectiveness of EE programs through education and training offered to users and also the contractors within the industry.

Hoicka and Parker (2018) investigated the EE programs within households. The study indicated that there are various EE systems that have been installed within homes with the aim of making sure there is effective management of energy use. One of the common systems that have been installed within the homes is the insulation system aimed at reducing any aspect of heat loss. However, in most of the homes, the insulation systems were not being upgraded, and thus at some point, they were not in a position to effectively manage heat loss as compared to newer versions. The study suggested that there is need to train and educate the users on the importance of having newer EE systems that have been improved.

Shoemaker, Gilleo, and Ferguson (2018) noted that the use of energy Service Companies (ESCos) is of great importance to companies, users, commercial sectors, and industries in terms of enhancing equipment efficiency through the provision of service (energy performance and/or credit risk). Additionally, the ESCos are implemented to promote EE within some of the European countries and also within other countries that are developed, such as Japan. Canada and USA.

Krarti, Ali, Alaidroos, and Houchati (2017), in their analysis, indicated that government-based programs such as the retrofit program in countries such as Qatar have been effective in promoting EE. Such programs have enabled buildings to reduce their energy consumption by a greater percentage, and also, there has been a reduction in emission of carbon, among other components that are toxic to the environment. Additionally, such programs have been able to create over 4000 job opportunities in Qatar on an annual basis.

A recent study by Filippini, Geissmann, Karplus, and Zhang (2020) on EE investment within the rental housing market in the U.S. has indicated that there is application of the EE systems such as insulators within most houses as part of the demand from the consumers. The study also indicated that in countries like Mexico, EE programs have not been effectively used and thus creating a situation whereby there is limited energy saving within a country. Thus, the country is losing 2-5% of national energy on an annual basis which in turn affects the costs of energy within the country, which is a burden to the users.

2.2.2.1 Economic Analysis of EEPs

Energy efficiency and conservation have long been critical elements in the energy policy dialogue and have taken on a renewed importance as concerns about global climate change and energy security have intensified. Many advocates and policymakers hold that reducing the demand for energy is essential to meeting these challenges, and analyses tend to find that

demand reductions can be a cost-effective means of addressing these concerns. With such great policy interest, a significant literature has developed over the past 30 years that provides an economic framework for addressing energy efficiency and conservation as well as empirical estimates of how consumers respond to policies to reduce the demand for energy. it is important to conceptualize energy as an input into the production of desired energy services (e.g., heating, lighting, motion), rather than as an end in itself. In this framework, energy efficiency is typically defined as the energy services provided per unit of energy input. For example, the energy efficiency of an air conditioner is the amount of heat removed from air per kilowatt-hour of electricity input. At the individual product level, energy efficiency can be thought of as one of a bundle of product characteristics, alongside product cost and other attributes (Newell et al. 1999). At a more aggregate level, the energy efficiency of a sector or of the economy as a whole can be measured as the level of Gross Domestic Product per unit of energy consumed in its production (see, e.g., Metcalf [2008] and Sue Wing [2008] for analyses of the determinants of energy intensity at the state and national levels).

In contrast, energy conservation is typically defined as a reduction in the total amount of energy consumed. Thus, energy conservation may or may not be associated with an increase in energy efficiency, depending on how energy services change. That is, energy consumption may be reduced with or without an increase in energy efficiency, and energy consumption may increase alongside an increase in energy efficiency. These distinctions are important when considering issues such as the rebound effect, whereby the demand for energy services may increase in response to energy efficiency–induced declines in the marginal cost of energy services. The distinction is also important in understanding the short- versus long-run price elasticity of energy demand, whereby short-run changes may depend principally on changes in consumption of energy services, while longer-run changes include greater changes in the energy efficiency of the equipment stock.

Maximizing economic efficiency—typically operationalized as maximizing net benefits to society—is generally not going to imply maximizing energy efficiency, which is a physical concept and comes at a cost. An important issue arises, however, regarding whether private economic decisions about the level of energy efficiency chosen for products are economically efficient. This will depend on both the economic efficiency of the market conditions the consumer faces (e.g., energy prices, information availability) as well as the economic behavior of the individual decisionmaker (e.g., cost-minimization).

This line of research has important implications both for assessing the cost of correcting

market failures—such as environmental externalities—as well as clarifying the role of policies that are oriented to correcting behavioral failures. For example, if behavioral failures lead to underinvestment in energy efficiency, then a degree of reductions in energy-related emissions could be available at low or even negative cost. At the same time, policies that provide an efficient means of correcting environmental externalities—such as an emissions price—may not be well-suited to inducing these relatively low-cost energy and emission reductions. In principle, a set of policies addressing both market and behavioral failures could therefore potentially provide a more efficient overall response. In practice, the value of individual policy components will depend on the extent of existing market problems and the ability of specific policies to correct these problems in a net beneficial manner.

2.2.3 Success Rate of Implementation of EEPs

Nelson (2015), based on his study, indicates that successful programs within the chemical industries in the U.S. have seen some of the companies experience 100% returns because of the energy-saving that they are involved in. However, such programs and their success are only reported within a few companies because there is poor adoption in the industry as many companies are yet to embrace such technologies. An example of successful EE programs that have been used includes the Green Lights program that is mainly applicable in the U.S. has led to huge returns within companies that have adopted it due to the low cost of energy that they are linked with.

Johansson and Thollander (2018), in their investigation, indicated that reduced use of energy and increased use of EE-based programs have created low-carbon economies. Industries that have improved EE programs experience low energy costs as they are using less energy in most cases. They are also in a position to have low cost of eliminating the wastes they are producing since there is a reduction in carbon-based wastes within the environment. Additionally, in such industries, there are situations where there is an efficient production process and thus a competitive advantage of the industries in ways that makes them improve on their profit margin.

Franco, Kuppens, Beckers, and Cruyplandt (2018), in their study, have noted that there are various challenges that are faced when it comes to the success of EE-based programs. Some of the challenges that have been documented include lack of education and training when it comes to users and use of systems that have not been approved as well as lack of government support for such programs. Finding effective solutions to such challenges is key in making sure that there is adoption. The research suggests that government should ensure that there are assisting with the promotion of such programs and also that there is massive public education that targets energy users in different industries.

2.3 Research Gap

There are various gaps that have been noted in the study. The first gap indicated in the study is that most of the similar studies have been done outside Kenya. For instance, Krarti, Ali, Alaidroos, and Houchati (2017), in their analysis indicated that government-based programs such as the retrofit program in countries such as Qatar have been effective in promoting EE. The second gap is that the studies have not captured efficiency within cities as in the case of the current study. For example, Hoicka and Parker (2018) found out that assessed the adoption of the house as a system approach to residential Energy Efficiency programs. Thus, the current study is aimed at filling the existing gaps. None of the studies mentioned above have captured Energy Efficiency Programmes within the Internal Operations of Nairobi City County Government. Thus, creating a gap that is to be fulfilled with the current study by assessing the Energy Efficiency Programmes Within the Internal Operations NCCG.

2.4 Chapter Conclusion

The chapter has covered the basic concept of the study that is Energy Efficiency and energy use. Related studies have also been included in the chapter in relation to the study objectives. They are studies that have been done by previous scholars in relation to the current study. Lastly, problem, formulation has been captured that indicates the existing problem and how the current study aims at solving it.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter reviewed previous methods employed in carrying out previous researches that are relevant to this study. It also discussed the proposed research methods and the conceptual framework on which this study was anchored.

3.2 Review of Previous Methods

In order to determine the best research method to employ on this study , a review of the methodologies that were used in previous similar studies was conducted as in subsection 3.2.1 and 3.2.2.

3.2.1 Case Study

Researchers use case studies to get a thorough, multi-faceted grasp of a complex topic in its real-world context. It is a thorough, methodical analysis of a single person, group, community, or other entity in which the investigator evaluates extensive data on multiple variables.

In their research of the city of Cape Town's Energy Efficiency programs, Mahmud and Town (2016) employed the use of first-hand observations and fieldwork to collect energy data that was then used to construct a business model. His study adopted a case study research design, in which the investigation concentrated on a single issue that was then thoroughly examined. Mahmud and Town (2016) subsequently, in their research methodology, employed a mixed-methods approach methodology in which both qualitative and quantitative analysis was done in order to guarantee a holistic approach (Beryman & Bell, 2011).

In a comparative study of Energy Efficiency of base transceiver stations, Oduor (2012) used a combination of case studies and descriptive research design to obtain information and explain energy conservation opportunities that could be exploited.

Adhiambo, Moses, and Nyete (2021), in their study, employed the use of a case study design, and they noted that the use of the cases study as being effective in detailed data analysis as it allowed for a detailed focus on the phenomenon under study.

3.2.1.1 Strength And Weakness Of Case Study Design

Case study is important in determining an intensive research on a phenomena or situation. It enables a detailed and thorough exploration of the subject under investigation. This makes it very appropriate for events that may not be recreated either physically or ethically. Another important strength of a case study research design is its ability to invigorate new research thematic areas as the findings of it can lead to advanced research in areas under study. Due to the first hand nature of the findings of a case study ,established ideas and theories can be challenged and improved upon making case studies the back bone of proving theories in research, this is in addition to the research method being able to give new insights on the phenomena or subject under study.

The main drawback of a case study is in its inability to be replicated making the study unable to be corroborated easily. Because of this, results are usually valid for only one phenomena and inference tend to be difficult. Researcher bias has a high tendency to creep within this research design and is mostly manifested in the way data is interpreted.

3.2.2 Mixed Methods

In this research design, both qualitative and quantitative aspects of a study is incorporated in carrying out analysis of data. The use of descriptive statistics, regression, and correlation analysis is always for the bulk of this design.

Koskei (2019) used a descriptive research design in his case study of energy utilization at the NCCRC. This design enabled his study to obtain data primarily through surveys and interviews. Wambugu (2014), in her study to formulate and implement an operation strategy for energy-efficient street lighting of Nairobi County. The analysis of data was based on qualitative and quantitative research analysis based on descriptive statistics and content analysis.

Ndegwa (2016), in his study of energy use efficiency in Kenya's cement factory, employed the use of a production-theoretic approach to approach Energy Efficiency measurement. Tobit regression analysis and data envelopment analysis were used as analytical tools. Overall, Ndegwa (2016) employed a descriptive research design to carry out and evaluate the study.

Ndichu et al. (2015), in their study, used the survey method. They indicated that the use of surveys is key whenever there is collection of data from a larger population, and it entails the use of questionnaires, but also interviews might be applied in the process. Catherine (2011), in her study, employed the use of questionnaires as part of the methodology. The study indicated that it adopted the use of a questionnaire based on the fact that it provides for the collection of large quantity of data within a short period of time.

3.2.2.1 Strength And Weakness Of Mixed Methods Research Design

The major strength of using mixed methods is that it combines the advantages of both qualitatitive and quantitative methods thereby offsetting the weaknesses of only using one design. This leads to results that are more objective and can be replicated with high levels of confidence. This design also takes a shorter time during data collection.The downside however is that it requires greater expertise to study a phenomena using two different methods simultaneously.

3.3 Method used ; Hybrid of Case Study And Mixed Methods

3.3.1 Case Study

This research employed a case study of the NCCG internal operations of street lighting, traffic lighting, and the building facility of the NCCG complex. Energy data was collected based on a one-month case study period of the units of analysis.

3.3.2 Mixed Methods

The study also employed the use of questionnaires. The questionnaire was used since the study adopted the use of a descriptive research design. According to Kothari (2008), the primary goal of descriptive research design was to describe the current state of affairs. The main objective of this study was to assess the Nairobi City County Energy Efficiency programmes within its internal operations. Additionally, the descriptive research design was used to describe the rate of energy use within the operations of Nairobi County, the Energy Efficiency programs within Nairobi County, and the success rate of implementation of Energy Efficiency programs in Nairobi County.

Self-administered structured questionnaires was used to collect data. A questionnaire is a research tool that collects data from a large number of people (Kombo and Tromp, 2006). Questionnaires, according to Orodho (2004), are widely used instruments for gathering important statistical data. Questionnaires have been selected since they require less time and effort while also being less expensive. Mugenda and Mugenda (2003) claim that questionnaires, which are often used in survey research, are appropriate for gathering information about present conditions and practices, as well as obtaining precise and rapid questions regarding attitudes and opinions.

A questionnaire was designed to gather information about Nairobi City County's internal Energy Efficiency programs. The questions was created with each study's purpose in mind. The questionnaire was broken into two sections in particular. The first section contained demographic questions, and the second section contained three research questions. Closed-ended questions were favoured over open-ended questions because they improved data reliability, validity, and analysis.

By including a variety of items that attempt to measure the study questions, content validity or sample validity was ensured. To improve the instrument's validity, relevant adjustments was made.

Pre-testing of the instruments was performed during the pilot research to determine their reliability. The reliability of internal consistency was applied. This describes the degree to which test or instrument items measure the same thing. Each item's reliability was also assessed. The Cronbach's Coefficient Alpha was used to estimate internal consistency (Mugenda & Mugenda, 2003), and r =.70 is the acceptable correlation coefficient.

3.4 Conceptual Framework

The study was based on the conceptual framework captured in Figure 3.1. The conceptual framework captures the relationship between the independent variables and the dependent variable. The independent variables are; rate of energy use, EE programs, the success rate of implementation of EE programs. The dependent variable is Energy Efficiency. The conceptual framework shows that the independent variables affect the dependent variable.

Independent Variables **Dependent Variable**

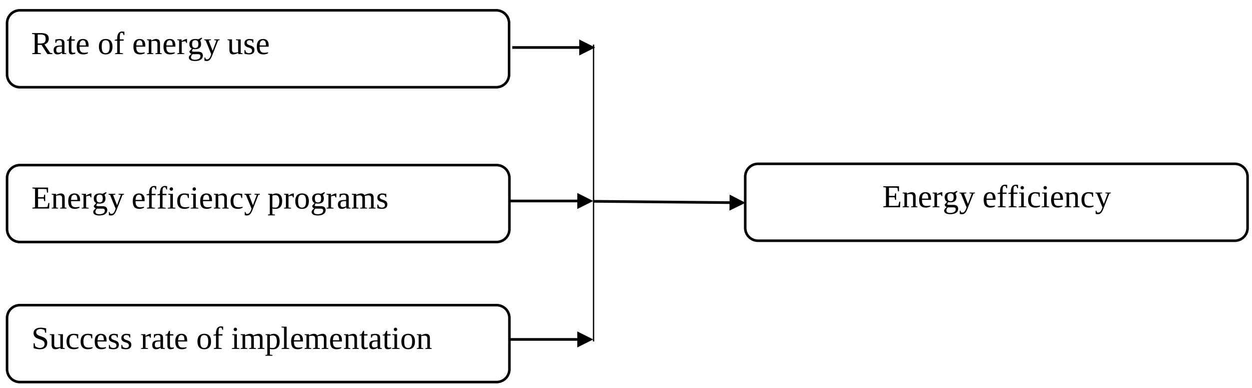

Figure 3.1: Conceptual Framework

3.5 Chapter Conclusion

The chapter has captured the review of previous methods where various methods that have been used in past related studies have been explained in detail and the reason for their application. The second section of the chapter is the selected method,that is the hybrid of both case study and mixed methods. The selected method has captured the method that was employed in the study and its advantages. The chapter also explained how to test the reliability of results. Lastly, the chapter captures the conceptual framework that shows the relationship between independent and dependent variables.

CHAPTER FOUR

RESULTS AND DISCUSSION

Chapter four presents the data analysis and findings of this research. Specific objectives guided the analysis as within the perview of the problem statement in section 1.2 of chapter one .

4.1. Background of Findings

Questionnaires were administered to twenty two respondents including seven engineers and fifteen supervisors from the Nairobi City County electrical department. Out of the twenty two questionnaires administered, six engineers and thirteen supervisors responded leading to a response rate of 86% and 87% respectively.

The first two questions of the first section of the study presented bio-data of the respondents. This background information specifies current job designation and number of years the respondent has been in employment at the Nairobi City County. A look at Table 4.1 indicated that most of the staff who participated in the study had over eight years' experience. The purpose of this background information was to verify that the respondents had adequate experience to give accurate information.

Table 4.1:Bio data of respondents

Number of years of service	Frequency			
	Engineers	Accountants	Energy Officers	Chief Officers
1-3	1	0	0	0
4-8	3	2	3	0
Over 8	15	2	9	3

The findings of this case study focused on the Nairobi City County Government's internal energy efficiency programs, providing an overview of NCCG's energy consumption. It also depicts the proportion of electricity consumed by NCCG as a whole. The energy efficiency strategy of the NCCG and the complementing plan on climate action is provided at a high level overview.Within the operations of NCCG, these policy have proven to be the primary motivators of EEPs.The findings of this case study therefore is provided in two sections with the first part providing an overview and evaluation of the EEPs implemented between 2016 and 2021. The second part analyses future business models that guarantee sustainability in the implementation of EEPs in the operations of NCCG.This chapter additionally highlights the critical areas of EEPs that have been rolled out within the period of 2016 to 2021 while discussing the background of key departments of NCCG that have been instrumental in the implementation of EEPs in the operations of NCCG in order to describe a future business model for a sustainable implementation of the EEPs.

4.2 Section I : Assessesment of The EEPs Implemented

Nairobi is the largest metropolis in Kenya with its population estimated at 4.8million people (KNBS,2015). This consequently means that the scope of public services that the county administration is mandated to provide is wide. Therefore, the NCCG employs well over 25,000 staff to be able to meet its obligations making it one of the country’s largest employers. Sanitization, housing development,roads,water, waste management and social services are just a few of the services provided by the NCC to all its citizens.The county owns and operates approximately 5000 facilities which includes Health centres and hospitals, administrative buildings,sports stadia etc.This is reflected in the energy consumption outlook of the county with annual electricity consumption averaging 449,977,809kWh(NCC,2015). This positions Nairobi as a single entity that consumes most energy, hence it plays a significant role in providing leadership with regards to efficient energy management and therefore there is need to optimize the energy consumption of the NCC in order to actualize this policy leadership to other units of government (NCC,2015).

As an intergral unit of the Environmental Resource Management Unit within the Energy Department,The Energy and Climate Change taskforce has been rolling out energy efficiency initiatives making NCCG one of the first counties in Kenya to design an Energy strategy (2006). This has led to the development of various reports as to the state of energy consumption and application, level of governance support, rollout of energy efficiency action plan and the establishment of an implementation project team to execute energy management initiatives within NCCG.This necessitated the development of a frame work for implementation of various EEPs within NCCG. This first section of this chapter asseses and investigates the extent with which EEPs within the operations of NCCG have been implemented effectively as well as the bottlenecks and the benefits accrued in the implementation of EEPs in the operations of the county.

4.2.1 The Energy Profile of NCC

According to the report by NEMA on greenhouse emissions, Nairobi used up a total of 45 billion kilo-watt hours with a resultant emission of greenhouse gases approximated at 5.2 tones-CO_2 per capita. These measures up to the emission rates that are experienced in Europe. (NEMA, 2015a).

Energy consumption in Nairobi is graded by the source of the energy.Figure 4.1 shows that Electricity makes up 29% of the total energy consumed by the county which is representative of 6% of the national electricity consumption(CEIC,2018).

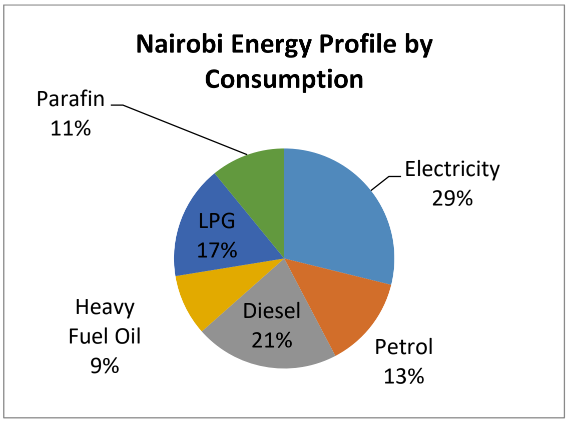

Figure 4.1: Nairobi Energy Profile by Source

In considering electric energy consumption by sector in Nairobi,NCCG as an organisation ranks among the biggest single consumers in the county taking up 4% of the 9% consumption by the county government as illustrated in Figure 4.2 .

From the Table 4.2 the EE programs deployed to the NCCG buildings of City Hall complex involved technology retrofits, energy monitoring and energy use behavior adjustment. For most part of the implementation phases, financing of these EE programs was done through grant financing.

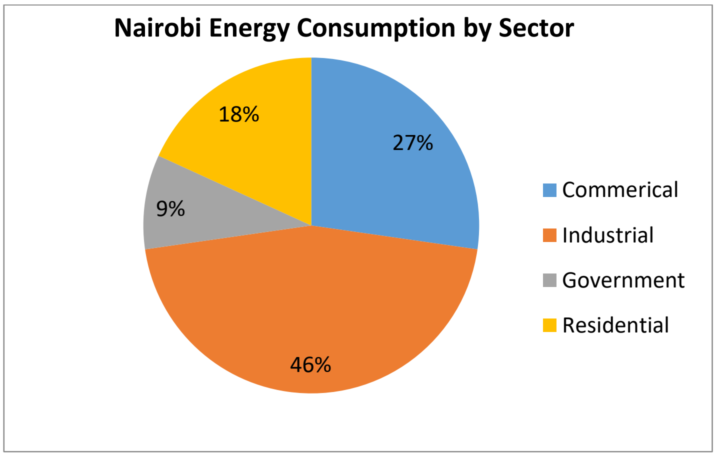

Figure 4.2:Nairobi Energy Consumption by Sector

Within the Internal operations of NCCG, Electricity takes up 71% of the total energy usage making electricity the major source of energy for the county. Figure 4.3 illustrates this with other sources of energy being diesel and petrol.Electricity is used as an energy source by NCCG to operate service buildings such as hospitals,administrative units etc,in waste water treatment ,streetlighting,street lighting and traffic lighting.

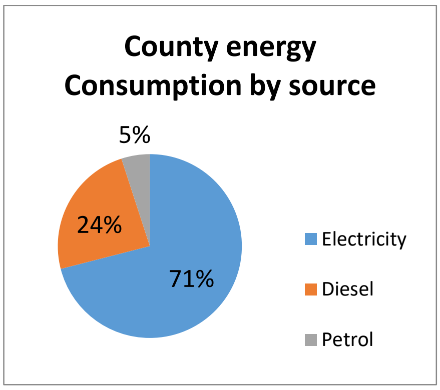

Figure 4.3:Nairobi County Energy Consumption by Source

From Figure 4.4, NCCG's 4% electricity consumption is made up of various components. Because county government buildings consume 27% of the city's electricity, they are highly inefficient energy users (NCC, 2015a). This inefficiency is exacerbate by the application of non standard building materials as well as the widely adopted design concepts of over specification of equipment designs as a common practice.These practices that have promoted inefficiencies in the usage of electrical energy are however changing with the adoption of newer technologies and design philosophies.Coupled with incestant black outs ,diminished capacity of generators and the ever increasing per unit cost of electricity,there is increasing need to reduce and optimize electricity consumption.(Christofordis et al.,2013).

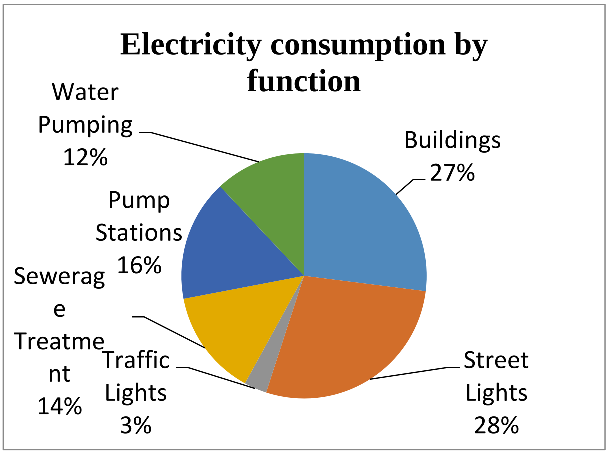

Figure 4.4:Nairobi City County Electricity Consumption by Function

4.2.2 Energy Efficiency Programmes In The NCCG Internal Operations

Since 2013, NCCG has been involved in energy efficiency programs. From 2016, the Department of Energy has consistently initiated a number of projects and programs with the aim of implementing energy efficiency in the county's operations. These energy efficiency initiatives saved NCC approximately Ksh. 87 million in electricity bills with the cost of investment of Ksh. 110 million from 2016 to 2021. This equates to savings of 65,832MWh from the EEPs implementated between 2016 and 2021 with the sectors of street lighting ,traffic lighting and building facility operations. Considering 2013 as baseline , this savings represent a 15% gain for the NCCG.

NCCG energy efficiency programs have been as a result of developments in the implementation of projects and project strategies ,collection of data of the operations of NCCG.The county has support from its various partners with these support being financial and technical towards the implementation of the EEPs. The partners of NCCG include international donors and national governments who have advanced grants and loans towards EEPs. NCCG has of late also started incorporating its own financing towards the EEPs by allocating funds from the county revenue contributions. This therefore forms part of a bigger advancement that involves gathering of information and raising awareness through energy audits and carrying out pilot projects with the core intention of determining the feasibility and benefits of EE technologies in the operations of NCCG. It also forms part of management of energy demand side by utilizing government funding to achieve efficiency through retrofits. The long-term strategy for the NCCG is to commit its own funds in EEPs projects so as to guarantee that EE implementation within the infrastructure of the county is integrated as institutional standards in the operating environment.

4.2.3 Building Facilities

Table 4.2 identifies the EE programs that have been rolled out at the city hall and city hall annex building facilities.

Table 4.2 EE programs that have been rolled out at the City Hall and City Hall Annex Building Facilities

Year	2016/17	2017/18	2018/19	2019/20	2020/21
Phase / EE program	1	2	3	4	5
Technology retrofits	Energy Efficient lighting (Fluorescent tubes T8), Solar Water Heating, hydro-boils	Energy Efficient lights (Fluorescent tubes T5), SWH and timers, temperature control on HVAC systems, timers, Power Factor Correction	Energy Efficient lighting (Fluorescent tubes T5) and motion sensors	Energy Efficient lighting (Light Emitting Diodes) and motion sensors	Energy Efficient lighting (Light Emitting Diodes) and motion sensors
Behavior Change programme	Yes	Yes	Yes	Yes	Yes
No of buildings	2	2	2	2	2
ModularMetering	Yes(Internal system used)	Yes(Internal system used)	Yes(Internal system used)	Yes(Internal system used)	Yes(Internal system used)
Funding Source	Grant	Grant	Grant	Grant	Nairobi City County

The Figure 4.5 shows the comparative energy consumption for City Hall complex for the year 2016 and 2021. It is seen that there is a considerable drop of energy consumption and this is attributable to some of the energy efficiency programmes that have been rolled out within the five year period. The results are similar for the city hall annex building as depicted in the graph.

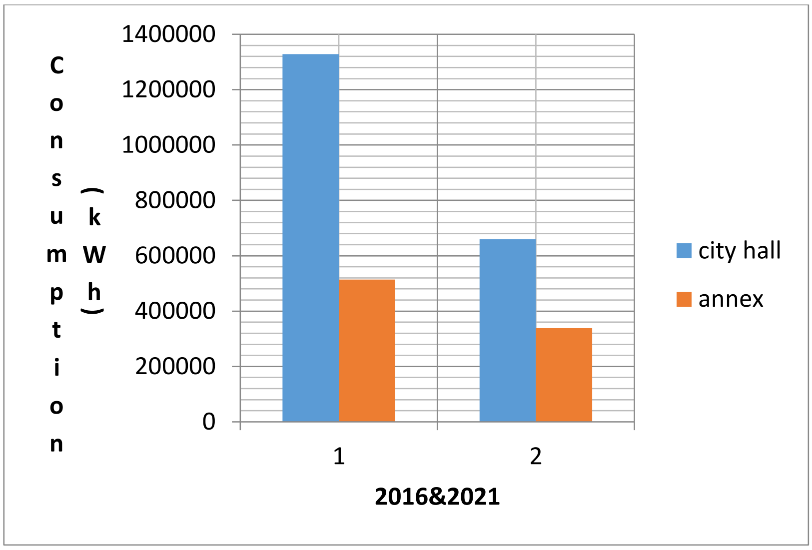

Figure 4.5: City Hall Building and City hall Annex Energy Consumption (2016&2021)

The County's department of energy developed a plan in 2015 that aimed at ensuring energy efficiency in the use of electrical energy within the county. The Table 4.3 shows a summary of the EE programs as identified by the county;

4.2.3.1 Building Facilities Retrofits

The roll out of EEPs within the NCCG city hall complex has involved retrofitting of a number of energy consumption loads such as lighting with more technologically efficicient alternatives as outlined in Table 4.2. Within the 5 year implementation period to 2021,significant annual energy savings have been achieved as outlined in Table 4.3.This has shown a co-linearity with the percentage retrofitting that has been done.

Table 4.3 : Building facilities Percentage retrofitting

Year	Energy Consumption(kWh)	Energy Target (kWh)	% retrofit
2016	1,842,304	800,000	0
2017	1,433,591	800,000	55
2018	1,115,550	800,000	71
2019	1,015,150	800,000	78
2020	1,004,998	800,000	79
2021	997,068	800,000	80

Due to the EEPs that have been rolled out within the City Hall Complex,there has been a cumulative retrofitting of 80% leading to an annual energy saving of 845,236kWh in the year 2021. However the Annual consumption still falls above the set Energy consumption targets of the NCCG. Figure 4.6 trends the energy consumption vis the target consumption while indicating the percentage completion of the retrofitting for the EEP .

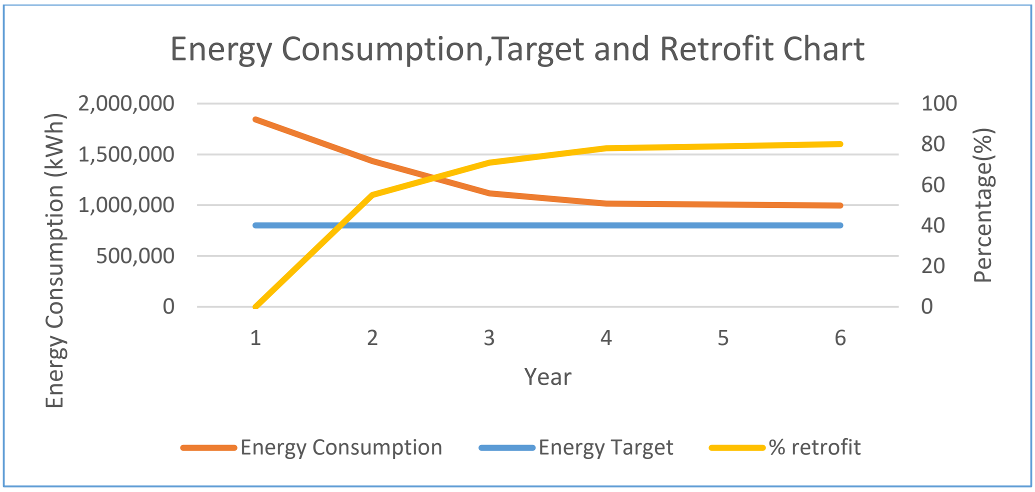

Figure 4.6; Energy Consumption ,Target and Retrofit Chart

Table 4.4;Building Facilities Energy Efficiency Programs

Maximize energy Performance	Energy Reliability	-Sustainable Energy Design	1.provide for supply redundancy by creating provisions for backups and uninterrupted power supply
			2.Develop a procedure for energy redundancy integration
			3.Crowd fund clean energy projects
		-Modernization	1.Computerize energy data and analyze trends
			2.Review insulation opportunities
			3.Install newer technology
		-Contingency Planning	1.Develop contingency plan for electricity use
			2.Determine alternative energy sources
			3.Establish shutdown procedure
	Energy Quality	-Energy monitoring	1.Establish permanent instrumentation for energy measurement
			2.Ensure Measuring instruments are calibrated to utility company standards
			3.Develop an energy reporting and evaluation system
		-load control	1.Assess building thermal envelop
			2.Optimize use of large loads
			3.Developprocedures for large load switching of the building i.e HVAC systems
	Energy Access	-strategic placements	1.Develop procedure for installation of power points
			2.Sensitize staff on the importance of power point strategic placement
			3.Training on effective access point location
		-Audit	1.Create an audit plan
			2.Implement audit findings on energy access
			3.create work groups to track implementations audit findings
		-Design optimization	1.Use latest design considerations in formulating a design framework
			2. Rollout CAD software to staff to assist in design and simulation.
Energy Cost Reduction	Energy Efficiency	-Retro-commissioning	1.Refit older buildings with more efficient facilities
			2.Develop Equipment and facility maintenance framework
			3.Automate facility functions that do not require staff intervention
		-Control/facility optimization	1.Assure proper functioning of existing controls
			2.Develop a low cost/no cost program for controls
			3.Evaluate and install EMCs where

4.2.4 Street Lighting

This study established that as of 2021 the number of working street lights in Nairobi City County CBD range between 5,000 and 7,000 as shown in Table 4.5.

Table 4.5;Number of Functional Street Lights in Nairobi City County

Type of Lamp	**Number of Street Lamps**	**Frequency**
High Pressure Mercury Vapour (MV)	680	10.5%
Metal Halide (MH)	96	1.5%
High Pressure Sodium Vapour (HPSV)	5350	82.3%
Low Pressure Sodium Vapour	-	-
Low Pressure Mercury Fluorescent Tubular Lamp (T12 &T8)	90	1.4%
Energy-efficient Fluorescent Tubular Lamp (T5)	24	0.4%
Light Emitting Diode (LED)	260	4%
Total	6500	100%

Approximately 82.3% of Nairobi City County's street lighting lamps constituted of High Pressure Sodium Vapour (HPSV) which was followed at a distance with High Pressure Mercury Vapour which constituted of approximately 10.5%. Of interest was the fact that Low Pressure Sodium Vapour lamp was not documented as used within Nairobi City County. Other lamps which were in use at very low numbers included Metal Halide (MH), Low Pressure Mercury Fluorescent Tubular Lamp (T12 &T8) and Light Emitting Diode (LED). Over half of the street lights in Nairobi City County were found within the CBD. The CBD takes a rectangular shape, around the Uhuru Highway, Haile Selassie Avenue, Tom Mboya street, and University Way and it features many of Nairobi's important buildings and streets.

According to NCC, HPSV street lamps currently in use have power rating of 150W, 250 and 400W. The approximate monthly electricity bill is Kshs. 37 million which translates into approximately Kshs 444 million annually. For the purpose of calculations, this study used 250W because it is the median value. A 120W LED street lamp can replace a 250W HPSV street lamp.

In considering the scope of this study that covers only the Nairobi CBD .Data collection was done for the major streets on the energy usage rate for 2016 and 2021 for comparative analysis.

4.2.4.1 Street Light Energy Consumption

Control pillars are the points along the street that street lights are switched and energy consumption metered. Longer streets have more than one control pillar depending on the amount of lighting load to be supported along the street. Table 4.6 shows the distribution of control pillars along each street.

Table 4.6 :Distribution of control pillars per street

Street	No. of Control Pillars
Uhuru Highway	4
Kenyatta Avenue	3
Tom-Mboya Street	5
Moi Avenue	4
Luthuli Avenue	1
Ronald Ngala	2
Mama Ngina	1
Koinange Street	2
Biashara street	1
Harambee Avenue	1
Haile Selassie	6
Parliament RD	1
Muindi Mbingu	1
University Way	2
River Road	6
Kirinyaga Rd	4
Accra Rd	2
City Hall way	1
Wabera Street	1

This study considered the energy consumption for street-lighting within the Nairobi CBD for the year 2016 and 2021 and the findings were as shown in the Fig 4.7;

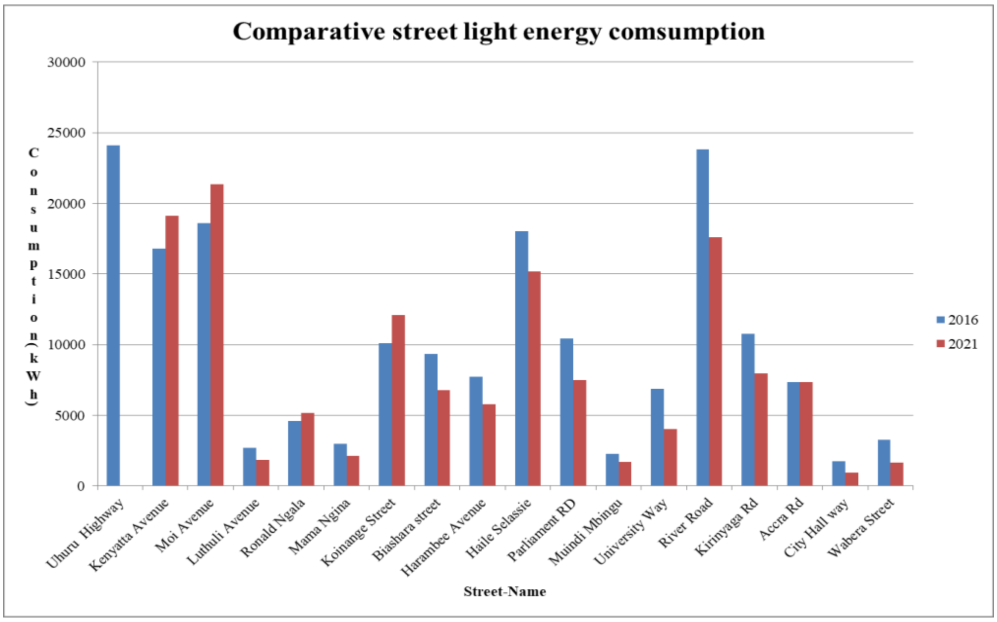

Figure 4.7 Street light Energy consumption (2016&2021)

Implementation of EE programs for street lighting has led to variations in the energy consumption. Within the CBD,EE programs have not been implemented across board as some of the streets still remain installed with the high energy consuming HPSV lamps. Figure 4.7 compares the energy consumption per street during 2016 when EE programs for street lighting had just kicked off and 2021 when there has been considerable progress in the roll out of these programes.Major streets like Kenyatta Avenue ,Moi Avenue and Koinange street have registered increase in consumption majorly because energy efficient lamps have not been retrofitted on these street-lights coupled up with the fact that there has been an expansion of street lighting units along these streets in the five years considered.Other streets like river road however has seen a concerted effort by the electrical department to roll out the energy efficient lamps hence there is a significant realization of energy savings.

4.2.4.2 Street lighting EEPs

This study also determined EE programmes that have been implemented in every street and identified the extent of implementation as shown in Table 4.7.

Table 4.7 Street lighting EE programs

No.	Street	No of Lights		EE upgrade	No. of HPS to LED	Lights Working
		2016	2021			
1	Luthuli Avenue	8	12	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	12	6
2	Ronald Ngala	27	32	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	32	25
3	Mama Ngina	12	12	-Timer Control Switching to Photocell switching	0	9
4	Biashara Street	20	20	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	20	18
5	Harambee avenue	22	22	-Replacement of HPS with solar powered lights	0	22
6	Haile Salassie	45	58	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	33	47
7	Parliament Rd	12	12	-Timer Control Switching to Photocell switching	0	12
8	Muindi Mbingu	6	6	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	6	6
9	University Way	18	18	-Timer Control Switching to Photocell switching	0	12
10	River Road	63	72	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	45	64
11	Kirinyaga Rd	22	22	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	22	10
12	City Hall Way	5	5	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	5	5
13	Wabera St	9	9	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	9	7
			300		184	243

4.2.5 Traffic Lights

Nairobi City County currently has around 30 traffic light intersections in the CBD (as of 2021). Previously, all traffic lights were based on the incandescent type of lamps with halogen lamps also used. As of 2018 , the re-engineering of traffic lighting took off in Nairobi with the older lamps being retrofitted with LED types as part of Energy Demand Side Management programme.Traffic management signal unit which is embended within the Transport Department of NCCG manages all of the countys traffic lights.

4.2.5.1 Savings From Traffic Lighting EEPs

The monthly consumption of traffic lights stood at 14,833 kWh during the baseline period of 2016, post retrofit in 2021 the energy consumption for traffic lights stood at 9754 kWh which translates to a 65% energy saving as shown in Table 4.8.

Table 4.8:Nairobi City County Traffic lights Energy Savings

Lighting technology intervention	Year completed	Current light (W)	Retrofit (W)	Total no of Lights	kWh per annum	% Saving off 2016 baseline
	2016	75	8	90	14833	
Incandescent to LED	2021	75	8	125	9754	65

Even though the number of traffic intersections has increased, the LED traffic lighting intervention has reduced electricity consumption by 65%. This is an excellent case of the added value of the efficiency of resource and decoupling (Schaffartzik, et al., 2014; West,et al, 2014).

4.3 Section II :NCC Business Model For EEPs

Figure 4.8 depicts the composition of this implementation model, which seeks to institutionalize EE in the operations of NCCG. A business model in the context of a City county is enumerated as a process that draws out the procedure needed to implement EE in a way that is sustainable. The business model is made up of three layers: a policy layer, a setting layer of the organization, energy targets and business plans at the department level.

These three aspects are needed to guarantee EE within the NCCs operations, is institutionalised.

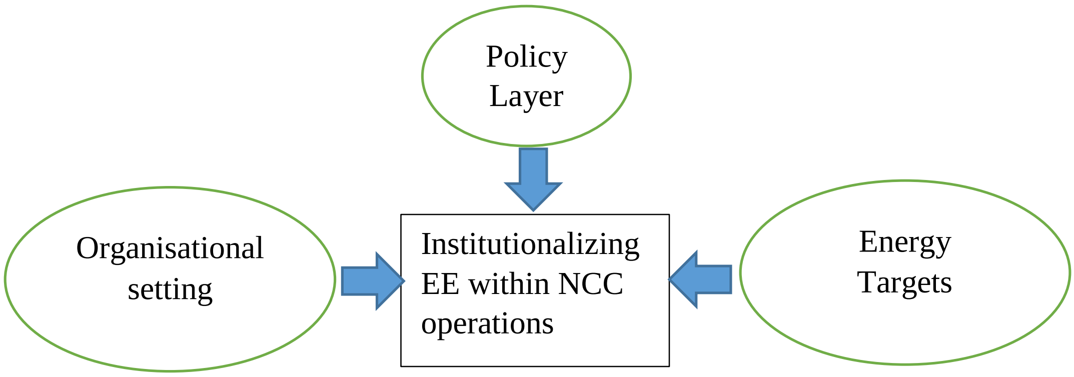

Figure 4.8;Implementation Model Building Blocks

4.3.1 Institutional Framework And Policy

Nairobi City County has an Energy Management Strategy (NCC, 2014) and Energy Efficiency Action Plan (NCC, 2016). The two strategies and policies serve as the overall policy framework that explains the reasons why the county requires a sustainable energy consumption. The Energy Efficiency Action Plan (NCC, 2016) establishes an energy consumption target for the county's internal operations. Through the Energy Efficiency Action Plan, these policies and strategies have enabled the implementation of various energy efficiency and renewable energy programs. The Energy Department has been able to secure a number of grant funding to initiate and implement EEPs.However there still exists a policy gap when it comes to continuation, consolidation, and mass roll out by all county departments. Departments need specific policy frameworks that definitively defines roles and responsibilities in order to drive and embed energy efficiency as part of their normal business plan. The IEM(Internal Energy Management) Protocol was created with the specific goal of clearly defining the department's energy responsibilities.

The IEM Protocol is the business model that has been adopted by the electrical department since 2017. The NCCG parent department responsible for energy supported the business model and tasked the Electrical Department with piloting it as part of the pilot phase of implementing the Internal Energy Management Protocol process.

The Energy Department has been tasked with assisting other departments in conducting a gap analysis, moving into the prioritization phase, and developing five-year business plans. The Electrical Department has been tasked with implementing the Internal Energy Management Protocol process with two pilot departments, namely Devolution, Public Service and Administration, and Environment Energy. Water and sanitation.

4.3.2 Recomended Business Model

For an optimized implementation and effective roll out of EEPs within NCCG operations, this study , developed a business model that would guarantee a sustainable implementation of EEPs within the county.This was made possible by the institutional framework and policy already existing. The variables under consideration in this business model are financing/investment,technology,policies and NCCG energy usage characteristics.The key objective of the business model therefore is to extract maximum value from the NCCG energy source with minimal cost implications.

4.3.2.1 Energy Performance Contracting (EPC) Model

Based on the analysis on the success rates of the current EEPs as analysed in table 4.6,table 4.8 and table 4.9,it is indicative that there exists challenges in the roll out of EEPs with success rate of the majority of the EEPs ranking at less than 50%.This is as a result of challenges associated with financing and those linked to the security of the programs i.e vandalism. The EPC model therefore addresses the gaps associated with financing which stands out as the major drawback in the EEPs implementation.An EPC therefore is defined as a mechanism of paying for the current facility upgrades using the future energy savings without the need of tapping into the NCCG capital budgets.

This model involves a partnership between the utility and the NCC and presents the advantage of being timely and cost effective in implementing EEPs that involve comprehensive energy upgrades. The Utility otherwise refered here in as Energy Service Company (ESCO) for Nairobi county is Kenya Power and Lighting Company Limited(KPLC).

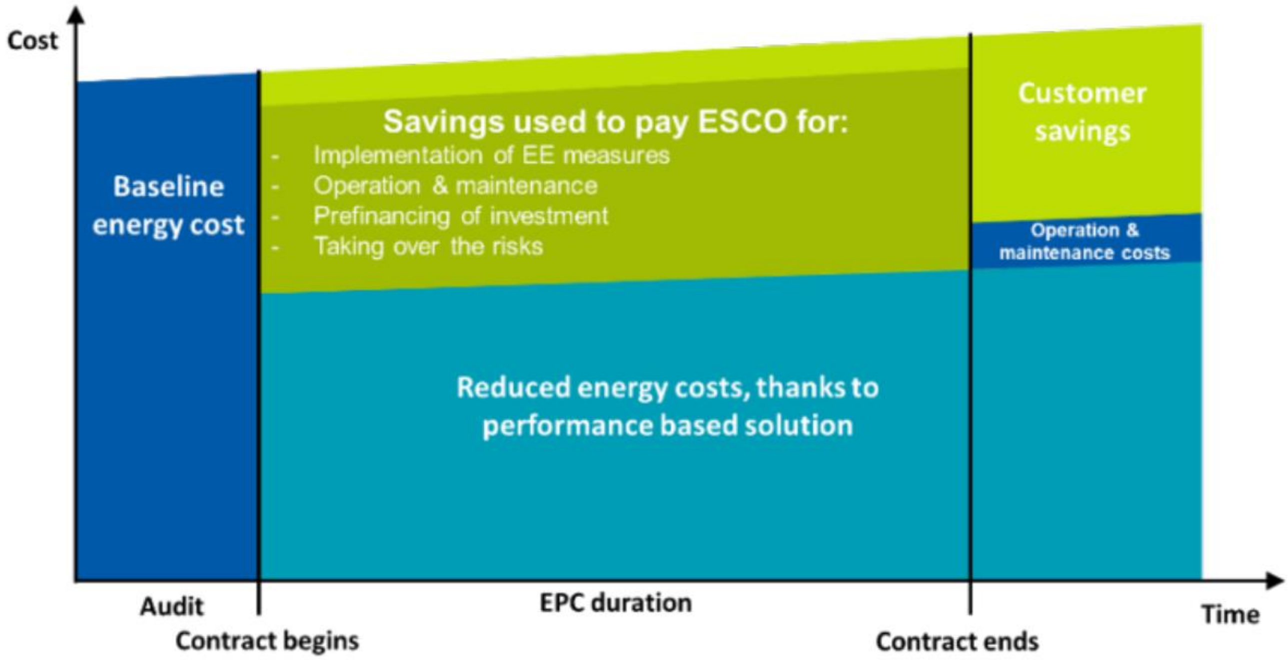

Fig 4.9 An EPC model time lines

In looking at EPC , figure 4.9 shows an implementation illustration for EEPs. This shows that the EPC is initiated after an energy audit of the NCCG inorder to determine the Baseline energy cost.During the EPC duration , there are energy saving realized after the implementation of performance based solutions and these savings are used to pay the utility-ESCo for the implementation of EE measures,operations and maintenance,Prefinancing of the EE investement and Risk mitigation. At the end of the EPC there is a reduced energy consumption and NCCG realizes energy savings onwards.Figure 4.10 shows the EPC implementation process. This process involves energy auditing,EEPs development and implementation,financing and evaluation.

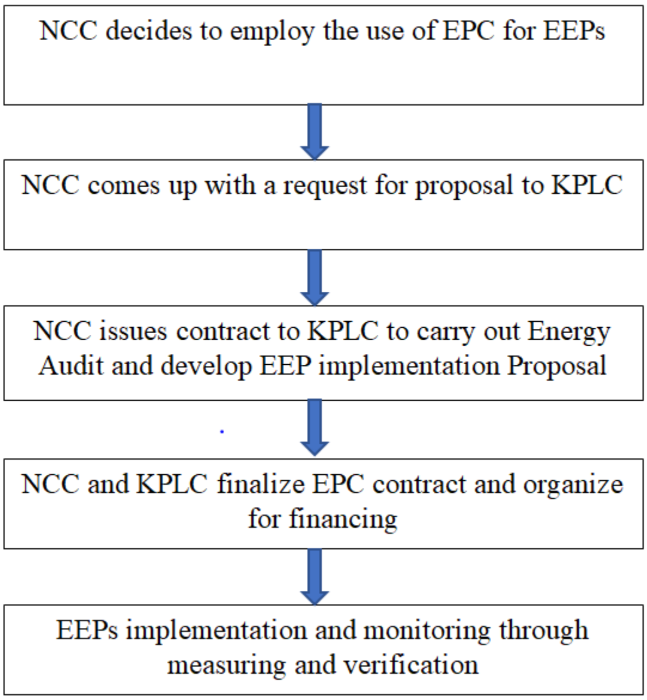

Fig 4.10 : EPC model main steps

Within the EPC model a complementing sub-model should also be incoperated. This model is refferd to as the Pay-as you save model which involves the NCC procuring EE devices and equipment such as LED luminaires from KPLC while the NCC continues to pay the baseline utility bill until such a time the ownership of these equipment is transferred to NCCG. This is key in acquiring capital intensive equipment such as transformers that are more energy efficient.

4.4 Summary of EEPs

The EEPs that the NCCG have rolled out in its operations have largely fallen within three key areas. These areas are in the County buildings,street lighting and traffic lighting.This is because these areas form the biggest bulk of electicity consumption in the running of the county operations.Each sector therefore has an identified number of EEPs that are aimed at achieving the objectives of the NCCG energy targets.These programmes include sustainable energy designs,energy monitoring,load control,retro-commisioning and Energy audits.The implementation rate of these programes were measured against the achievement targets of the programes and challenges to implementation identified .Some of these EE programmes however remain unimplemented due to the nature of the sector i.e existing building designs pause a challenge in redesigning due to the logistical and heavy capital challenges associated with such programmes. EE programmes that are procedural and behavioural on the hand have seen a good success rate of implementation as shown in Table 4.9.

Table 4.9 Summary of EEPs proposed in Buildings,Street lights and Traffic Lights and the Implementation Rate

Sector	EEP	Detail	Implementation Rate
Building	Sustainable Energy Design	-Improved Natural ventilation -Adoption of Solar Energy supply and solar water heating systems	0% - NCC buildings are still dependent on forced ventilation ,adoption of solar supply remain insignificant Solar water heating not done
	Energy Monitoring	-Metering of all energy usage area -Energy Reporting and evaluation system	100% - Modular metering for building usage exist with a complete energy reporting system
	Load Control	-Large loads switching procedure -Load optimization	100% - Porcedures for load switching exist
	Retro-Commisioning	-Replacing older lamps with more energy efficient options -Low cost/no cost programes for control	25% - There stil exist a considerable number of street light that have not neen retrofitted
	Audit	-Energy Audit for NCC buildings -Implimentation of Audit findings	50% - Periodic energy audits are done while Audit findings remain unclosed
Street Lighting	Energy Monitoring	-Implement control optimal control column frame work for closer energy monitoring -Monthly reading of energy meters	50% - Control columns have been implemented while readings are not regular

	Retrofitting street lights	-Replacing HPMV and HPSV lamps using energy efficient LED lamps -Replacing Convectional street lighting with Solar street lighting	4% - A large number of street lights still depend on HPMV and HPSV lamps. Solar lamps have only been deployed on a pilot basis
Traffic Lights	Retrofit	-Traffic lights using incadesent lamps replaced with LED options	65% - a significant number of traffic lights have been replaced with LED options

4.5 Economic Analysis of EEPs implementation

Investments in EEPs are required to plough back returns for the purposes that they were initiated.The table 4.10 shows the NCCG budgetary allocation for the EEPs for the periods of 2016-2021 as per the budget schedules of the county assembly of the Nairobi City Government (NCCG budget report 2016/17,2017/18,2018/19,2019/20,2020/21)

Table 4.10 NCCG EEPs budgetary allocation

FY	Operation Areas		
	Building Installations Retrofits	Street Lighting Upgrade	Traffic lights Retrofit
2016/17	Kshs. 10million	Kshs. 22million	Kshs. 5million
2017/18	Kshs. 34million	Kshs. 7million	Kshs. 1.8million
2018/19	Kshs. 13million	Kshs. 95million	Kshs. 2million
2019/20	Kshs. 53million	Kshs. 112million	Kshs. 3million
2020/21	Kshs. 25million	Kshs. 75million	Kshs. 5million
Total Amount allocations	Kshs.135 million	Kshs.311million	Kshs.16.8million

From Table 4.11, the total budgetary allocation for the retrofit of building installation over the 5 year period was Kshs. 135 million ,street light upgrade was Kshs. 311million and traffic lighting was Kshs. 16.8 million.

In Table 4.3,the annual energy savings for building facilities was 845,236kwh translating to a financial savings of Kshs. 21,130,900 annually.The payback period for the EEPs of the building facilities is calculated as ;

$$T_{Payback} = \frac{135million}{21130900} = 6.38years$$

The streetlighting annual electricity bill droped from Kshs. 444million in 2016 to Kshs. 396 million leading to a decrease of 10.8%. The payback period attributable to street lighting is calculates as

$$T_{Payback} = \frac{311million}{48million} = 6.7years$$

In Table 4.9, the annual energy savings from traffic lights as at 2021 was a monthly savings of 5,079kWh/yr translating to Kshs. 126,975 per month of savings. The payback period for the traffic lights is therefore as calculated;

$$\mathrm{T_{payback}} = \frac{16.8\text{million}}{126{,}975*12} = 11.02 \text{ years}$$

Table 4.11 Summary of Payback period

Item	Duration	Description	Financial Allocation	Annual Savings	Payback Period (years)
1	2016-2021	Building facilities	Kshs.135M	Kshs.21.3M	6.4
2	2016-2021	Street lighting	Kshs.311M	Kshs.48M	6.7
3	2016-2021	Traffic lighting	Kshs.16.8M	Kshs.1.53M	11

From the payback values , the EEPs are able to derive economic value to the NCCG within a medium term plan.

4.6 Validation

This study was specific to assessment of electrical energy efficiency programmes within the public sector thereby bridging gap in research on energy policy implementation within the public sector in Kenya and the challenges to the success of adoption. Similar studies of this nature have been carried out globally focusing both on the public sector and private sector. One such study was the assesmnet of implementation of energy efficiency measures,savings achieved and barriers to implementation in the hospitality industry in Kenya.The objective of this study was to identify and recommend the best energy management practises that would aid the hospitality industry in rolling out energy efficient measures so as to attain better cost savings.This study did rely on the efficient management procedures that are not found in government organisations and the variables of this study were confined to lighting strategies.(Kariuki&Odhiambo,2021)

In a study of the municipality of Cape town,Mohamed(2016) assessed the energy efficiency programes within the operations of the municipality with a focus on understanding the achieved outcomes of these programmes. The research made use of a case study to analyse the energy situation of the municipality with key focus on municipality buildings ,street lighting and traffic lighting with the aim of developing a business model to aid in the sustainability of the EEPs within the Municipality.The study therefore beared similarity with this research as scope of this research was on NCCG.These similarities stem from the fact that both areas of study involve a government organisation and therefore the challenges are similar.Mohamed(2016) develops a business model that enables municipal departments to design a standardised means of setting energy targets,Implementing EE measures and tracking financial and environmental performance.

Energy Efficiency in Kenya : Public awareness ,strategies,Challenges and opportunities is another study that is relatable.The scope of this study is limited to households and how they consume energy based on their awareness on energy consumption.It also evaluates pertinent policy instruments with regards to EE,the associated measures and challenges facing EE in Kenya (Martin et al,2019). In drawing inference, the study on EEPs of NCCG within its operation builds on this research by considering the awareness of NCCG staff towards EE and the Challenges the EEPs face in their implementation.

4.7 Chapter Conclusion

This Chapter on Results and discussion has two sections. The first section looks into the EEPs that have been implemented and those that are planned for implementations by focusing on the NCCG internal operations of building services,street lighting and traffic lighting. The results show that the energy consumption for the city hall complex reduced from annual consumption of 1,842,304kWh in 2016 to 997,068kWh in 2021 due to the EEPs that have been instituted.This section also identifies the EE measures that have been done in streetlighting as shown in appendix III. The challenges of EEPs implementation have also been identified. Section two dissects the business model that the NCCG can use in rolling out EEPs by analysing the institutional framework and policy where energy targets and organisational setting are key tenets of the proposed model. This chapter sums up the results and discussion by highlighting the summary of EEPs, economic analysis of the EEPs implemented so far and a comparative analysis of similar studies that validate this study.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study aimed to assess the energy efficiency programmes of Nairobi City County Government within its internal operations and document the challenges faced during implementation. The targeted population of the study comprised the electrical department.

This chapter also summarizes the key findings that could be used as a framework by other counties and possibly other government state-owned entities to standardize the implementation of energy efficiency within their infrastructure and operations.

Possible suggestions and the drawbacks to this research are highlighted with regard to resolving them. Key improvements are summarized within the business model developed while opportunities for future research are identified.

5.2 Key Findings of Study

Through this study, there has been an enhancement in an understanding of energy efficiency within Nairobi City County Government internal operations, and the research objectives that were set up were answered. Electricity constitutes 29% of energy usage in the Energy Profile of Nairobi County, with county buildings consuming 27% of the electricity while street lights and traffic lights consume 28% and 3%, respectively. The EEPs that have been instituted in the city hall complex have led to a 32% decrease in electricity consumption between the years 2016 and 2018, with the EEPs including the replacement of luminaires with more energy-efficient options. One hundred eighty-four lamps have been replaced with LED options translating to a 4% conversion rate for the street lighting, with some not operational due to faults and vandalism. Finally, traffic lighting has a 65% LED conversion rate, with incandescent lamps being 14833 in 2016 and 9754. The study's findings are summarised as follows, with points (a) to (e) summarizing all results of the research questions of this study.

5.2.1 Connecting the Literature with Practice

A thorough review of the literature confirmed the barriers, lessons learned, and best practices in energy efficiency within the city-county context. Energy efficiency interventions and programs are inextricably linked to climate change mitigation goals, and the case for increasing energy efficiency is made from both a financial and environmental standpoint.

NCCG has followed the emerging trend by making the advantages of integrating energy efficiency visible within the organization by developing a data monitoring and reporting system and energy development through its policy framework. This procedure has proven to be beneficial. The case study chapter evaluated NCCG's current energy efficiency programs. According to the case study, most departments are only concerned with projects' financial and personnel implications. As a result, any benefits, programs, or processes developed must demonstrate how they will positively impact departments' financial and staff components.

The results and impact of energy efficiency interventions implemented in the NCCG's internal operations were presented in Chapter 4. The findings confirmed those found in the literature review section. Simple measures to implement, such as energy-efficient street, traffic, and building lighting interventions, result in significant savings. Energy-efficient street and traffic lighting is not difficult to implement. Because energy-efficient building programs are more complex, an energy audit and smart metering must develop a baseline and confirm savings. This necessitates a rethinking of how the benefits of energy efficiency projects are communicated to various actors within the organization.

Monitoring and data collection necessitate a different and more robust approach to ensure that the maintenance and staff benefits are considered in addition to the energy and financial savings recorded.

5.2.2 Data Access and Collection

This study emphasized the importance of an integrated and consolidated data system within the NCCG's internal operations to monitor and manage the NCCG's internal energy consumption effectively. This study revealed a large amount of data available in the NCCG's systems. The NCCG's fragmented systems have been the real challenge. Piecing together a department's energy profile is monumental, as energy data is scattered across many disparate systems. Creating an integrated and consolidated energy data management system within the NCCG will open up numerous opportunities to implement additional energy efficiency interventions. NCCG's energy data management system will be a one-stop-shop for all energy data. Departments will know their total energy consumption for the first time. This will enable several behavioural changes and basic energy management opportunities, resulting in additional energy savings.

5.2.3 Barriers To EEP implementation in NCCG

This study also revealed some key barriers to EEP implementation in NCCG and summarized them in table 4.12.

Table 4.12 : Barriers To EEP implementation in NCCG

Barrier	Components	Identification Criterion
Uncertainty and Risk	External Risk	Investments into EEPs only make practical sense if savings are assured in the long term. However there exists uncertainty about future energy prices as energy may get cheaper due to more cost effective acquisition of sustainable energy source. Additionally ,Policy regulation environment with regards to emerging technologies that aid in EEP implementation may affect the rate at which NCCG approves the deployment of EEPs
	Technical Risks	These risks are associated with technology itself given the quick evolving nature of technologies associated with EEPs. Technology must also be useful to the NCCG operation processes and uncertainty exists in its usefulness to that process
Hidden Costs	Overhead costs	These are the costs that are indirectly related to an investment in energy efficiency programmes and involves costs associated with investment decisions and technology scouting
	Specific investment costs	Costs not embedded in the cost price of the new technology for EEP, but which are necessary to make the machine/equipment fit in the current operation processes of NCCG
Organizational Barriers	Organization structure	NCCG is a government organization hence decision making is largely consultational. Information flow and management is

		therefore asymmetrical making coordination of EEPs form financing to implementation tedious
	Organization Culture	This is based on the work ethics that exist in NCCG and points to factors of Resistance to renewal, inertia and personal involvement.
Availability and allocation of capital	Availability of Capital	EEPs can only be implemented when there is sufficient capital to sustain them. NCCG needs to source for capital from within its own revenues or seek external finance to capitalize the EEPs. This becomes a barrier to NCCG because a lot of times, it is unable to find the financing for the EEPs.
	Allocation of Capital	NCCG allocates money according to its investment priorities. In most instances, other functions of NCCG rank higher in priority I,e the recurrent expenses than development projects and therefore budgetary allocations are either constrained or redirected elsewhere.

Table 4.12 is supported by Masselink (2018) who identifies factors to do with Organization, uncertainty, risks, financing, information and knowledge and creep costs as major barriers in the adoption of EEPs within the private sector organizations. In order to guarantee the success of EEPs in NCCG operation, the barriers identified in Table 4.12 should form the back bone of all EEP planning in the city government as part of their SWOT analysis. This enables the NCCG to be abreast and aware of the bottlenecks that may arise and develop a mitigation plan with a long-term projection.

5.2.4 Business Model

Research question number three required the development of a model that guarantees a sustainable implementation of EEPs in NCCG operations. Given the findings, recommendations are considered by this study. Internal Energy Management Protocol(IEMP) is the proposed business model for NCCG operations concerning implementing EEPs. It allows for a streamlined business process that all the NCCG departments implementing EEPs can consider adopting.

5.3 Recommendations for Further Work

This study has realised what is needed to institutionalize EE to win NCCG operations. However, for a more refined improvement to the outcomes of this study, further improvement areas are proposed. These are summarized as follows.

5.3.1 Improvements to Implementation Model

There is need for improved data that considers the factor of investment cost, as was found in the design of the EEPs business model for NCCG. The investment cost factor (ICF)involves the overall cost of acquiring the technology alongside the associated savings accrued from the investment cost.

Therefore, obtaining a larger data set to validate the investment cost factor within a specified period is prudent. The ICF is concurrently updated for future projections of the cost of investments. There is a gap for further research in this area as the nature of interventions implemented; the savings gained per technology type are required to develop an ICF. An improvement and expansion of the sample size for the data set is key to ensuring reliability in the establishment of an ICF per technology type.

5.3.2 Collection of Data and Monitoring

The development and implementation of an energy data management system will require complete operationalization to show a reliable trendline of electricity consumption from the metered baseline and subsequently assess the effect of the interventions of EEPs. This is because the EDMS is dependent on the level of success of the roll-out of smart meters. The electrical department has developed a theoretical standard operating procedure to mitigate this challenge in determining the county's electricity consumption. However, the major drawback that still exists is that no tool or method enables the electrical department to track all the EE interventions carried out in all the departments of NCCG. Presently only one department has its EE interventions monitored, with the other remaining 12 departments still lacking a means of monitoring their EE measures. This makes the determination of the collective impact of EEPs unknown. A much more robust methodology is needed during the absence of metering to capture the effect of all internal NCCG departments.

5.3.3 Keeping Updated with Technology Improvements

This study recommends that all NCCG departments carry out a detailed market analysis within two or three years for the county government to be kept up to date with the advancements in technology within building energy efficiency, street lighting, and traffic lighting. This will easily guarantee easier and timely adoption of these technologies in the county government's business process when upgrades are due or a need for acquisition.

5.3.4 Recommendation For Adoption Of Findings

This study recommends the adoption of findings to improve the rollout of EEPs in the operations of NCCG as follows;

(i) Carry out a comprehensive energy audit for the county building facilities and determine the extent of EEPs instituted in the building facilities county-wide. This should therefore identify the energy consumption profile of each building and tailor-make the appropriate EEPs that build on the energy objectives of the county.

(ii) Install smart meters for efficient tracking of energy usage especially in street lighting.

(iii) Develop solutions to the challenges identified in this study, impeding the implementation of EEPs. These challenges, vandalism and rollout bottlenecks should be mapped, and a mitigation plan should be developed. This should be under the responsibility of the Energy department of the NCC.

(iv) The business model for implementing EEPs should be incorporated into the EEPs planning. This will guarantee predictable and sufficient financing for the EEPs while ensuring that the programmes are suited for the desired objectives. This will also streamline the EEPs workstream to ensure greater implementation success and sustainability. This initiative has its responsibility in managing the Department of Energy of NCC.

5.4 Limitations of the Study

This study concentrated on the Nairobi City County electrical department only. Many factors influence Energy-efficiency in the county government . In this study, the intervening factors were inferred from the responses of the targeted population of the study. Nevertheless, the study could have been more inclusive if other departments such as human resources, procurement, and finance were incorporated.

Other large players in street lighting within the Nairobi City County, including private companies in the PPPs, KeNHA, KURA and KPLC, could also have contributed to the study. The organizations above were not inclusively covered in the study.

5.5 Main Contribution

This study contributes to the understanding of the usage of electrical energy of the NCC. Due to the nature of the NCC organisation, a comprehensive energy outlook is lacking for energy planning and initiatives employed with regard to the operations of the county government. Therefore, this study evaluates and develops an energy outlook of the county regarding operations involving electrical energy consumption. Additionally, EEPs within the county are not tracked in their implementation; hence, the global outlook on the effect and implementation outline has been missing. Therefore, this research provided a platform for evaluating the implementation of EEPs within the county and provided the performance level within county building facilities,street lighting programmes, and traffic lighting.NCC management can make an informed policy decision and carry out better energy planning using this study as a comprehensive reference in rolling out additional EEPs while streamlining the implementation of the current EEPs.

The success of implementing EEPs is highly reliant on the business model to guarantee the sustainability of the programs and encourage further roll-out of additional energy-saving measures. The study proposes an optimal business model based on an institutional framework premised on energy targets, policy layers and organisational setting. This will lead to an alignment of EEPs towards the attainment of sustainable implementation by adopting a practical financing model within the county operations.

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APPENDICES

Appendix I: Introduction Letter

Dear Respondent,

RE: <u>REQUEST FOR INFORMATION</u>

I am a Master of Energy Management student at The University of Nairobi. I request you to take part in the study. Your identity will be kept in the utmost confidence. Kindly do not append your name anywhere on this questionnaire.

Yours Sincerely,

AUDREY ADHIAMBO OBWANDA

Reg No. F56/37922/2020

audreyobs11@gmail.com

<u>RESEARCHER</u>

APPENDIX II: Questionnaire

Part A: Background Information

1. What is your gender? Male [ ] Female [ ]
2. What is your age? 18-25 years [ ] 26-40 years [ ] Over 40 years [ ]
3. How long have you worked within the energy department in the county?

   1-3 years [ ] 4-8 years [ ] Over 8 years [ ]

Part B: Research Questions

4. **Rate of energy use**

a. Are there measures that have been put in place to measure the rate of energy use of the internal operations? Yes [ ] No [ ]

b. How frequent is the rate of energy use reviewed?

   Weekly [ ] Monthly [ ] Quarterly [ ] Semi-annually [ ] Annually [ ] None [ ]

c. Kindly rate the following statements in relation to rate of energy use within Nairobi County's internal operations.

Key: 1= Strongly disagree; 2=Disagree; 3=Not sure; 4=Agree; 5 Strongly agree

Rate of energy use	1	2	3	4	5
The energy use is rated based on county's industrial usage					
The energy use is rated based on consumption by county buildings					
The energy use is rated based on consumption by the county street lights					
The energy use is rated based on domestic use by county employees					
The energy use is rated based on commercial operations of the county					

Others (specify):

5. **Energy Efficiency Programmes**

Kindly rate the following statements in relation to Energy Efficiency programs within Nairobi County's internal operations.

Energy Efficiency programs	1	2	3	4	5
There is the adoption of policy on use of green programs within the county					
There is training and behaviour change regarding energy efficiency					
There are building codes and appliances standards adopted by the county					
There are energy benchmarking measures					
There is promoting use of the energy saving bulbs					

Others (specify):

____

____

6. **Kindly rate the following statements in relation to Energy Efficiency success within Nairobi County's internal operations**

Key: 1= Strongly disagree; 2=Disagree; 3=Not sure; 4=Agree; 5 Strongly agree

Rate of energy use	1	2	3	4	5
There has been saving of energy in the process					
The cost of energy has reduced and thus reducing cost of operations					

Others (specify):

____

APPENDIX III: Energy Data

Reading for City Hall-2016 (Before Energy Saving measures)

	kWh1	kWh2	kWh3	kVA	Total kWh
Nov	4296937	1815769	846162	98	
Dec	4301069	1898518	859949	101	100668
Jan	4315029	1981267	873458	102	110218
Feb	4329178	2064016	887523	96	110963
Mar	4353525	2146765	901310	102	120883
Apr	4367677	2229514	918102	100	113693
May	4381829	2312263	929454	101	108253
Jun	4395981	2395012	942671	102	110118
Jul	4410133	2477761	961784	101	116014
Aug	4424285	2560510	970245	104	105362
Sep	4438437	2643259	988631	97	115287
Oct	4452589	2726008	997819	96	106089
Nov	4466741	2808757	1011606	101	110688
TOTAL					1328236

Reading for City Hall-2021 (After Energy Saving Measures)

	kWh1	kWh2	kWh3	kVA	Total kWh
Nov	5987592	3643599	2204580	109	
Dec	6008725	3657515	2224469	109	54938
Jan	6027843	3671430	2244357	107	52921
Feb	6050962	3685339	2264237	109	56908
Mar	6072092	3699253	2284118	109	54925
Apr	6098412	3713167	2304009	111	60125
May	6113430	3727088	2323884	109	48814
Jun	6135165	3740995	2343768	107	55526
Jul	6156581	3754909	2363650	109	55212
Aug	6174304	3768826	2383533	108	51523
Sep	6197945	3782737	2403419	109	57438
Oct	6219950	3796651	2423299	109	55799
Nov	6241073	3810564	2443182	112	54919
TOTAL					659048

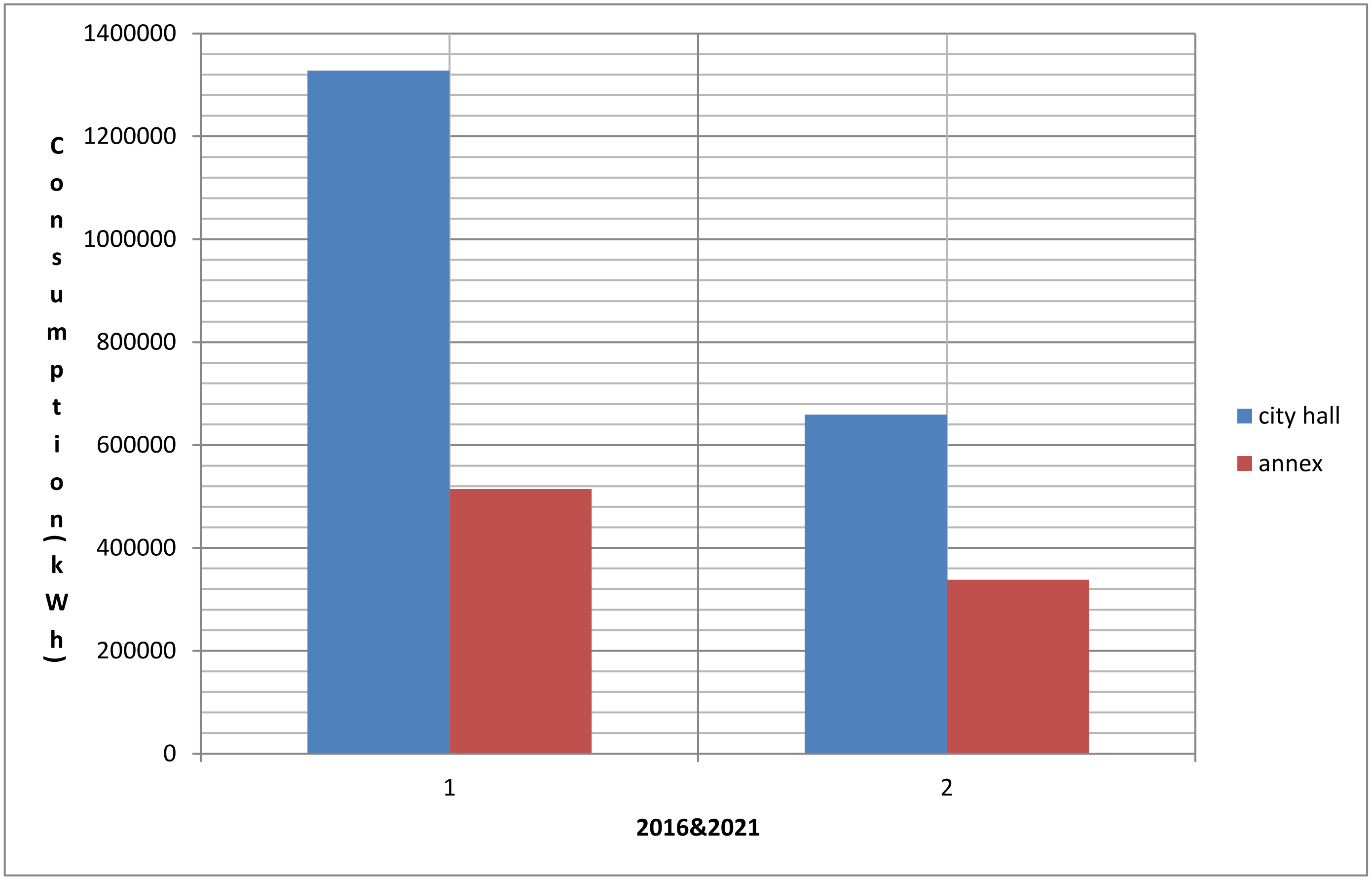
Readings for City hall Annex-2016(Before Energy saving measures)

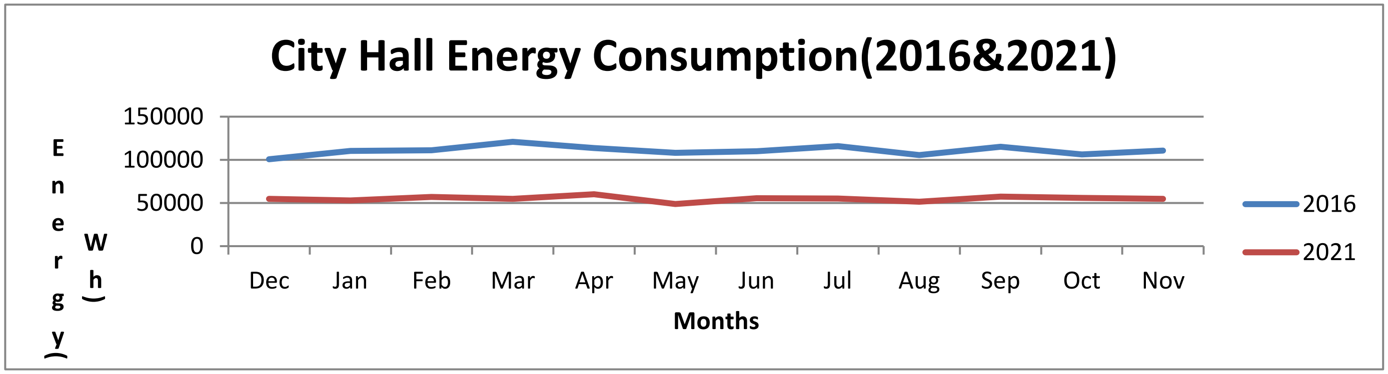
	kWh1	kWh2	kWh3	kva	Total kWh
Nov	3803314	2146894	909066	123	
Dec	3818157	2162236	921720	119	42839
Jan	3833000	2177578	934374	118	42839
Feb	3847843	2192920	947028	122	42839
Mar	3859639	2208262	959682	121	39792
Apr	3877529	2223604	972336	128	45886
May	3892372	2238946	984990	126	42839
Jun	3907215	2254288	997644	127	42839
Jul	3922058	2269630	1010298	124	42839
Aug	3938746	2284972	1022952	122	44684
Sep	3951744	2299415	1035606	120	40095
Oct	3966587	2315656	1048260	119	43738
Nov	3981430	2330998	1060914	124	42839
TOTAL					514068

Readings for City hall Annex-2021(After Energy saving measures)

	kWh1	kWh2	kWh3	kva	Total kWh
Nov	4739542	2915710	1746210	81	
Dec	4753738	2920831	1755312	81	28419
Jan	4764041	2927952	1760113	79	22225
Feb	4771129	2939073	1770911	75	29007
Mar	4779326	2948194	1782282	74	28689
Apr	4794522	2955673	1792050	76	32443
May	4804718	2964436	1803486	80	30395
Jun	4815043	2972557	1810586	79	25546
Jul	4825110	2980678	1821354	79	28956
Aug	4835306	2983799	1831122	81	23085
Sep	4842956	2994532	1839673	75	26934
Oct	4855698	3005041	1850658	74	34236
Nov	4865894	3013162	1860426	79	28085
TOTAL					338020

GRAPH OF ENERGY CONSUMPTION FOR CITY HALL AND CITY HALL ANNEX IN 2016 AND 2021 RESPECTIVELY





Nairobi CBD sub-county Street light Control Pilars

	Uhuru Highway	Kenyatta Avenue	Tom-Mboya Street	Moi Avenue	Luthuli Avenue	Ronald Ngala	Mama Ngina	Koinange Street	Biashara street	Harambee avenue	Haile salassie	Parliament RD
No. of Control Pilars	4	3	5	4	1	2	1	2	1	1	6	1

	Muindi Mbingu	University Way	River Road	Kirinyaga Rd	Accra rd	City Hall way	Wabera Street
No. of Control Pilars	1	2	6	4	2	1	1

Uhuru Highway 2016

	Control Pilar No.1			Control Pilar No.2		Control Pilar No.3		Control Pilar No.4				Control Pilar No.5	**Total Usage (kWh)**
	Meter 1	Meter 2	Meter3	Meter 1	Meter 2	Meter 1	Meter 2	Meter1	Meter 2	Meter 3	Meter 4	Meter 1	
Nov	26548	647648	47684	548443	38595	4875	683649	54247	59596	48645	9645	653785	
Dec	26631	648108	47826	548558	38647	4897	684057	54301	59669	48781	9645	654054	1814
Jan	26723	648590	47979	548683	38693	4921	684472	54365	59737	48917	9645	654328	1879
Feb	26810	649065	48124	548809	38738	4950	684880	54425	59799	49051	9645	654594	1837
Mar	26899	649575	48269	548928	38786	4975	685293	54486	59863	49181	9645	654861	1871
Apr	26984	650070	48420	549052	38837	4998	685687	54544	59929	49315	9645	655132	1852
May	27074	650550	48559	549186	38886	5025	686086	54607	59988	49454	9645	655400	1847
Jun	27155	651020	48702	549314	38948	5049	686492	54669	60049	49590	9645	655670	1843
Jul	27234	651502	48854	549442	39004	5087	686904	54725	60114	49735	9645	655924	1867
Aug	27316	652003	49001	549565	39058	5099	687314	54783	60186	49877	9645	656183	1860
Sep	27391	652499	49144	549681	39108	5126	687721	54841	60259	50018	9645	656448	1851
Oct	27471	653009	49278	549813	39146	5151	688139	54901	60330	50160	9645	656712	1874
Nov	27560	653494	49407	549940	39187	5190	688544	54960	60404	50296	9645	656979	1851
Dec	27645	653990	49539	550064	39240	5211	688940	55018	60475	50434	9645	657250	1845
TOTAL													24091

Uhuru Highway 2021

	Control Pilar No.1			Control Pilar No.2		Control Pilar No.3		Control Pilar No.4				Control Pilar No.5	**Total Usage (kWh)**
	Meter 1	Meter 2	Meter3	Meter 1	Meter 2	Meter 1	Meter 2	Meter1	Meter 2	Meter 3	Meter 4	Meter 1	
Nov	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	
Dec	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Jan	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Feb	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Mar	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Apr	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
May	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Jun	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Jul	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Aug	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Sep	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Oct	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Nov	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
Dec	34227	692042	60699	559790	43110	7227	720686	59644	65749	61168	9645	678040	0
TOTAL													

N/B the street lights were removed due to express way construction

Kenyatta Avenue

2016							
	Control Pilar No.1		Control Pilar No.2	Control Pilar No.3			Total Usage (kWh)
	Meter 1	Meter 2	Meter 1	Meter 1	Meter2	Meter 3	
Nov	69530	309829	4021	84984	98481	48819	
Dec	69677	310542	4072	85145	98695	48819	1286
Jan	69830	311268	4118	85303	98915	48819	1303
Feb	69981	311989	4164	85465	99133	48819	1298
Mar	70133	312708	4209	85619	99355	48819	1292
Apr	70281	313429	4258	85775	99570	48819	1289
May	70426	314142	4313	85936	99785	48819	1289
Jun	70571	314860	4372	86092	100009	48819	1302
Jul	70709	315594	4426	86253	100238	48819	1316
Aug	70856	316323	4482	86402	100457	48819	1300
Sep	70998	317038	4530	86554	100677	48819	1277
Oct	71143	317744	4583	86708	100886	48819	1267
Nov	71280	318445	4634	86872	101097	48819	1264
Dec	71421	319186	4690	87032	101313	48819	1314
TOTAL							16797

2021							
	Control Pilar No.1		Control Pilar No.2	Control Pilar No.3			Total Usage (kWh)
	Meter 1	Meter 2	Meter 1	Meter 1	Meter2	Meter 3	
Nov	82767	375328	8704	99320	118305	48819	
Dec	82870	376171	8751	99495	118528	48819	1391
Jan	83068	377005	8802	99667	118753	48819	1480
Feb	83252	377844	8849	99856	118987	48819	1493
Mar	83441	378701	8899	100037	119218	48819	1508
Apr	83628	379546	8947	100233	119447	48819	1505
May	83822	380403	8995	100419	119665	48819	1503
Jun	84013	381244	9049	100594	119884	48819	1480
Jul	84199	382093	9104	100774	120094	48819	1480
Aug	84374	382927	9153	100950	120316	48819	1456
Sep	84552	383778	9200	101104	120540	48819	1454
Oct	84734	384625	9254	101265	120759	48819	1463
Nov	84914	385464	9322	101427	120977	48819	1467
Dec	85100	386285	9384	101582	121195	48819	1442
TOTAL							19122

Moi Avenue

2016							
	Control Pilar No.1			Control Pilar No.2	Control Pilar No.3	Control Pilar No.4	Total Usage (kWh)
	Meter 1	Meter2	Meter3	Meter1	Meter1	Meter 1	
Nov	5698	94752	8726	59382	32958	946321	
Dec	5772	95204	8806	59496	33124	946869	1434
Jan	5843	95657	8882	59615	33293	947421	1440
Feb	5916	96116	8960	59729	33455	947971	1436
Mar	5990	96572	9039	59837	33619	948517	1427
Apr	6064	97033	9117	59952	33788	949051	1431
May	6138	97494	9189	60074	33960	949602	1452
Jun	6216	97950	9264	60191	34114	950151	1429
Jul	6288	98408	9338	60315	34274	950704	1441
Aug	6363	98862	9410	60436	34432	951253	1429
Sep	6433	99322	9489	60557	34593	951785	1423
Oct	6504	99773	9565	60675	34751	952320	1409
Nov	6580	100224	9639	60795	34914	952856	1420
Dec	6656	100679	9713	60911	35073	953396	1420
TOTAL							18591

2021							
	Control Pilar No.1			Control Pilar No.2	Control Pilar No.3	Control Pilar No.4	Total Usage (kWh)
	Meter 1	Meter2	Meter3	Meter1	Meter1	Meter 1	
Nov	12404	136241	15635	70085	47763	995846	
Dec	12404	136525	15708	70431	48084	996456	1634
Jan	12404	136801	15786	70783	48420	997079	1665
Feb	12404	137071	15862	71141	48751	997684	1640
Mar	12404	137348	15930	71490	49086	998292	1637
Apr	12404	137629	16004	71854	49414	998904	1659
May	12404	137908	16075	72212	49744	999523	1657
Jun	12404	138189	16144	72567	50071	1000148	1657
Jul	12404	138467	16212	72902	50371	1000757	1590
Aug	12404	138744	16284	73245	50678	1001368	1610
Sep	12404	139023	16360	73595	51003	1001988	1650
Oct	12404	139305	16429	73944	51324	1002593	1626
Nov	12404	139585	16501	74298	51659	1003207	1655
Dec	12404	139864	16570	74659	51991	1003822	1656
TOTAL							21336

Luthuli Avenue

2016

	Control Pilar No.1		**Total Usage (kWh)**
	Meter1	Meter2	
Nov	14782	24832	
Dec	14856	24955	197
Jan	14929	25082	200
Feb	15002	25208	199
Mar	15080	25339	209
Apr	15157	25468	206
May	15238	25595	208
Jun	15317	25724	208
Jul	15394	25856	209
Aug	15474	25982	206
Sep	15552	26110	206
Oct	15630	26245	213
Nov	15711	26374	210
Dec	15790	26505	210
TOTAL			2681

2021

	Control Pilar No.1		**Total Usage (kWh)**
	Meter1	Meter2	
Nov	21838	36543	
Dec	21889	36630	138
Jan	21937	36715	133
Feb	21989	36800	137
Mar	22043	36889	143
Apr	22089	36982	139
May	22135	37071	135
Jun	22185	37154	133
Jul	22238	37239	138
Aug	22291	37325	139
Sep	22348	37416	148
Oct	22402	37505	143
Nov	22464	37591	148
Dec	22523	37678	146
TOTAL			1820

Mama Ngina

2016

	Control Pilar No.1	**Total Usage (kWh)**
	Meter 1	
Nov	59083	
Dec	59308	225
Jan	59538	230
Feb	59765	227
Mar	59993	228
Apr	60221	228
May	60433	212
Jun	60664	231
Jul	60904	240
Aug	61142	238
Sep	61380	238
Oct	61615	235
Nov	61844	229
Dec	62078	234
TOTAL		2995

2021

	Control Pilar No.1	**Total Usage (kWh)**
	Meter 1	
Nov	80048	
Dec	80212	164
Jan	80381	169
Feb	80550	169
Mar	80711	161
Apr	80870	159
May	81035	165
Jun	81199	164
Jul	81367	168
Aug	81529	162
Sep	81689	160
Oct	81855	166
Nov	82022	167
Dec	82189	167
TOTAL		2141

Ronald Ngala

2016

	Control Pilar No.2			Control Pilar No.2		
	Meter 1	Meter 2	Meter 3	Meter 1	Meter 2	**Total Usage (kWh)**
Nov	46735	9436	38654	76451	17482	
Dec	46791	9537	38735	76493	17563	361
Jan	46835	9636	38809	76537	17649	347
Feb	46915	9742	38886	76575	17735	387
Mar	46967	9847	38958	76616	17817	352
Apr	47028	9957	39030	76661	17900	371
May	47092	10053	39102	76697	17981	349
Jun	47166	10150	39176	76737	18066	370
Jul	47239	10252	39212	76779	18145	332
Aug	47305	10351	39236	76812	18229	306
Sep	47364	10450	39305	76849	18312	347
Oct	47426	10561	39371	76888	18398	364
Nov	47495	10667	39442	76929	18482	371
Dec	47562	10770	39511	76969	18563	360
TOTAL						4617

2021

	Control Pilar No.2			Control Pilar No.2		
	Meter 1	Meter 2	Meter 3	Meter 1	Meter 2	**Total Usage (kWh)**
Nov	52524	18774	44653	80077	25049	
Dec	52593	18895	44722	80129	25127	389
Jan	52661	19020	44788	80186	25212	401
Feb	52723	19141	44856	80241	25293	387
Mar	52794	19260	44927	80292	25380	399
Apr	52866	19380	44996	80346	25472	407
May	52935	19506	45066	80401	25563	411
Jun	53008	19628	45131	80450	25655	401
Jul	53084	19754	45203	80501	25744	414
Aug	53157	19873	45277	80555	25832	408
Sep	53230	19996	45349	80607	25922	410
Oct	53305	20114	45417	80668	26016	416
Nov	53380	20234	45433	80724	26110	361
Dec	53451	20353	45458	80778	26201	360
TOTAL						5164

Koinange Street

2016

	Control Pilar No.1		Control Pilar No.2	**Total Usage (kWh)**
	Meter1	Meter2	Meter1	
Nov	8908	0	78028	
Dec	9184	0	78495	743
Jan	9456	0	78957	734
Feb	9729	0	79422	738
Mar	10010	0	79893	752
Apr	10288	0	80349	734
May	10568	0	80818	749
Jun	10850	0	81269	733
Jul	11132	0	81718	731
Aug	11408	0	82174	732
Sep	11686	137	82635	876
Oct	11955	262	83089	848
Nov	12230	390	83543	857
Dec	12506	514	84003	860
TOTAL				10087

2021

	Control Pilar No.1		Control Pilar No.2	**Total Usage (kWh)**
	Meter1	Meter2	Meter1	
Nov	34094	3598	119853	
Dec	34388	3732	120357	932
Jan	34690	3858	120852	923
Feb	34987	3987	121351	925
Mar	35284	4118	121862	939
Apr	35579	4237	122368	920
May	35885	4378	122877	956
Jun	36188	4517	123374	939
Jul	36499	4655	123854	929
Aug	36808	4797	124343	940
Sep	37107	4935	124830	924
Oct	37408	5073	125312	921
Nov	37720	5208	125803	938
Dec	38023	5347	126293	932
TOTAL				12118

Biashara Street

2016

	Control Pilar No.1	**Total Usage (kWh)**
	Meter1	
Nov	9037	
Dec	9750	713
Jan	10462	712
Feb	11174	712
Mar	11903	729
Apr	12626	723
May	13344	718
Jun	14069	725
Jul	14785	716
Aug	15501	716
Sep	16221	720
Oct	16942	721
Nov	17651	709
Dec	18362	711
TOTAL		9325

2021

	Control Pilar No.1	**Total Usage (kWh)**
	Meter1	
Nov	74312	
Dec	74836	524
Jan	75355	519
Feb	75876	521
Mar	76394	518
Apr	76916	522
May	77438	522
Jun	77962	524
Jul	78482	520
Aug	79001	519
Sep	79526	525
Oct	80047	521
Nov	80564	517
Dec	81086	522
TOTAL		6774

City Hall Way

2016

	Control Pilar No.1	**Total Usage (kWh)**
	Meter1	
Nov	22098	0
Dec	22234	136
Jan	22359	125
Feb	22495	136
Mar	22622	127
Apr	22758	136
May	22882	124
Jun	23025	143
Jul	23160	135
Aug	23290	130
Sep	23424	134
Oct	23568	144
Nov	23701	133
Dec	23828	127
TOTAL		1730

2021

	Control Pilar No.1	**Total Usage (kWh)**
	Meter1	
Nov	34208	
Dec	34292	84
Jan	34367	75
Feb	34443	76
Mar	34517	74
Apr	34592	75
May	34659	67
Jun	34729	70
Jul	34803	74
Aug	34879	76
Sep	34953	74
Oct	35022	69
Nov	35097	75
Dec	35168	71
TOTAL		960

Harambee Avenue

2016					2021			
	Control Pilar No.1		Total Usage (kWh)			Control Pilar No.1		Total Usage (kWh)
	Meter 1	Meter2				Meter 1	Meter2	
Nov	635987	754738			Nov	641559	803339	
Dec	636051	755274	600		Dec	641605	803731	438
Jan	636113	755821	609		Jan	641651	804128	443
Feb	636174	756352	592		Feb	641697	804521	439
Mar	636235	756894	603		Mar	641746	804922	450
Apr	636298	757431	600		Apr	641793	805321	446
May	636357	757959	587		May	641840	805723	449
Jun	636417	758489	590		Jun	641891	806121	449
Jul	636478	759016	588		Jul	641935	806512	435
Aug	636539	759556	601		Aug	641981	806915	449
Sep	636599	760096	600		Sep	642024	807314	442
Oct	636664	760632	601		Oct	642067	807712	441
Nov	636725	761152	581		Nov	642115	808116	452
Dec	636783	761681	587		Dec	642158	808515	442
TOTAL			7739		**TOTAL**			5775

Haile Salassie

2016

	Control Pilar No.1	Control Pilar No.2			Control Pilar No.3		Control Pilar No.4	Control Pilar No.5		Control Pilar No.6		**Total Usage (kWh)**	
	Meter1	Meter1	Meter2	Meter3	Meter1	Meter 2	Meter1	Meter1	Meter2	Meter1	Meter2		
Nov	54765	679868	82426	19762	79054	45218	98347	45385	56749	450065	467279		
Dec	55004	679922	82518	20032	79121	45239	98403	45430	56897	450286	467466	1400	187
Jan	55227	679976	82609	20307	79190	45264	98464	45477	57046	450510	467642	1394	176
Feb	55457	680032	82703	20588	79251	45287	98521	45523	57191	450729	467822	1392	180
Mar	55702	680084	82795	20866	79309	45310	98576	45569	57329	450957	468001	1394	179
Apr	55941	680133	82883	21142	79369	45329	98637	45613	57468	451181	468178	1376	177
May	56180	680186	82975	21422	79433	45353	98696	45658	57610	451406	468359	1404	181
Jun	56415	680238	83065	21701	79494	45374	98755	45700	57756	451636	468534	1390	175
Jul	56656	680287	83161	21973	79550	45397	98814	45748	57898	451863	468716	1395	182
Aug	56891	680348	83254	22249	79615	45425	98875	45795	58046	452084	468895	1414	179
Sep	57133	680404	83343	22529	79678	45446	98936	45842	58197	452313	469074	1418	179
Oct	57259	680461	83434	22800	79741	45464	98992	45891	58346	452532	469254	1279	180
Nov	57496	680514	83523	23074	79800	45484	99049	45939	58497	452753	469430	1385	176
Dec	57736	680565	83614	23343	79861	45506	99106	45981	58652	452972	469611	1388	181
TOTAL												18029	

Haile Selassie

2021

	Control Pilar No.1	Control Pilar No.2			Control Pilar No.3		Control Pilar No.4	Control Pilar No.5		Control Pilar No.6		**Total Usage (kWh)**
	Meter1	Meter1	Meter2	Meter3	Meter1	Meter 2	Meter1	Meter1	Meter2	Meter1	Meter2	
Nov	75562	684747	90742	44829	84703	47234	103660	49557	70070	470414	483603	
Dec	75773	684749	90829	45025	84775	47256	103660	49608	70165	470704	483718	1141
Jan	75982	684749	90930	45220	84850	47281	103660	49657	70268	471015	483837	1187
Feb	76189	684751	91042	45421	84919	47302	103661	49705	70373	471320	483951	1185
Mar	76397	684751	91150	45636	84990	47321	103661	49756	70470	471621	484067	1186
Apr	76606	684751	91255	45837	85058	47345	103661	49802	70564	471921	484188	1168
May	76816	684753	91363	46034	85130	47369	103662	49852	70665	472217	484306	1179
Jun	77021	684755	91462	46226	85199	47397	103662	49897	70770	472516	484427	1165
Jul	77227	684755	91568	46420	85269	47425	103662	49948	70876	472809	484547	1174
Aug	77433	684756	91669	46608	85314	47450	103663	50000	70979	473110	484661	1137
Sep	77642	684756	91765	46802	85388	47473	103663	50052	71078	473409	484762	1147
Oct	77850	684756	91863	47002	85459	47499	103663	50107	71182	473712	484871	1174
Nov	78061	684760	91957	47211	85527	47524	103663	50158	71280	474019	484981	1177
Dec	78270	684760	92072	47409	85597	47548	103664	50214	71382	474299	485090	1164
TOTAL												15184

Parliament Rd								
2016					2021			
	Control Pilar No.1		**Total Usage (kWh)**			Control Pilar No.1		**Total Usage (kWh)**
	Meter1	Meter2				Meter1	Meter2	
Nov	75437	453721			Nov	89126	513179	
Dec	75578	454371	791		Dec	89224	513675	594
Jan	75731	455029	811		Jan	89321	514186	608
Feb	75880	455674	794		Feb	89418	514692	603
Mar	76029	456323	798		Mar	89519	515197	606
Apr	76180	456974	802		Apr	89621	515694	599
May	76337	457635	818		May	89714	516154	553
Jun	76488	458294	810		Jun	89809	516616	557
Jul	76639	458949	806		Jul	89900	517088	563
Aug	76788	459596	796		Aug	89996	517557	565
Sep	76941	460247	804		Sep	90090	518022	559
Oct	77095	460909	816		Oct	90184	518493	565
Nov	77243	461563	802		Nov	90279	518962	564
Dec	77393	462215	802		Dec	90379	519432	570
TOTAL			10450		**TOTAL**			7506

City Hall Way

2016	Control Pilar No.1 Meter1	Total Usage (kWh)	2021	Control Pilar No.1 Meter1	Total Usage (kWh)
Nov	22098	0	Nov	34208	
Dec	22234	136	Dec	34292	84
Jan	22359	125	Jan	34367	75
Feb	22495	136	Feb	34443	76
Mar	22622	127	Mar	34517	74
Apr	22758	136	Apr	34592	75
May	22882	124	May	34659	67
Jun	23025	143	Jun	34729	70
Jul	23160	135	Jul	34803	74
Aug	23290	130	Aug	34879	76
Sep	23424	134	Sep	34953	74
Oct	23568	144	Oct	35022	69
Nov	23701	133	Nov	35097	75
Dec	23828	127	Dec	35168	71
TOATAL		1730	**TOATAL**		960

Muindi Mbingu

2016	Control Pilar No.1 Meter1	Control Pilar No.1 Meter2	Total Usage (kWh)	2021	Control Pilar No.1 Meter1	Control Pilar No.1 Meter2	Total Usage (kWh)
Nov	58543	7674		Nov	69666	12595	
Dec	58667	7721	171	Dec	69763	12630	132
Jan	58785	7776	173	Jan	69856	12662	125
Feb	58906	7828	173	Feb	69951	12699	132
Mar	59034	7885	185	Mar	70045	12735	130
Apr	59159	7937	177	Apr	70140	12771	131
May	59281	7989	174	May	70233	12803	125
Jun	59403	8043	176	Jun	70324	12841	129
Jul	59524	8094	172	Jul	70415	12882	132
Aug	59642	8154	178	Aug	70512	12921	136
Sep	59761	8211	176	Sep	70608	12960	135
Oct	59885	8266	179	Oct	70703	13000	135
Nov	60007	8322	178	Nov	70798	13042	137
Dec	60132	8377	180	Dec	70892	13080	132
TOTAL			2292	**TOTAL**			1711

University Way

2016

	Control Pilar No.1			Control Pilar No.2	**Total Usage (kWh)**
	Meter1	Meter2	Meter3	Meter1	
Nov	62197	2971	729110	10984	
Dec	62314	2995	729171	11308	526
Jan	62439	3024	729232	11626	533
Feb	62558	3051	729291	11947	526
Mar	62679	3079	729354	12273	538
Apr	62796	3107	729415	12598	531
May	62919	3134	729472	12918	527
Jun	62924	3159	729523	13235	398
Jul	63002	3188	729581	13554	484
Aug	63117	3215	729644	13878	529
Sep	63242	3243	729706	14187	524
Oct	63363	3274	729765	14499	523
Nov	63482	3303	729826	14820	530
Dec	63600	3330	729882	15136	517
TOTAL					6686

2021

	Control Pilar No.1			Control Pilar No.2	**Total Usage (kWh)**
	Meter1	Meter2	Meter3	Meter1	
Nov	72018	5484	734514	40048	
Dec	72101	5512	734560	40204	313
Jan	72182	5537	734602	40365	309
Feb	72267	5559	734648	40522	310
Mar	72346	5583	734692	40676	301
Apr	72427	5606	734736	40843	315
May	72505	5633	734778	41006	310
Jun	72586	5664	734823	41161	312
Jul	72670	5695	734862	41318	311
Aug	72752	5723	734893	41485	308
Sep	72835	5751	734927	41647	307
Oct	72914	5778	734961	41806	299
Nov	72994	5805	734997	41968	305
Dec	73073	5836	735031	42126	302
TOTAL					4002

River Road

2016

	Control Pilar No.1		Control Pilar No.2	Control Pilar No.3			Control Pilar No.4		Control Pilar No.5	Control Pilar No.6		**Total Usage (kWh)**
	Meter 1	Meter2	Meter1	Meter1	Meter2	Meter3	Meter1	Meter2	Meter1	Meter1	Meter2	
Nov	708094	64682	92948	9704702	877024	79207	7927	6828	79274	78882	93297	
Dec	708178	64713	92950	9704803	877475	79320	7946	7030	79800	79053	93422	1825
Jan	708262	64741	92953	9704912	877933	79435	7965	7241	80313	79219	93546	1830
Feb	708343	64769	92954	9705018	878391	79550	7986	7450	80833	79387	93670	1831
Mar	708421	64800	92956	9705129	878846	79656	8004	7665	81355	79560	93791	1832
Apr	708502	64831	92957	9705238	879302	79770	8021	7877	81864	79733	93918	1830
May	708583	64861	92959	9705348	879757	79884	8038	8082	82391	79902	94044	1836
Jun	708660	64891	92960	9705458	880218	80003	8057	8294	82922	80056	94175	1845
Jul	708737	64923	92961	9705570	880677	80121	8074	8501	83447	80217	94304	1838
Aug	708815	64954	92963	9705676	881136	80239	8095	8719	83958	80386	94435	1844
Sep	708896	64983	92964	9705782	881595	80356	8115	8928	84477	80555	94557	1832
Oct	708977	65014	92965	9705891	882049	80473	8136	9139	84985	80717	94683	1821
Nov	709061	65041	92967	9705994	882511	80593	8154	9345	85504	80875	94809	1825
Dec	709143	65072	92970	9706097	882971	80709	8173	9558	86028	81036	94932	1835
TOTAL												23824

River Road

2021

	Control Pilar No.1		Control Pilar No.2	Control Pilar No.3			Control Pilar No.4		Control Pilar No.5	Control Pilar No.6		**Total Usage (kWh)**
	Meter 1	Meter2	Meter1	Meter1	Meter2	Meter3	Meter1	Meter2	Meter1	Meter1	Meter2	
Nov	715437	67412	93010	9714467	918653	89721	9649	25938	126552	93960	104742	
Dec	715501	67444	93012	9714531	918963	89793	9670	26091	126964	94098	104825	1351
Jan	715563	67477	93013	9714592	919268	89870	9694	26247	127369	94239	104904	1344
Feb	715625	67508	93015	9714661	919577	89945	9715	26396	127778	94376	104985	1345
Mar	715686	67537	93017	9714728	919892	90014	9735	26547	128193	94518	105066	1352
Apr	715749	67568	93018	9714789	920204	90090	9757	26702	128610	94657	105141	1352
May	715811	67603	93021	9714853	920517	90163	9776	26854	129016	94947	105226	1502
Jun	715878	67634	93024	9714915	920824	90231	9794	27013	129428	95079	105310	1343
Jul	715941	67666	93025	9714974	921134	90302	9816	27163	129824	95211	105396	1322
Aug	716002	67696	93028	9715035	921431	90379	9842	27315	130225	95347	105478	1326
Sep	716061	67729	93029	9715100	921735	90453	9866	27463	130629	95478	105569	1334
Oct	716124	67758	93030	9715162	922046	90524	9887	27614	131040	95613	105654	1340
Nov	716186	67785	93033	9715230	922353	90595	9905	27769	131440	95739	105737	1320
Dec	716251	67816	93035	9715293	922665	90665	9924	27918	131909	95871	105816	1391
TOTAL												17622

Kirinyaga Rd

2016

	Control Pilar No.1		Control Pilar No.2		Control Pilar No.3		Control Pilar No.4			**Toatal Usage (kWh)**
	Meter1	Meter2	Meter1	Meter2	Meter1	Meter2	Meter1	Meter2	Meter3	
Nov	754389	45	376543	2343876	48756	17654	454986	6907	367788	
Dec	754495	130	376602	2343940	48825	17711	455234	6911	367854	758
Jan	754602	213	376663	2344005	48895	17771	455488	6921	367918	774
Feb	754712	296	376724	2344070	48972	17840	455738	7007	367980	863
Mar	754808	379	376785	2344134	49051	17902	455983	7081	368045	829
Apr	754926	455	376845	2344199	49129	17964	456230	7152	368104	836
May	755034	542	376905	2344266	49204	18032	456490	7224	368165	858
Jun	755139	630	376967	2344329	49279	18097	456724	7298	368231	832
Jul	755249	711	377029	2344392	49355	18158	456964	7369	368294	827
Aug	755352	793	377091	2344453	49428	18211	457203	7449	368365	824
Sep	755456	881	377153	2344513	49499	18272	457467	7520	368417	833
Oct	755562	961	377215	2344576	49573	18335	457720	7593	368479	836
Nov	755672	1041	377279	2344639	49647	18395	457969	7665	368544	837
Dec	755781	1122	377344	2344704	49717	18460	458225	7742	368615	859
TOTAL										10766

Kirinyaga Rd

2021

	Control Pilar No.1		Control Pilar No.2		Control Pilar No.3		Control Pilar No.4			**Toatal Usage (kWh)**
	Meter1	Meter2	Meter1	Meter2	Meter1	Meter2	Meter1	Meter2	Meter3	
Nov	764133	7584	382150	2349672	55483	23296	477659	12752	373577	
Dec	764205	7674	382192	2349715	55495	23335	477849	12793	373619	571
Jan	764276	7762	382232	2349760	55505	23376	478044	12838	373664	580
Feb	764350	7853	382274	2349805	55516	23414	478236	12880	373708	579
Mar	764421	7939	382319	2349849	55528	23454	478428	12923	373750	575
Apr	764494	8027	382364	2349898	55537	23497	478615	12965	373792	578
May	764563	8118	382408	2349945	55610	23536	478805	13006	373838	640
Jun	764633	8209	382457	2349992	55685	23576	478996	13050	373883	652
Jul	764708	8298	382502	2350024	55756	23617	479172	13094	373928	618
Aug	764780	8388	382549	2350051	55828	23658	479356	13138	373969	618
Sep	764852	8478	382596	2350093	55901	23697	479545	13179	374012	636
Oct	764928	8569	382643	2350134	55976	23740	479737	13222	374059	655
Nov	765002	8658	382692	2350176	56047	23783	479926	13263	374104	643
Dec	765073	8752	382739	2350218	56117	23826	480117	13304	374147	642
TOTAL										7987

Accra Rd

2016

	Control Pilar No.1	Control Pilar No.2		
	Meter1	Meter2	Meter3	**Total Usage (kWh)**
Nov	1442574	7645	347487	0
Dec	1442693	7764	347816	567
Jan	1442817	7886	348120	550
Feb	1442932	8002	348449	560
Mar	1443045	8120	348809	591
Apr	1443168	8243	349126	563
May	1443292	8357	349455	567
Jun	1443411	8474	349802	583
Jul	1443524	8589	350123	549
Aug	1443642	8697	350475	578
Sep	1443759	8811	350812	568
Oct	1443876	8925	351115	534
Nov	1443989	9042	351432	547
Dec	1444107	9161	351798	603
TOTAL				7360

2021

	Control Pilar No.1	Control Pilar No.2		
	Meter1	Meter2	Meter3	**Total Usage (kWh)**
Nov	1453305	18257	377664	0
Dec	1453422	18370	377992	558
Jan	1453534	18486	378325	561
Feb	1453648	18599	378688	590
Mar	1453762	18712	379023	562
Apr	1453881	18829	379349	562
May	1453998	18947	379704	590
Jun	1454119	19066	380034	570
Jul	1454237	19183	380362	563
Aug	1454353	19299	380692	562
Sep	1454469	19413	381030	568
Oct	1454584	19530	381361	563
Nov	1454698	19648	381689	560
Dec	1454809	19763	381999	536
TOTAL				7345

Wabera Street

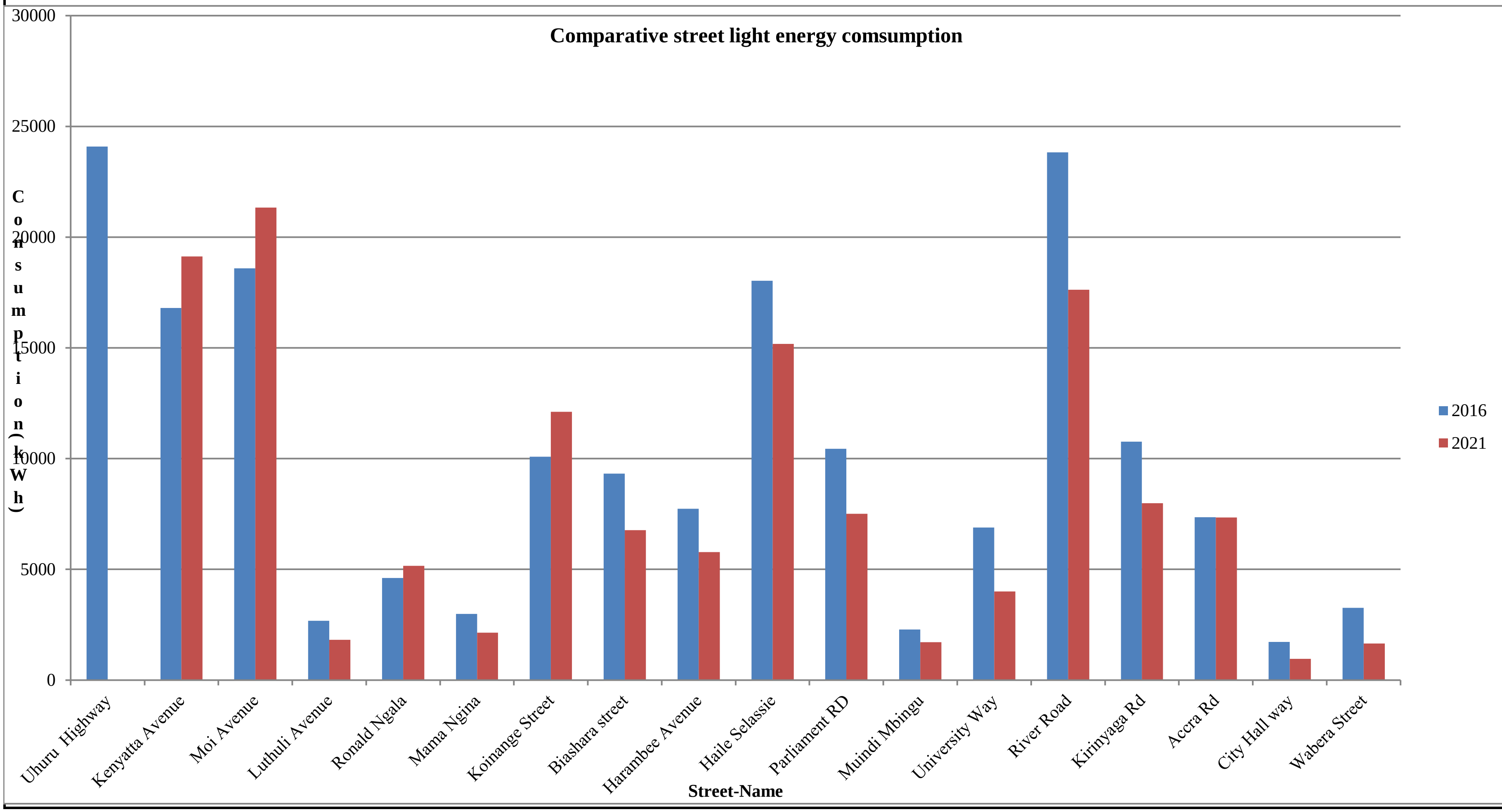
2016					2021			
	Control		Usage (kWh)			Control		Usage (kWh)
	Meter1	Meter2				Meter1	Meter2	
Nov	4567843	6487351	0		Nov	4578924	6499090	0
Dec	4567992	6487498	296		Dec	4579004	6499127	117
Jan	4568101	6487605	216		Jan	4579051	6499207	127
Feb	4568236	6487738	268		Feb	4579104	6499275	121
Mar	4568375	6487865	266		Mar	4579195	6499309	125
Apr	4568494	6487992	246		Apr	4579237	6499395	128
May	4568643	6488116	273		May	4579293	6499465	126
Jun	4568732	6488246	219		Jun	4579367	6499512	121
Jul	4568871	6488353	246		Jul	4579413	6499603	137
Aug	4568910	6488550	236		Aug	4579482	6499666	132
Sep	4569119	6488607	266		Sep	4579549	6499722	123
Oct	4569208	6488744	226		Oct	4579617	6499794	140
Nov	4569327	6488881	256		Nov	4579693	6499851	133
Dec	4569426	6489028	246		Dec	4579769	6499901	126
TOTAL			3260		**TOTAL**			1656

TOTAL ENERGY CONSUMPTION PER AVENUE IN 2016 & 2021

Street	Uhuru Highway	Kenyatta Avenue	Moi Avenue	Luthuli Avenue	Ronald Ngala	Mama Ngina	Koinange Street	Biashara street	Harambee Avenue	Haile Selassie	Parliament RD	Muindi Mbingu	University Way	River Road
Consp.-2016 (kWh)	24091	16797	18591	2681	4617	2995	10087	9325	7739	18029	10450	2292	6886	23824
Consp.-2021 (kWh)	0	19122	21336	1820	5164	2141	12118	6774	5775	15184	7506	1711	4002	17622

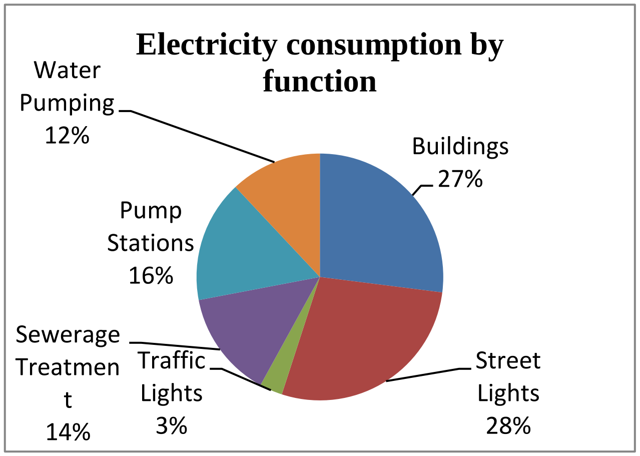
TOTAL ENERGY CONSUMPTION PER AVENUE IN 2016 & 2021 CTND'

Street	River Road	Kirinyaga Rd	Accra Rd	City Hall way	Wabera Street
Consp.-2016 (kWh)	23824	10766	7360	1730	3260
Consp.-2021 (kWh)	17622	7987	7345	960	1656

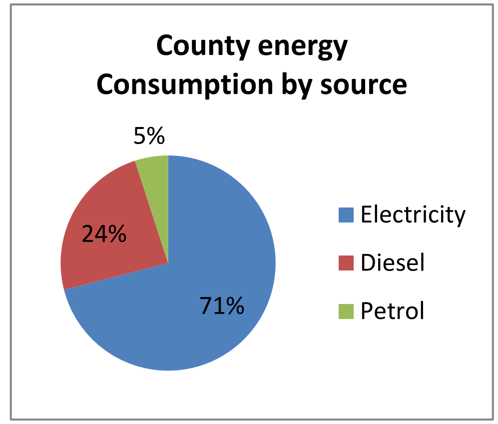


ELECTRICITY CONSUMTION BY FUNCTION IN NCC

FUNCTION	% CONSUMPTION
Buildings	2.7
Street Lights	2.8
Traffic Lights	0.3
Sewerage Treatment	1.4
Pump Stations	1.6
Water Pumping	1.2

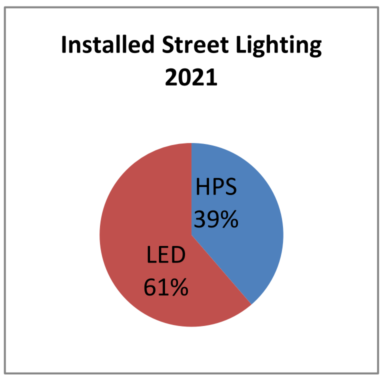


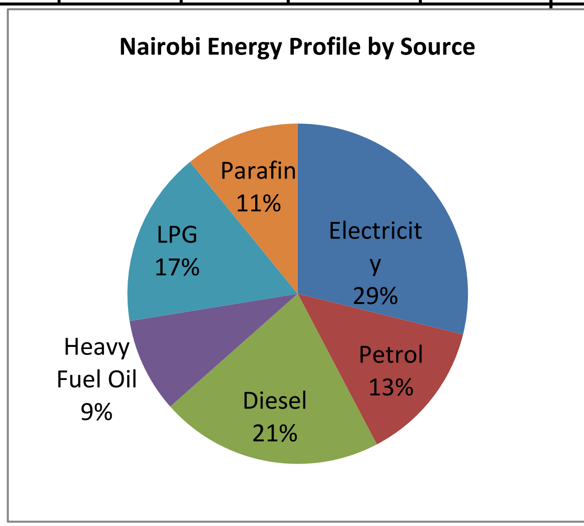
Electricity			7.1
Diesel			2.4
Petrol			0.5



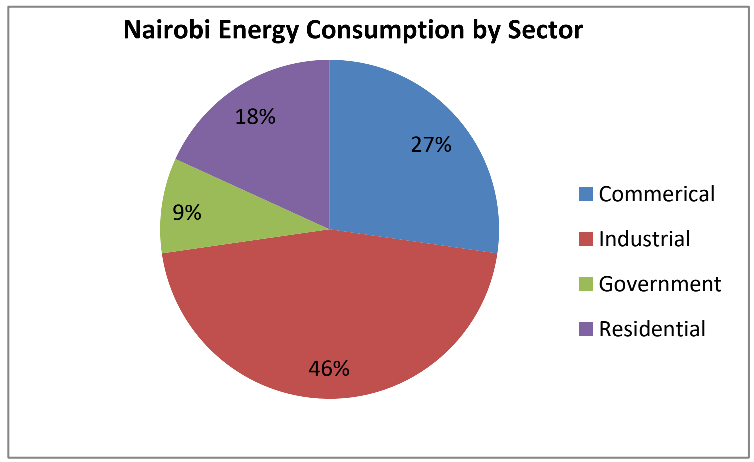
HPS	LED
116	184

Electricity	Petrol	Diesel	Heavy Fu	LPG	Parafin	Total
45	21	33	14	26	17	156





Commerical	Industrial	Government	Residential
3	5	1	2



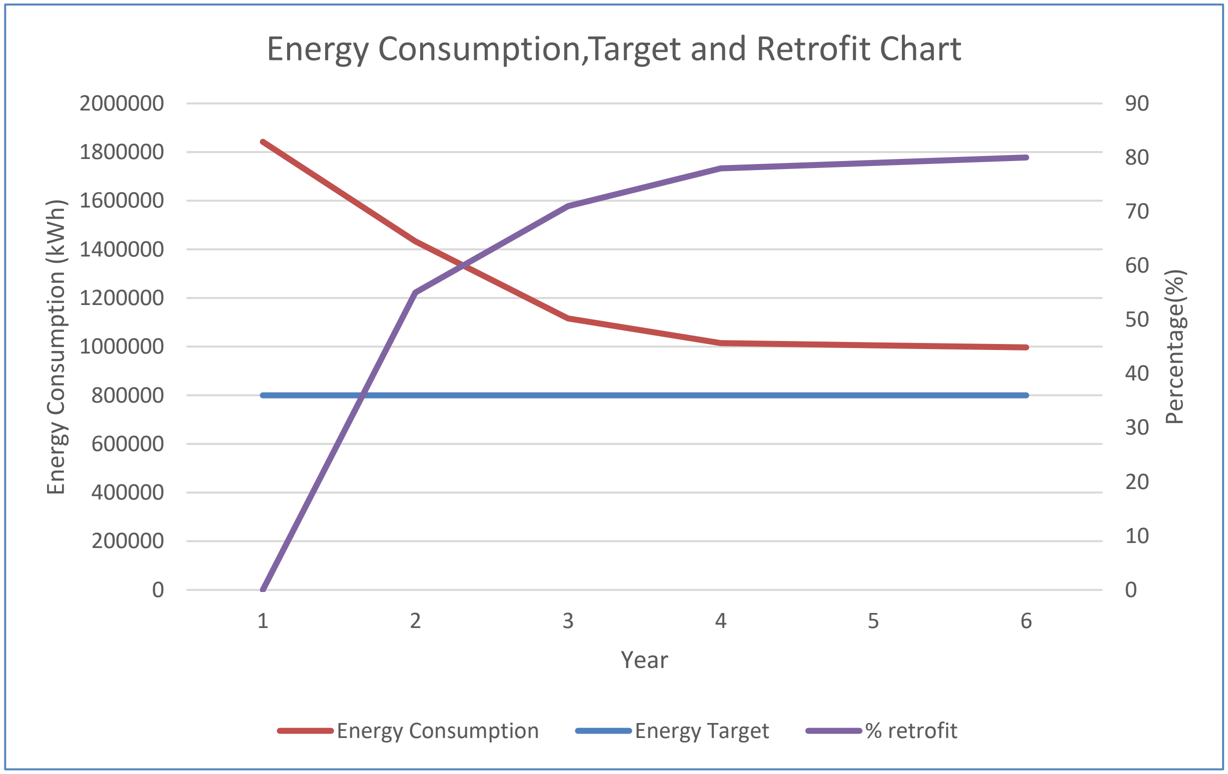
EE PROGRAMS ON STREET LIGHTS

No.	Street	No of Lights		EE upgrade	No. of HPS to LED	Lights Working
		2016	**2021**			
1	Luthuli Avenue	8	12	Replacement of HPS lamps with LED Timer Control Switching to Photocell switching	12	6
2	Ronald Ngala	27	32	Replacement of HPS lamps with LED Timer Control Switching to Photocell	32	25
3	Mama	12	12	Timer Control Switching to Photocell	0	9
4	Biashara Street	20	20	Replacement of HPS lamps with LED Timer Control Switching to Photocell	20	18
5	Harambee	22	22	Timer Control Switching to Photocell	0	22
6	Haile Salassie	45	58	Replacement of HPS lamps with LED Timer Control Switching to Photocell	33	47
7	Parliament Rd	12	12	Timer Control Switching to Photocell switching	0	12
8	Muindi Mbingu	6	6	Replacement of HPS lamps with LED Timer Control Switching to Photocell	6	6
9	University	18	18	Timer Control Switching to Photocell	0	12
10	River Road	63	72	Replacement of HPS lamps with LED Timer Control Switching to Photocell switching	45	64
11	Kirinyaga Rd	22	22	Replacement of HPS lamps with LED Timer Control Switching to Photocell switching	22	10
12	City Hall Way	5	5	Replacement of HPS lamps with LED Timer Control Switching to Photocell switching	5	5
13	Wabera St	9	9	Replacement of HPS lamps with LED Timer Control Switching to Photocell switching	9	7
	Total		300		184	243

EE PROGRAMS ON BUILDINGS			
Maximize energy Performance	Energy Reliability	-Sustainable Energy Design	1.provide for supply redundancy by creating provisions for backups and uninterrupted power supply
			2.Develop a procedure for energy redundancy integration
			3.Crowd fund clean energy projects
		-Modernization	1.Computerize energy data and analyze trends
			2.Review insulation opportunities
			3.Install newer technology
		Contingency Planning	1.Develop contingency plan for electricity use
			2.Determine alternative energy sources
			3.Establish shutdown procedure
	Energy Quality	-Protection systems	1.Develop a framework for installation of energy protection systems
			2.incorporate protection mechanisms in the initial building designs
			3.Provide for acceptable standards of energy protection
		-Energy monitoring	1.Establish permanent instrumentation for energy measurement
			2.Ensure Measuring instruments are calibrated to utility company standards
			3.Develop an energy reporting and evaluation system
		-load control	1.Assess building thermal envelop
			2.Optimize use of large loads
			3.Developprocedures for large load switching of the building i.e HVAC systems
	Energy Access	-strategic placements	1.Develop procedure for installation of power points
			2.Sensitize staff on the importance of power point strategic placement
			3.Training on effective access point location
		-Audit	1.Create an audit plan
			2.Implement audit findings on energy access
			3.create work groups to track implementations audit findings and outcomes on energy access
		ign optimiz	1.Use latest design considerations in formulating a design framework
			2. Rollout CAD software to staff to assist in design and simulation.
Energy Cost Reduction	Energy Efficiency	-Retro-commissioning	1.Refit older buildings with more efficient facilities
			2.Develop Equipment and facility maintenance framework
			3.Automate facility functions that do not require staff intervention
		Control/facility optimizati	1.Assure proper functioning of existing controls
			2.Develop a low cost/no cost program for controls
			3.Evaluate and install EMCs where

A GRAPH OF PERCENTAGE RETROFIT BASED ON THE COUNTY'S CONSUMPTION ENERGY TARGET

Year	Energy Consumption	Energy Target	% retrofit
2016	1,842,304	800,000	0
2017	1,433,591	800,000	55
2018	1,115,550	800,000	71
2019	1,015,150	800,000	78
2020	1,004,998	800,000	79
2021	997,068	800,000	80



Assessment of the Energy Efficiency Programmes within the Internal Operations of Nairobi City County Government

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***Abstract*—Energy Efficiency (EE) is an emerging concept in the management of public institutions. The main objective of the study was to assess the Energy Efficiency Programmes (EEPs) of the Nairobi City County Government (NCCG) within its internal operations. It did this by conducting an energy audit, identifying & determining success rates of the EEPs and developing a sustainable implementation model for these programmes. A case study was analyzed for electrical energy consumption of Nairobi Central Business District with a focus on the sub sectors of street lighting, building facilities and traffic lighting.**

The results of this study indicated that there have been EEPs instituted by NCCG and these measures have led to a 32% reduction in energy consumption in city hall complex between the years 2016 and 2021 with the EEPs including replacement of fluorescent luminaires with LEDs, behavior change among others .For the street lighting, 184 lamps have been replaced with LED options translating to 4% conversion rate with some not operational due to faults and vandalism. Finally traffic lighting has a 65% LED conversion rate with incandescent lamps being 14,833 in 2016 and down to 9,754 in 2021.The economic analysis shows that the EEPs implemented are able to derive economic value to the NCCG within a medium term plan. Various Barriers to implementation has also been highlighted and how to mitigate them. The business model developed allows departments to follow a standardized process in setting energy targets, implementing energy efficiency measures and tracking financial, environmental and energy savings.

Keywords—Energy efficiency, energy audit, style, lighting, programmes, Sustainability. Public Sector, Nairobi City County.

I. Introduction

Energy conservation is an emerging issue around energy generation and utilization in order to guarantee its sustainability and environmental conservation [1].To this end, organizations, institutions and populations are encouraged to be more energy conscious in their operations. The private sector has largely taken the baton in integrating energy conservation measures in their operations in line with their profit maximization objectives while public sectors still lag behind in adoption of EE measures. NCCG is one of the public institutions that is mandated by the Kenya Energy policy of 2016 to initiate and implement measures geared towards guaranteeing EE of its day to day operations. There, however, exists gaps in the global understanding of the extent to which measures have been rolled out by NCCG [2] and a clear framework of the implementation of the identified EEPs:

A. Study Objectives

The general objective of this study was to assess the EE programmes within internal operations of NCCG, under the specific objectives of; to carry out electrical energy audit of the operations of NCCG's buildings, street lights and traffic lights; to determine the Energy Efficiency programs within NCCG; to assess the success rate of implementing Energy Efficiency programs in NCCG and to formulate a sustainable Energy Efficiency program implementation model.

Global perspective

Global concerns with regards to energy security and climate change have indicated that there is need to have specified interventions in relation to the future climate and energy needs. EE is among the interventions. EE can be implemented quickly and it is effective through reducing carbon emission and energy use and also environmental improvement [3].

Energy Efficiency Programs (EEPs)

Energy Efficiency is a means of reducing energy use by utilizing less energy to achieve the same objective of useful output [4].

There is a great potential of having economic, safer, secure and cleaner energy. This is easily achievable by adopting EE programmes that optimize and conserve use of energy as well as adopting renewable energy options in the supply availabilities [5]. Developing countries are therefore able to outgrow traditional sources without posing a threat to the environment.

B. Nairobi City County Energy Efficiency Programmes

EEPs implementation in Kenya was stimulated by grant funding and government subsidies through the Ministry of Energy to support NCCG's EEPs in 2016. According to the Kenya national Energy Efficiency strategy paper [6], this subsidies by the government was to enable the NCCG transition to more energy efficient facilities with an aim of flattening the demand curve during peak hours and subsequently lower the cost of energy bills. However, in the Energy policy paper of the GOK [7], these grants and subsidies are only guaranteed until the end of financial year 2029/2030. There is no much information on continued support from the government after the year 2030. It is thus crucial to examine the uncertainty associated with funding regarding EE within counties and the need to come up with business models that are capable of enhancing and sustaining future EE programs.

Nairobi faces various challenges, one of the major challenge is lack of complete data that points to Energy Efficiency and also lack of awareness amongst the people inform of measures that

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can increase Energy Efficiency within the city. As of FY 2020/2021, the county government had accrued pending utility bill of Kshs.1B owed to KPLC, a 20% increment from the previous financial year (NCCG, 2021). This has on several occasions led to operational clash with the utility company and hampered the operation of the county government due to withdrawal of service by KPLC. This is indicative of non-performance.

Contribution: This paper analyses the electrical energy position of the NCCG by identifying the contribution of the EE programmes that it has established in place and identifying the implementation and financing challenges.

Paper Organization: The organization of this paper is outlined as follows: Literature Review is illustrated in Section II while Section III defines the Proposed Methodology, Section IV is Problem Formulation and Section V outlines the Presentation of Results and Analysis. Section VI Concludes this study. A list of References used in the study is included at the end of the paper.

II. Literature Review

A. Energy Efficiency Concept

Energy Efficiency (EE) has become a serious issue within the policy-making initiatives in developing countries. EE is important because of the energy security, commercial, competitiveness and industrial, benefits that have been associated with it, such as the reduction in the amounts of CO_2. Despite the efforts that have been placed in developing various policies, there are still no concrete efforts in the definition of EE [8].

In Kenya, EE has been found to be a key player in the realization of the climate management objectives in keeping up with the Paris Agreement on climate change. EE is crucial in the achievement of vision 2030 by the country with the aim of making sure that the country achieves its middle-income goals by the same year. Despite the importance that EE has in Kenya, available data indicates that about 66% of the EE potential within the country will remain unrealized by the year 2035, and this is due to the undervalue that is placed on EE [8].

B. Theoretical Framework

This study develops a theoretical framework based on two theories premised on an energy use policy outlook.

Theory of the firm: Neoclassical economics have indicated that a firm is a monolithic actor that is keen on having costs reduced and at the sometime enhancing its profit margin and also improve their corporate performance. The behavior of the firm is dictated by the forces that are found within the market such as the present opportunities. Loasby [9] points out that a firm cannot exist as a research unit on its own. Thus, research studies have looked at the prices and other market factors such as barrier to entry, monopoly and products that can act as complements or substitutes. NCCG is the firm in this study.

Habit Theory: Habit is mainly formed due to the regular performance of a certain action and thus making it become an automated behavior. Habits tend to occur unplanned and involuntarily in some of the cases. Habits tend to come about through the application of associative learning that is there between the actions that one and environment have. Additionally, mental and mind-set that one has can also influence the habit forming process. When there is a strong habit, there is tendency for one to have a weak behavior relationship and thus indicating that intention has a little effect [10].

III. Methodology

This chapter outlines a review of the previous methods employed in carrying out previous research that are relevant to this study. It also discusses the proposed research method, the expected results from this study and the conceptual framework on which this study is anchored.

A. Previous Methods

Case study :A research approach that is employed to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context is considered as a case study and involves an intensive and systematic investigation of a phenomena or any other unit that interests a research for in-depth data relating to several variables.

[11] Applies direct observations and fieldwork to gather energy data used to develop a business model in a study to assess EE programs of Cape Town municipality in their internal operations. The research design for this study was a case study design in which the research focused on a particular case which was subsequently analyzed in depth. [12] Also employs a mixed methods approach methodology in which both qualitative and quantitative analysis are done in order to guarantee a holistic approach.

B. Mixed Methods

In this research design, both qualitative and quantitative aspects of a study are incorporated in carrying out analysis of data. The use of descriptive statistics, regression and correlation analysis accounts for the bulk of this design. [13] In her study to formulate and implement a strategy for operations of an energy efficient street lighting of Nairobi County. The analysis of data was based on qualitative and quantitative research analysis based on descriptive statistics and content analysis.

C. Scope

This study was a case study of the assessment of EE programmes of NCCG in its internal operations with a focus on Nairobi Central business district. The electrical department of the NCCG was the primary target population while street lighting, city hall and annex, and traffic lighting were the core subsectors considered as the core components of internal operations of NCC

D. Concept Framework

The conceptual framework of this study was derived from 3 independent variables and one dependent variables as shown Fig.1.

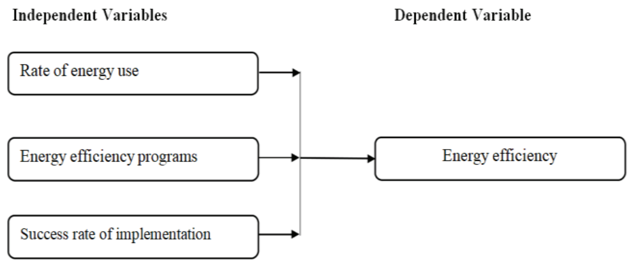

Fig. 1.Concept Framework

IV. RESULTS AND FINDINGS

The case study was of the internal operations of NCCG within the Central business district within the subsectors of street-lighting, traffic lighting and building facilities of City hall complex buildings. The study identifies the various EEPs within these sectors and determines the level of success in reducing energy consumption by comparing energy consumption values between 2016 (baseline) and 2021.

For NCCG internal operations Electricity is predominantly used in buildings, waste water treatment plants, and street lighting, as illustrated in Fig. 2

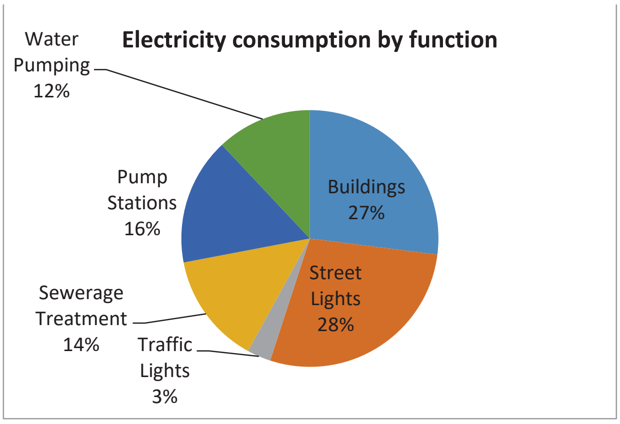

Fig. 2.NCCG operations energy use spread

A. *Energy Efficiency Programmes in the operations of NCCG.*

Building Facilities

Since 2016, NCCG has rolled out EEPs within the Department of Energy consistently leading various projects aimed at introducing EEPs within the County Governments operations. Table 1 highlights the implementation the various programs that have been rolled out in the city hall complex over a five year period, the source of funding and the percentage retrofit to date.

Table 1: EE Implementation for City Hall Complex

Year	2016/17	2017/18	2018/19	2019/20	2020/21
Phase	1	2	3	4	5
Technology retrofits	Energy Efficient lighting Solar Water Heating, hydro-boils	Energy Efficient lighting , SWH and timers,	HVAC systems Temperature control, Power Factor Correction	Energy Efficient lighting and motion sensors	Energy Efficient lighting (and motion sensor systems
Behavior Change programme	Yes	Yes	Yes	Yes	Yes
Modular Metering	Yes	Yes	Yes	Yes	Yes
Funding Source	Grant	Grant	Grant	Grant	Nairobi City County
% retrofit	55	71	78	79	80

Fig.3 shows the comparative energy consumption trends of the city hall complex that comprises of the city hall and the city hall annex buildings. The figures show a general reduction in the energy consumption since the roll out of the EE programmes.

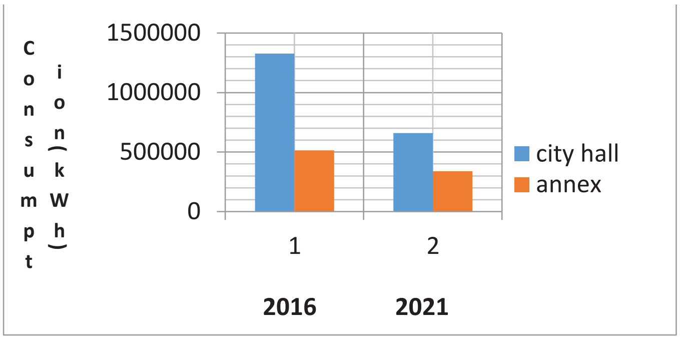

Fig. 3.City Hall & City Hall Annex Energy Consumption Comparison

Street Lighting

Fig 4 shows energy consumption of streetlights within CBD between the year 2016(baseline) before EE programmes roll out and 2021 after the roll out.

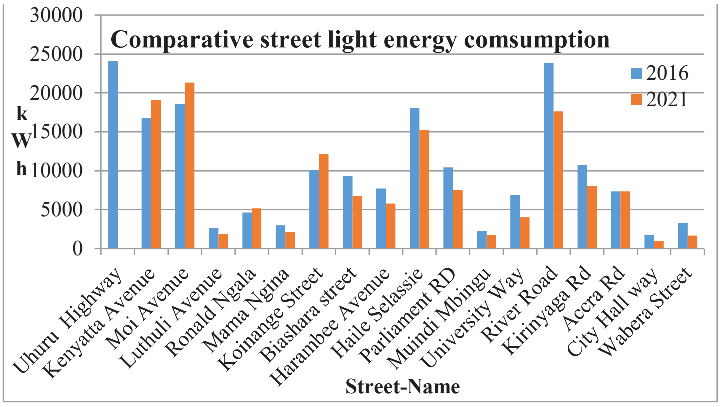

Fig.4.Comparative Street light energy consumption

From the Fig.4, streets that benefited from EE programmes had a reduced rate of energy consumption. Table 2 shows the level of implementation and the level of success of the EE programme based on lamps that are operational.

Table 2: EE Programmes Implementation For Street Lights

Year	No of lights	Operational lights	EE upgrade	No of Upgrade
2016	267	172	-	-
2021	300	243	-Replacement of HPS lamps with LED -Timer Control Switching to Photocell switching	184

The challenges to the implementation of EE programmes for street lights within the CBD were found to be associated with vandalism, program funding and operations and maintenance costs. This has crippled the rate of implementation of EE streetlights.

Traffic Lights

Traffic lights on the other hand are still undergoing a phased conversion from halogen lamps to LED lamps. NCCG has roughly 30 intersections of traffic lights in the CBD. Traffic Lights in Nairobi are managed by The Traffic Signal Department, which is part of the Transport Department, in charge of managing all of NCCG's traffic lights.

The savings determined from this EE programme is as shown in Table 4 having been compiled from comparative consumption rates with and without the EE programmes.

Table 4: Savings from Traffic Light EE Programmes

Lighting technology intervention	Year complete	Current light (W)	Total no of Lights	kWh per annum	%Saving off 2016 baseline
	2016	75	90	14833	
Incandescent to LED	2021	8	125	9754	65

It is evident that the EE programmes that have been implemented so far have led to energy savings of up to 65%.

B. Success Rate Of EE implementation

Table 5: EE implementation success Rate

Sector	EEP	Detail	Implementation Rate
Building	Sustainable Energy Design	-Improved Natural ventilation -Adoption of Solar Energy supply and solar water heating systems	0% - NCC buildings are still dependent on forced ventilation. -adoption of solar supply remain insignificant.
	Energy Monitoring	-Metering of all energy usage area -Energy Reporting and evaluation system.	100% - Modular metering for building usage exist with a complete energy reporting system
	Load Control	-Large loads switching procedure -Load optimization	100% - Procedures for load switching exist
	Retro-Commissioning	-Replacing incandescent and fluorescent with LED lamps -Low cost/no cost programs for control	25% - There still exist a considerable number of street light that have not been retrofitted
	Audit	-Energy Audit for NCC buildings -Implementation of Audit findings	50% - Periodic energy audits are done while Audit findings remain unclosed
Street Lighting	Energy Monitoring	-Implement control pillars for closer energy monitoring -Monthly reading of energy meters	50% - Control pillars have been implemented while readings are not regular
	Retrofitting street lights	-Replacing HPMV and HPSV lamps with LED lamps -Replacing Convectional street lighting with Solar street lighting	4% - A large number of street lights still depend on HPMV and HPSV lamps. Solar lamps have only been deployed on a pilot basis
Traffic Lights	Retrofit	-Traffic lights using incandescent lamps replaced with LED options	65% - a significant number of traffic lights have been replaced with LED options

C. Economic Analysis of EEPs implementation

Investments in EEPs are required to plough back returns for the purposes that they were initiated.
Table 6 shows a summary of the payback period of the EEPs implemented in various sectors under study.

Table 6: Summary of Payback Period of EEPs implemented

Item	Duration	Description	Financial Allocation	Annual Savings	Payback Period (years)
1	2016-2021	Building facilities	Kshs.135M	Kshs.21.3M	6.4
2	2016-2021	Street lighting	Kshs.311M	Kshs.48M	6.7
3	2016-2021	Traffic lighting	Kshs.16.8M	Kshs.1.53M	11

From the payback values, the EEPs are able to derive economic value to the NCCG within a medium term plan.

D. Formulation of EE implementation model of NCCG operations

Formulation of EE implementation model was made possible by the institutional framework and policy already existing. The variables under consideration in this business model are financing/investment, technology, policies and NCCG energy usage characteristics.

Energy Performance Contracting (EPC) Model

EPC model addresses the gaps associated with financing which stands out as the major drawback in the EEPs implementation. It is the mechanism of paying for the current facility upgrades using the future energy savings without the need of tapping into the NCCG capital budgets and involves a partnership between the utility and the NCCG and presents the advantage of being timely and cost effective in implementing EEPs that involve comprehensive energy upgrades.

The steps of the Model is as shown in Fig 5

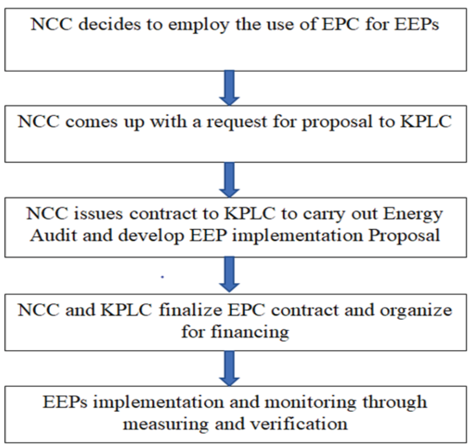

Fig.5 EPC model main steps

V. CONCLUSION

A. Conclusion

NCCG has developed a data monitoring and reporting system which has elevated the visibility of the benefits of Energy Efficiency implementation within the institution. The supporting policy framework has also been a critical pillar in deploying EEPs thus making the process instrumental .This study as a case study of the NCCG CBD Sub County did an assessment of the Energy Efficiency programmes implemented by NCCG up to 2021. The findings confirmed that energy-efficient street lighting, traffic lighting, and building lighting interventions resulted in significant savings. Energy-efficient street and traffic lighting is not difficult to implement. Because energy efficient building programs are more complex, an energy audit, in addition to smart metering, is required to develop a baseline and confirm savings.

This study points out that it is important to have an energy data system that is consolidated and integrated so as to enable an effective monitoring and management of internal energy consumption by the county. This study also finds that there exist a lot of energy data resident in the NCCG systems but notes that there is difficulty of accessing the data due to the fragmented nature of the NCCG data management systems.

This study also identified some barriers to EEPs implementation as highlighted in Table 7.

Table 7: Barriers to EEP implementation in NCCG

Barrier	Components	Identification Criterion
Uncertainty and Risk	External Risk	Investments into EEPs only make practical sense if savings are assured in the long term. However there exists uncertainty about future energy prices as energy may get cheaper due to more cost effective acquisition of sustainable energy source.
	Technical Risks	These risks are associated with technology itself given the quick evolving nature of technologies associated with EEPs. Technology must also be useful to the NCCG operation processes and uncertainty exists in its usefulness to that process.
Organizational Barriers	Organization structure	NCCG is a government organization hence decision making is largely consultational. Information flow and management is therefore asymmetrical making coordination of EEPs form financing to implementation tedious
	Organization Culture	This is based on the work ethics that exist in NCCG and points to factors of Resistance to renewal, inertia and personal involvement.
Availability and allocation of capital	Availability of Capital	EEPs can only be implemented when there is sufficient capital to sustain them. NCCG needs to source for capital from within its own revenues or seek external finance to capitalize the EEPs. This becomes a barrier to NCCG because a lot of times, it is unable to find the financing for the EEPs.
	Allocation of Capital	NCCG allocates money according to its investment priorities. In most instances, other functions of NCCG rank higher in and therefore budgetary allocations are either constrained or redirected elsewhere.

In order to guarantee the success of EEPs in NCCG operation, the barriers identified in Table 7 should form the back bone of all EEP planning in the city government as part of their SWOT analysis. This enables the NCCG to be abreast and aware of the bottlenecks that may arise and develop a mitigation plan with a long-term projection.

The development of a business model to implement energy efficiency was critical in order to determine a sustainable energy efficiency implementation model. The Internal Energy Management Protocol is the business model in the NCCG context. This enables a unified business process to be followed by all

Recommendations

Collection of Data and Data Monitoring: Due to the dependence on the implementation of smart meters, the development of a management system for energy data requires time to roll out in order to display a metered electricity consumption baseline. For this scenario to be mitigated, the Department of Energy has deployed a manual system that depends on a theoretical methodology to determine and predict electrical energy consumption NCCG in general. However, the tracking and determination of the effectiveness of the EE measures still remain a challenge due to lack of management tools for effecting them. This has led to undetermined impact on the collective effect of the EEPs. With lack of metering, there is need for a methodology that is robust to capture the effect in all the NCCG internal departments.

Updated technology improvements: This study recommends market analysis to determine the technological advancements that have been developed around energy efficiency in street lighting, traffic lighting and building energy management in the past five years. This is to be done for all the departments of NCCG. This will keep the NCCG staff up to date of the technological developments so that as they carry out energy planning they can adopt these newer technologies accordingly during upgrades to NCCG installations. An example of this technology will be installing a Building Management System that will help in tracking energy usage in order to reduce wastage and to gauge the effectiveness of EE programs installed.

In assessing the energy efficiency programmes with the operations of NCCG, it is important that a framework is developed so that energy planning and financing of projects are streamlined. This enables the definition and identification of challenges that affect the implementation of Energy Efficiency Programmes of the operations of NCCG, hence helping in the planning of mitigation measures in order to improve the rate of absorption of the EE programmes.

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