

**FORMULATION AND IMPLEMENTATION OF OPERATIONS  
STRATEGY FOR ENERGY-EFFICIENT STREET LIGHTING:  
THE CASE OF NAIROBI CITY COUNTY**

**BY**

**FLORENCE NGUNJU WAMBUGU: D61/64835/2010**

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## DECLARATION

I declare that this research project submitted is my original work and has never been submitted to any other university for assessment or award of a degree.

Signature..... Date.....

**Florence Ngunju Wambugu**

**D61/64835/2010**

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

Signature..... Date .....

**Kariuki C. Ngugi**

**Lecturer, Department of Management Science**

## **DEDICATION**

This study is dedicated to my husband Peter, my daughter Abigail and my sons Michael and Jeremy for their moral and emotional support during the long hours spent on this research project.

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## **ABBREVIATIONS AND ACRONYMS**

BIS	Bureau of Indian Standards
BOT	Build, Operate and Transfer
CIBSE	Chartered Institution of Building Services Engineers
CCI	Clinton Climate Initiative
DCCEE	Department of Climate Change and Energy Efficiency.
EPA	United States Environmental Protection Agency
EPEC	European PPP Expertise Center
GE	General Electric Company
HPSV	High Pressure Sodium Vapour
ICC	International Conference Center
ILO	International Labour Organization
IPMVP	International Performance Measurement & Verification Protocol
LED	Light-Emitting Diode
NCC	Nairobi City County
NYCGP	New York City Global Partners
NYSERDA	New York State Energy Research and Development Authority
PPP	Public-Private Partnerships
PWC	Pricewaterhousecoopers
USAID ECO-III	United States Agency for International Development and Energy Conservation and Commercialization

## **ABSTRACT**

The purpose of this study was to investigate operations strategy formulation for energy-efficient street lighting at the Nairobi City County. The study was guided by the following three objectives: to establish the extent of operations strategy formulation; to determine the extent that the operations strategy has been implemented and to establish the challenges experienced in the implementation of the operations strategy for energy-efficient street lighting for Nairobi City County.

Descriptive survey research design was used in conducting this study. The target population for the study was the electrical department of the Nairobi City County. Seven engineers and fifteen supervisors in the department were targeted for data collection. Primary data collection method was a self-administered questionnaire administered using “drop and pick later” basis. Data was analyzed using descriptive statistics such as frequency tables, percentages, mean value, standard deviations and content analysis.

Results revealed that operations strategy formulation for energy-efficient street lighting in Nairobi City County takes place at the Nairobi City County and the electrical department plays a major role in the formulation of the operations strategy. Operations strategy implementation through development of programs, budgets and procedures occurred in varying extent. The research findings indicated that the main challenges to the implementation of operations strategy were vandalism and lack of financial and human resources channeled towards energy-efficiency.

The study recommended that an energy policy be incorporated in the operations strategy formulation. The research findings also recommended replacement of all 25,500 HPSV street lamps, constituting 82.3% of all street lamps, with 120W LED street lamps. This would translate to total annual cost savings of Kshs 106.7 million or a 24% reduction in annual electricity costs. With an initial cost of Kshs. 1.02 billion, NCC would recover its capital investment in 9.5 years. It was also recommended that the top management make a commitment to continuous improvement and allocate adequate staff and funding to the electrical department. Lastly, it was recommended that all PPPs contracts be reviewed in order to enforce energy-efficiency practices in street lighting within Nairobi City County.

# CHAPTER ONE: INTRODUCTION

## 1.1 Background

Organizations today face various challenges in respect to operations strategy, from formulation to effective implementation. A survey of 93 *Fortune 500* firms revealed that more than half of the organizations experienced challenges when attempting to implement an operations strategy. These challenges included inadequate leadership, insufficient capabilities of involved employees and an inadequately monitored information system (Wheelen and Hunger, 2006). Operations strategy outlines the “how” and this study will examine how operations strategy can assist Nairobi City County in achieving energy-efficient street lighting.

### 1.1.1 Operations Strategy

Operations strategy specifies the policies and plans for using organizational resources to support long-term competitive advantage. The role of operations strategy is to provide a plan for the operations function so that it can make the best use of resources (Voss, 1995). Developments in the study of operations strategy has made it possible for service and public organizations to apply concepts and techniques which were hitherto applied only in the manufacturing sector (Krajewsky and Ritzman, 2002). Creating an integrated system and an alignment with the broader strategic goals is the task of operations strategy (Lee and Ritzman, 2005).

Operations strategy formulation is the development of long-range policies and plans for effective management of environmental opportunities and threats, in light of corporate strengths and weaknesses. Operations strategy formulation and implementation is important because it aligns resources with requirements thus developing a sustainable competitive advantage for the organization. It outlines how and where a product or service is to be manufactured, the level of vertical integration in the production process, the deployment of physical resources, relationships with suppliers as well as the optimum level of technology (Slack and Lewis, 2002). Operation strategy implementation is a process by which policies and plans are put into action through the development of programs, budgets and procedures. Implementation refers to activities needed to accomplish a plan (Wheelen and Hunger, 2006).

### **1.1.2 Energy-Efficiency in Street Lighting**

Providing street lighting is one of the most important and expensive responsibilities of cities. Street lighting can account for 10 – 38% of the total energy bill in typical cities worldwide (NYCGP, 2009). Many street lighting systems are outdated and therefore highly inefficient. Energy-efficient street lighting uses a balance of proper energy-efficient technologies and design layout to meet performance, aesthetic and energy criteria required by pedestrians, motorists, community residents, municipalities and utilities (CIBSE, 2004).

Street lighting has come a long way and is still developing. During the Greek and Roman civilizations, oil lamps were used for lighting up streets. The oil lamps gave a dim but long lasting and moderate flame. It was the duty of the lamp-lighter to go round the town at dusk, lighting each lamp. Since this work was very cumbersome to execute, consequent designs employed ignition devices that would automatically strike the flame when gas supply was activated (Kenya Power and Lighting, 2014).

During the year 1807, gas derived from coal was used to light the Westminster Bridge in London. Baltimore became the first American city to have its streets lit up in 1816 using this primeval model. Modern street lights, as we know them today, were first put up in Paris (City of Lights) with actual electric arc lamps lining the streets. Arc lights had two major disadvantages. Firstly, they emitted an intense harsh yellow light which caused light pollution and secondly, they were maintenance intensive as the lamps required constant replacement. In 1879, incandescent light bulbs were invented. The first street to be lit with the new technology was Newcastle, England. Africa experienced its first street lights in 1882 at Kimberly, South Africa (Kenya Power and Lighting, 2014).

As innovations into street lighting progressed, high-intensity discharge lamps were invented and are still commonly used for today's lighting needs. Street lights are made up of a number of features. Firstly, a structural system consisting of poles and the pole's foundation; secondly, the electrical system consisting of lamps, ballasts and service cabinets (fuse box); and lastly, the optical system made up of a luminaire.

The most common reasons for inefficient street lighting systems include; selection of inefficient street lamps, poor design and poor maintenance practices (Alexandru et al., 2012). Existing street lights can be retrofitted or replaced to increase energy-efficiency. To retrofit is to add a component or accessory to something that already exists (Oxford, 2011). The decision to retrofit or to replace new street lights should be based on the purpose and lighting requirements of the roadway, age of existing lighting infrastructure and whether existing poles can be used with replacement of luminaires or new poles have to be put up (New York State Energy Research and Development Authority, 2002).

A directive by the European Parliament and Council on street lighting outlines eco-design requirements for energy using products, focusing on energy consumption during the entire product lifecycle including production, transport, scrapping and recycling. One aspect of the directive is the phasing-out of high-pressure mercury (HPM) lamps by 2015 and of medium efficient metal halide lamps by 2017 (EPEC, 2009). Due to the energy required by incandescent bulbs, solar power was not previously viable. However, according to Davis & Shirtliff (2012), Kenya's largest alternative energy supplier, the development of reliable LED bulbs, which use about 5% of energy used by incandescent types, solar power is now a cost effective and reliable alternative to conventional power.

There are major economic, environmental and social benefits in energy-efficient Street lighting. Firstly, economic benefits, whereby companies that improve energy efficiency will have lower energy and maintenance bills. Secondly, environmental benefits, which will ensure lower carbon emission, preservation of available resources, energy security and responsible utilization of natural resources. Lastly, social benefits, whereby street lighting structures enhance the appeal of cities, towns and communities as commercial and cultural centers by highlighting attractive local landmarks or accentuating the atmosphere during important public events (PWC, 2011).

### 1.1.3 Energy-Efficiency in Street Lighting for Nairobi City County

Nairobi came into existence in 1899 when it was established as an inland center for the Kenya Uganda Railways. The center steadily developed and in 1950, it was upgraded into the capital city of Kenya. Road transport is the predominant mode of transport and conveys about 93% of all cargo and passengers in Kenya (Kibwage, 2002). The road network classification in Kenya is shown in Table 1.1.

**Table 1.1: Road Network Classification System in Kenya**

CLASS	DESCRIPTION	FUNCTION
A	International Trunk Roads	Link important and cross international boundaries or terminate at international ports or airports (e.g. Mombasa)
B	National Trunk Roads	Link nationally important centers (e.g. Provincial Headquarters)
C	Primary Roads	Link provincially important centers to each other or to higher class roads (e.g. District Headquarters)
D	Secondary Roads	Link locally important centers to each other or to more important centers or to a higher class road (e.g. divisional head quarters)
E	Minor Roads	Any link to a minor centre

Source: Kenya Roads Board, 2014

The Kenya Roads Act, which was operationalized in 2007, gave rise to the formation of three new roads authorities; Kenya National Highways Authority (KeNHA), Kenya Urban Roads Authority (KURA) and Kenya Rural Roads Authority (KeRRA). KeNHA manages and maintains roads of class A, B and C while KURA and KeRRA develops and maintains roads of class D, depending on the location. Urban roads are those falling within the urban areas and transverse areas with dense populations. Under the new constitution, functions, powers and resources are divided between the National and County governments. Street lighting in urban and rural roads falls under the County governments while street lighting in major highways falls under KeNHA (Kenya Roads Board, 2014).

The first electricity supplying company in Nairobi was the Nairobi Power and Lighting Syndicate (NP&LS) founded in the year 1908 by Clement Hertzell. The company merged with Mombasa Electric Power and Lighting Company (MEP&LC) to form the East African Power and Lighting Company (EAP&L) which had exclusive rights to supply electricity in Kenya. In 1954, the Kenya Power Company (KPC) was created with the Kenyan government's partial ownership– to be managed by EAP&L. EAP&L was renamed Kenya Power and Lighting Company Limited (KPLC) in 1983 (Kenya Power and Lighting, 2014).

Nairobi's first street lights consisted of oil lamps, with extremely inefficient lighting as there was no electricity supply. The first modern street lighting project in Nairobi was done in 1910. One major opportunity that economical usage of energy in street lighting can grant to Kenya is the achievement of Vision 2030. The economic pillar of the Vision 2030 targets the tourism, agriculture, IT manufacturing, wholesale/retail trade, and financial services which require sufficient energy to run effectively and efficiently (Government of Kenya, 2008).

## **1.2 Statement of the Problem**

Operations strategy specifies policies and plans for using organizational resources to support long-term competitive advantage while operation strategy implementation is a process by which these policies and plans are put into action through the development of programs, budgets and procedures. Conversely, energy-efficient street lighting is a street lighting system that uses a balance of proper energy-efficient technologies and design layout to meet performance, aesthetic and energy criteria required by pedestrians, motorists, community residents, municipalities and utilities (USAID ECO-III Project, 2009).

Operations strategy outlines the “how” of achieving energy efficiency in street lighting within Nairobi City County. The formulation of an operations strategy shows the long-term aspirations and intent of an organization and its implementation ensures that it is realized. Attention to design and energy saving objectives set out at the beginning of street lighting projects, and communication of these objectives to all participants, greatly assists in meeting these objectives (NYSERDA, 2002).

Global key studies in energy-efficient street lighting have enlightened some countries to embrace this concept of energy efficiency in a large way. In Europe, energy efficiency is crucial to the European Union's (EU) transition to a resource-efficient economy leading to the realization of EU's 2020 strategy for smart, sustainable and inclusive growth. This objective has three corresponding energy efficiency targets: to lower greenhouse gas emissions by 20% relative to 1990 projections, to generate 20% of primary energy from renewable sources and to achieve 20% primary energy savings relative to the 2007 projections (EPEC, 2013). A study done in Los Angeles, USA, indicated that a replacement and proper maintenance of 140,000 conventional street lights with LED fixtures would lead to total savings of \$10 million annually as a result of reduced energy requirements and lower levels of maintenance (CCI, 2009).

Other studies have been conducted on energy-efficient solar street lighting. An ILO (2013) report concluded that a green economy could yield up to 60 million jobs worldwide, annually. A comparative study conducted in India by the Regional Science Centre in collaboration with Malabar Christian College in 2013 revealed that while a sodium vapour lamp consumes 200 W of electricity per hour, a solar powered LED light uses only 24W and recommended the use of solar powered LED street lights to reduce energy consumption (The Hindu, 2013). Another study conducted in 2012 by United Nations Environmental Programme (UNEP) and the Global Environment Facility (GEF) in collaboration with Philips Lighting, demonstrated that a total of five percent of global electricity consumption could be saved every year through a transition to solar efficient lighting; resulting in annual worldwide savings of over US \$10 billion..

According to case study conducted in India, when designing or making changes in street lighting, it is important to first understand the light requirements of the road. Energy efficient technologies and design can cut street lighting costs dramatically by up to 60% (USAID ECO-III Project, 2009). The design of the street lighting system should be appropriate for the site and should provide the level of illumination required. Other considerations include maintenance, replacement costs and ease of use of technology. In India, guidelines for lighting of public streets, roads and highways are provided for in the Indian standard (BIS, 1981).



In Durban, South Africa, the ICC street lighting project which was an initiative of by Philips, Eskom, the South African Department of Environmental Affairs and the Ethekwini Municipality, replaced 149 old standard lighting technologies of metal halide lamps with the latest and energy-efficient LED street luminaires creating annual energy savings of 27% ([www.lighting.philips.com](http://www.lighting.philips.com)).

Organizations which have successfully formulated and implemented their operations strategies include Colgate-Palmolive, GE and McDonalds. Colgate-Palmolive and GE have done this through the restructuring of their organization structure in order to give their employees mental space and time. As a matter of fact, an organization running on very lean staffing will have other competing activities and crises taking attention away from implementation of their operations strategy. McDonalds, on the other hand, has a strong positive culture grounded on the operations strategies formulated and implemented by the company founders. Quality service, cleanliness and value were critical practices in their operations strategy and these practices have been successfully passed on to subsequent managers (Faull, 2004).

A study by Magutu (2010) focused on formulation and implementation of operations strategy in the Nairobi City County's solid waste management. The study found that the Nairobi City County (formerly known as City Council of Nairobi) had not invested enough time and effort in analyzing environmental capabilities to develop and implement their operations strategy on solid waste management.

There are many studies on formulation and implementation of operations strategy while others are on energy-efficient street lighting. However no research, to the best of my knowledge, has focused on formulation and implementation of operations strategy for energy-efficient street lighting in Nairobi City County, thus there was a necessity to bridge the gap. This study attempted to answer the question on whether the Nairobi City County undertakes formulation and implementation of operations strategy in creating energy-efficient street lighting.

### **1.3 Objectives of the Study**

The objectives of this study were:

- i. To establish the extent of operations strategy formulation for energy-efficient street lighting in Nairobi City County
- ii. To determine the extent that the operations strategy has been implemented to develop energy-efficient street lighting for Nairobi City County
- iii. To establish the challenges experienced in the implementation of the operations strategy for energy-efficient street lighting for Nairobi City County

### **1.4 Importance of the Study**

The major beneficiary of this study will be the Nairobi City County. The institution will have a clearer understanding of formulating and implementing operations strategy for an energy-efficient street lighting system that takes care of all its stakeholders.

The findings of this study will assist gated communities to formulate and implement operations strategies for Energy-Efficient Street lighting. This will assist the property managers to save on electricity and maintenance costs associated with street lighting and this savings will then be passed on to the residents.

This study will be an incentive for energy-efficiency research and development into energy efficient operations strategies by other counties and firms. The study can be used as a benchmark by other firms which may require energy efficiency in their operations.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1 Introduction**

This chapter examines prior studies covering the concept of formulation and implementation of operations strategy, energy-efficient street lighting guidelines including lamp technology. It further examines the operations strategy and energy-efficient street lighting for Nairobi City County.

### **2.2 Operations Strategy**

The operations function is responsible for managing the resources needed to produce the company's products and services and furthermore specifies the design and use of these resources to support the business strategy (Lowson, 2001). The operations strategy must be aligned with the company's business strategy and enable the company to achieve its long-term plans. Operations strategies are developed from the competitive priorities of an organization, which are cost, quality, flexibility and fast delivery. A firm's competitive priorities and its operations strategy must be congruent. The fit between these two and the necessary investments in operations structure and infrastructure may justify the role of operations area as a source of sustainable competitive advantage and continuous improvement (Hayes et al., 1998).

A firm should continually evaluate its service delivery system to ensure that it is not overtaken by competition (Anderson et al., 1989). The essence of strategy is choosing a unique and valuable position rooted in systems of activities that are much more difficult to match. Activities are the basic units of competitive advantage and it is the performance of these activities better that gives a company operational effectiveness (Porter, 1996). Operational effectiveness is the domain of the operations strategy. It includes improved technologies, superior inputs, well trained employees and a more effective management structure. Technologies will have an increasingly important role to play including technological know-how in product and process innovation (Wheelen and Hunger, 2006).

A company needs to examine its value chain and decide where it can add value most effectively (Burnes, 2004). A company's value chain is only as strong as its weakest link and success depends on how well each department performs its work of adding customer value and on how well the activities of various departments are coordinated (Kortler and Armstrong, 2006).

### **2.3 Operations Strategy Formulation and Implementation**

In general, strategy formulation is the development of long-range policies and plans for effective management of environmental opportunities and threats, in light of corporate strengths and weaknesses (SWOT). On the other hand, Strategy implementation is a process by which policies and plans are put into action through the development of programs, budgets and procedures. Budgets are costs to the programs while, procedures are sequence of steps needed to do the job. For the implementation process to advance, the following questions need to be considered: Who are the people who will carry out the strategic plan? What must be done to align the company's operations in the new intended direction? How is everyone going to work together to do what is needed? (Wheelen and Hunger, 2006). Operations strategy has three levels: first, alignment of resources with requirements (fit); secondly, developing sustainable competitive advantage (sustainability) and lastly including the impact of uncertainty (Nigel and Lewis, 2002).

A fresh viewpoint into operations strategy, together with advances in information technology and business process reengineering techniques can provide huge opportunities for operational efficiencies (Magutu, 2010). An operations strategy determines how and where a product or service is to be manufactured, the level of vertical integration in the production process, the deployment of physical resources, and relationships with suppliers. It also deals with the optimum level of technology the firm should use in its operations processes. Operations strategy implementation is becoming much more of a concern than formulation. Formulating a strategy is one thing, implementing it is an entirely different matter. The main thrust of implementation is to translate the formulated operations strategy into actions (Burnes, 2004).

A company's track record in implementing its operations strategy should be presented in terms of a Desired Vs Actual (Current) Outcome. Outcome should be defined in terms of average and variability of cost, quality, flexibility and delivery. For there to be a Desired Outcome, leadership should be brought to consciousness about what is to be achieved and how it will be achieved. The commitment of the leadership will then motivate other stakeholders whose collaboration is needed for the Desired Outcome to be achieved. The leadership ought to create a fault-tolerant environment as plans are not foolproof and employees learn in the process of getting things done (Faull, 2004).

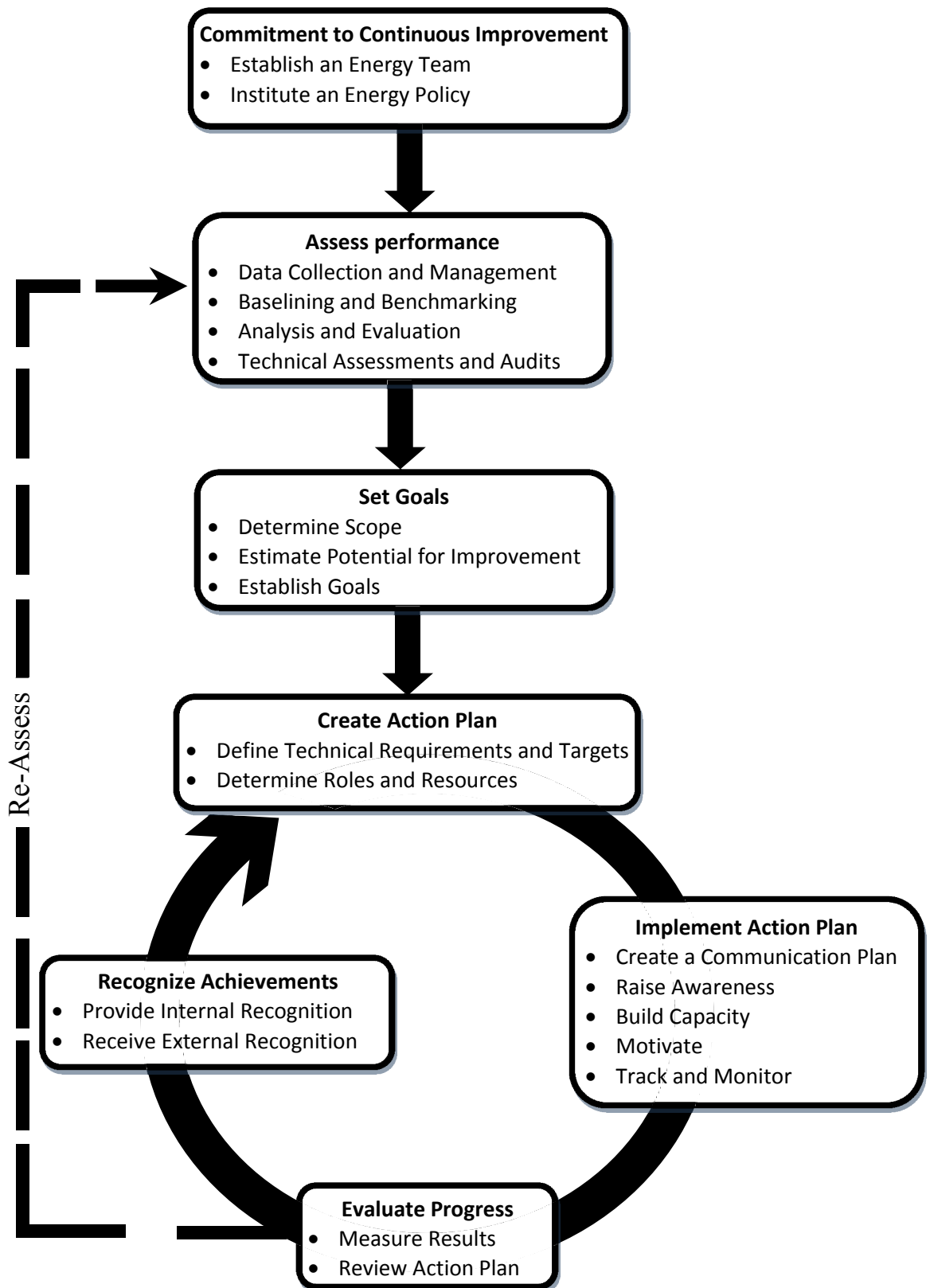
The formulation of an operations strategy shows the long-term aspirations and intent of an organization and its implementation ensures that it is realized. There are three main parts of implementation; firstly, decisions and actions start cascading down through the organization; secondly, performance is monitored to ensure that results are achieved; thirdly, ensuring that appropriate infrastructure is in place. The infrastructure consists of organizational structure and systems, human resources, culture and resources (Fleming, 1977).

## **2.4 Energy-Efficient Street Lighting**

Street lighting is a major concern for public authorities especially in developing countries because of its strategic importance in economic and social stability. Inefficient street lighting wastes significant financial resources each year while poor lighting creates unsafe conditions. Energy efficient technologies and design can cut street lighting costs dramatically by up to 60% (USAID ECO-III Project, 2009).

These savings can reduce need for new energy generating plants and provide the capital for alternative energy solutions for populations in remote areas. These savings can also enable public authorities to expand street lighting to additional areas especially to low income neighbourhoods. Figure 2.1 shows energy-efficient street lighting guidelines outlined by the United States Environmental Protection Agency (US EPA, 2013).

**Figure 2.1: Energy-efficient street lighting guidelines**



Source: US EPA, 2013

The first step is making a commitment to continuous improvement. The common element of successful energy management is commitment to allocate staff and funding to achieve continuous improvement. An organization's success is based on regularly assessing energy performance and implementing steps on energy performance. Any organization, regardless of size, function, or mission can develop an effective energy program if the management is willing to make the commitment.

Operations strategy looks at the long-term approach on how to manage the resources which produce products and services as well as the optimum level of technology the firm should use in its operations processes (Nigel and Stuart, 2010). For operations strategy to be effectively implemented, a dedicated energy team and management policy needs to be put in place. The energy team should include representatives from engineering, purchasing, operations and maintenance, environmental health and safety, contractors and suppliers. An Energy Policy provides the foundation for setting performance goals and integrating successful energy management (U.S. EPA, 2013).

Secondly, an organization needs to find out its current position and where it would wish to be by assessing its performance. This is done by understanding current and past energy use and identifying opportunities to improve energy performance and gain financial benefits. Establishing baselines helps determine the starting point from which to measure progress and benchmarking assists in comparing the organization's energy-efficiency performance to peers to discover areas of improvement. Technical assessments and audits evaluate the operating performance of facilities, systems and equipment to determine improvement potential (U.S. EPA, 2013).

Technical assessment of street lighting technologies, such as lamp technology, for energy-efficiency is crucial. Decisions on lamp technology should take into account such characteristics as lamp efficacy, color rendering and light distribution (BIS, 1981). Table 2.1 shows the various types of lamps and their characteristics.

**Table 2.1: Lamp Technology**

Type of Lamp	Luminous Efficacy (lm/W)	Colour Rendering Properties	Lamp life in Hours	Remarks
High Pressure Mercury Vapor (MV)	35-65 lm/W	Fair	10,000-15,000	High energy use, poor lamp life
Metal Halide (MH)	70-130 lm/W	Excellent	8,000-12,000	High luminous efficacy, poor lamp life
High Pressure Sodium Vapor (HPSV)	50-150 lm/W	Fair	15,000- 24,000	Energy-efficient, poor color rendering
Low Pressure Sodium Vapor	100-190 lm/W	Very Poor	18,000-24,000	Energy-efficient, very poor color rendering
Low Pressure Mercury Fluorescent Tubular Lamp (T12 &T8)	30-90 lm/W	Good	5,000-10,000	Poor lamp life, medium energy use, only available in low wattages
Energy-efficient Fluorescent Tubular Lamp (T5)	100-120 lm/W	Very Good	15,000-20,000	Energy-efficient, long lamp life, only available in low wattages
Light Emitting Diode (LED)	70-160 lm/W	Good	40,000- 90,000	High energy savings, low maintenance, long life, no mercury. High investment cost, nascent technology

Source: USAID ECO-III Project, 2009

Thirdly, setting SMART performance goals is critical in achieving intended results, developing an effective operations strategy and reaping financial gains. Performance goals drive energy management activities and promote continuous improvement. Goal setting will aid the energy team measure success, identify progress and setbacks. It also fosters ownership and creates a sense of purpose among the staff (U.S. EPA, 2013).

Fourthly, successful implementation of an operations strategy requires a detailed action plan. The action plan should be regularly updated to reflect recent achievement, changes in performance and shifting priorities. The organization should define technical steps and targets for upgrading facilities to the desired level of performance. The action plan should also have performance targets, timelines and a tracking system. Determination of who should be involved and their responsibilities will depend on the organization and will ensure that employees understand their roles in the achievement of performance goals. Consultants, service providers and vendors are identified at this point. Resources in terms of human and capital outlay for each program in the action plan are estimated and secured (U.S. EPA, 2013).



For most organizations, the cost of operation and maintenance is a significant fraction of the total cost (Naylor, 1996). The main objectives of maintenance include to enable product quality and customer satisfaction through correctly adjusted, serviced and operated equipment; maximize the useful life of equipment; keep equipment safe and prevent the development of safety hazards; minimize the frequency and severity of interruptions and; maximize production capacity from given equipment resources (Mulwa, 2000).

Energy consumption for street lighting can be reduced by incorporating good maintenance practices such as replacing defective lamps, accessories, and wires; early rectification of cable faults; regular maintenance of service cabinet/fuse box to avoid loose connections and; regular cleaning of the luminaire cover to keep it free of dust/dirt and increase light output (CIBSE, 2004).

The Fifth Step consists of motivating key people in order to gain support and cooperation from different levels within the organization for the successful implementation the action plan. Effective programs make employees, managers and other key stakeholders aware of the energy goals and initiatives, as well as their responsibility in carrying out the program. The organization should build their staff capacity through training in order to assist employees undertake their responsibilities successfully (U.S. EPA, 2013). The maintenance staff should be trained in order to ensure that improvements in street lighting are sustained (Mulwa, 2000).

The Sixth Step is evaluating progress which includes formal review and comparison of current performance to established performance goals. The review identifies what worked and what did not and is used to create new action plans, identify best practices and set new performance goals. During progress evaluation, the energy team and other employees give feedback and with this information, employee awareness of energy issues is assessed. Evaluating progress gives insight into new action plans, helps organizations avoid repeating mistakes and provides success stories to communicate to stakeholders outside the organization (U.S. EPA, 2013).

The main objective of evaluating progress is to provide a credible process that can be used to quantify and assess the impact and sustainability of the implemented energy-efficiency project. The basic principle is to compare the measured electricity consumption and demand before and after implementation to determine the electricity savings. This is demonstrated in the International Performance Measurement & Verification Protocol (IPMVP)'s equation illustrated as follows: Electricity Saving = (Pre-implementation electricity use) – (Post-implementation electricity use) ± Adjustments (Efficiency Valuation Organization, 2007).

Advanced technologies like remote switching points in street lights and metering are important components in a street lighting system as they: monitor the performance of the system and energy use; measure and verify the energy savings in case the system needs to be updated; identify and analyze reasons for increases or decreases in energy consumption; increase automatic failure identification; support preventive maintenance; assist in remote testing and monitoring of streetlights on city maps and; report outages (Alexandru et al., 2012).

The seventh and very important step is recognizing achievements in order to sustain momentum and support for the energy efficiency initiatives. This is done through acknowledging contributions of specific people, teams or entire departments. Achievements include; best energy savings ideas, increased savings or greatest reduction in energy use. External recognition may come from investment partners, achievement awards or even ISO certifications. This recognition enhances the organization's public image and contributes to the organization's competitive advantage by making it more attractive to customers (U.S. EPA, 2013).

Continuous improvement of energy performance requires establishing effective energy management practices and processes to guide the energy program. The guidelines for energy-efficiency, can assist an organization improve its energy and financial performance. There is a tremendous potential to improve lighting quality while reducing energy use, costs and greenhouse emissions in any organization and all it takes is commitment, performance assessment, goal setting, creation of an action plan, implementation of the action plan, evaluation of progress and recognition of achievements (U.S. EPA, 2013).

## **2.5 Operations Strategy and Energy-Efficient Street Lighting in Nairobi City County**

The Nairobi City County needs an energy-efficient street lighting system that uses a balance of proper energy-efficient technologies and design layout to meet performance, aesthetic and energy criteria required by pedestrians and motorists. Operations strategy outlines the “how” of achieving this. The operations capabilities of a firm can be viewed as a portfolio best suited to adapt to the changing product and service needs of a firm’s customers (Hill, 1993). Thus planning for energy-efficient street lighting is imperative in order to reduce costs and save energy in the long run (NYSERDA, 2002).

In Kenya, county governments are encouraged to form Public-Private Partnerships (PPP) with private service providers. The county councils have the authority to select the street lighting technology and managers that they want. This would mean that county governments could find alternate managers for their street lighting if the private company is unable to provide competitive energy-efficient street lighting. According to the Nairobi City County, the PPPs are based on the concept of build, operate and transfer (BOT) where the private companies put up street lighting infrastructure, operate them for five years before transferring them back to the county government. The companies get their returns from renting out advertisement space on street poles ([www.standardmedia.co.ke](http://www.standardmedia.co.ke)).

Another PPP is the Sh1.1 billion contract between the Kenya National Highways Authority and Sinhydro Joint Venture to maintain the Thika Superhighway. The company will be required to replace vandalized guardrails, street poles, road-signs and ensure drainage systems are working (Daily Nation, 2014). Training of human resources on energy-efficient technology used in street lighting is important and is one of the most important aspects of operations strategy, given that employees of the Nairobi City County are the ones who provide all the labour during installation and maintenance even for the private companies in the PPP. The maintenance staff ought to be given specialized and continuous training in order to keep up with technological development as well as to ensure energy-efficiency improvements on street lights are sustained.

The Nairobi City County needs to determine the most suitable technological and economic solution for street lighting within its policy, resource and energy context. There are a various challenges to upgrading or installing an energy-efficient street lighting system.

Firstly, financial Implications of implementation may be significant. These costs include both the investment costs of providing whatever additional resources the strategy requires, and also what could be termed as the adjustment cost of making any changes. Adjustment costs are losses that could be incurred before the new strategy is functioning as intended (Slack and Lewis, 2002). Before making a decision about whether to change technologies to achieve energy efficiency it is necessary to accurately assess the net benefits of doing so. The concerned institutions must decide whether the benefits from upgrading to effective energy-efficient street lighting supersede the costs caused, then they would have an incentive to upgrade (DCCEE, 2011).

Secondly, uptake of new technology can be a significant barrier especially if the current systems for managing street lighting are highly conventional as is the case of the Nairobi City County (Hayes & Jaikumar, 1998). Most of the current street lighting system uses obsolete lighting technology which consumes large amounts of energy and financial resources while failing to provide high quality lighting. Phasing out old technology requires technical assessments and planning from experts to guarantee a seamless transition into new technology. For example, LED lamp technology is a fast-evolving technology with significant energy-saving potential and low maintenance cost (USAID ECO-III Project, 2009).

Thirdly, as earlier stated, skill barrier can be overcome if the Nairobi City County can gain access to good information and experts. The staff will then be able to select, install and maintain street lighting and deliver the best outcomes. Regional approaches and outsourcing are essential in case of lack of in-house expertise in street lighting. The county needs to identify skills gaps and fund activities to address skills shortages including in energy auditing and advisory services (EPA, 2013).

Fourthly, although more energy-efficient street lighting system will deliver a good financial return to the Nairobi City County, misaligned incentives, monopoly control and political interferences may hamper improvements to street lighting. The management of the Nairobi City County needs the right incentives, support and processes to drive investment into a more energy-efficient street lighting. The institution needs to promote best practice and innovation (DCCEE, 2011).

Another challenge is the information barrier. Accurate, timely and comprehensive information is fundamental to the development and successful implementation of new energy efficiency measures in street lighting. Currently, the availability of broad and consistent energy efficiency information is limited, with little information about energy use in critical parts of the County. Improved information will assist in county and national energy efficiency policy development and in evaluation, reporting, and benchmarking (U.S. EPA, 2011).

Lastly, rampant vandalism has meant that instead of maintenance, there is a new installation. Information technology can be very useful as an operations strategy tool in the fight against vandalism. Types of vandalism include tapping of power meant for street lighting for home use and metal dealers who offer a ready market for vandalized street poles ([www.standardmedia.co.ke](http://www.standardmedia.co.ke)).

## **2.6 Summary and Conceptual Framework**

This section will summarize the foregoing discussions on operations strategy formulation and implementation for energy-efficient street lighting in Nairobi City County. It will also identify conceptual factors and display them within the conceptual framework diagram.

### **2.6.1 Summary**

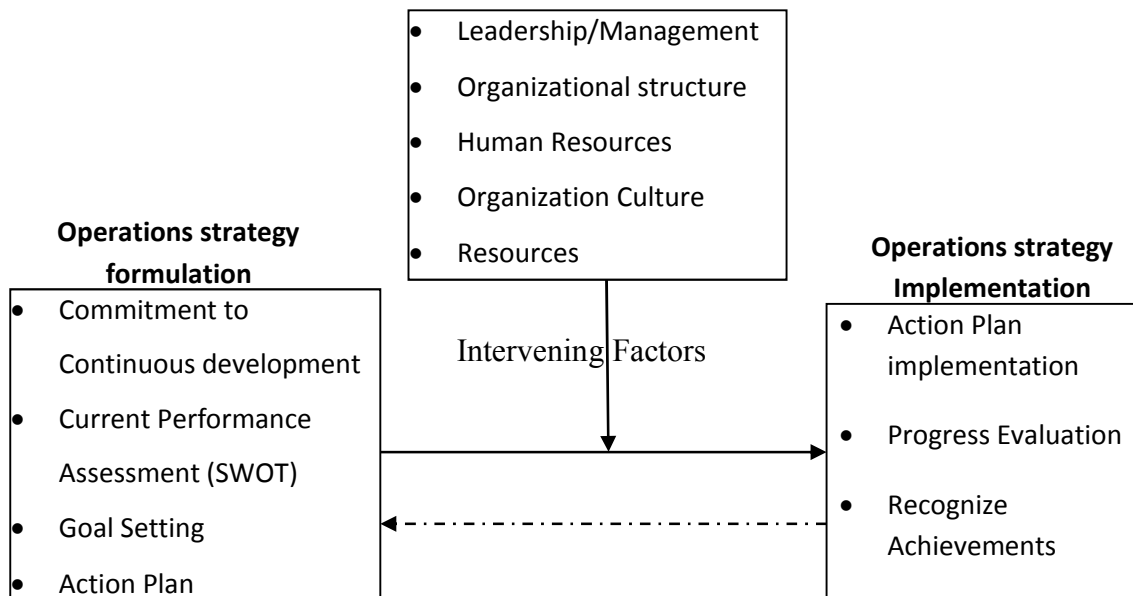
Developments in the study of operations strategy has made it possible for service and public organizations to apply concepts and techniques which were hitherto applied only in the manufacturing sector. An operations strategy determines “how” and “where” of a product or service and is tailored to the available resources and pre-existing regulatory framework.

Organizations seeking to continuously improve their energy efficiency will allocate competent staff and adequate funding to achieve these goals. Establishing baselines and benchmarks facilitates the determination of a starting point from which to measure progress and to discover areas of improvement. Organizations need to create an action plan with defined roles and resources in order to successfully formulate and implement their operations strategy. Providing recognition and rewards to teams or employees who achieve their goals is a proven way to sustain a culture that supports energy efficiency initiatives.

## 2.6.2 Conceptual Framework

Based on the foregoing discussions, the conceptual framework is shown in Figure 2.2.

**Figure 2.2: Conceptual Framework**



Source: Researcher, 2014

The conceptual framework illustrates that in order for the operations strategy formulated to be implemented, the intervening must be functioning properly; the leadership should be motivated enough to see the implementation process through; the organization structure must support the process; well trained employees should be able to carry out the action plan activities and; resources have to be available to facilitate the whole implementation process. The framework also illustrates that operations formulation and implementation is an interactive process and feedback after implementation leads to better and more informed operations strategy formulation.

## **CHAPTER THREE: RESEARCH METHODOLOGY**

### **3.1 Research Design**

This study was a descriptive study as the research questions were clearly stated and attempted to find out who, when or how many/much (Cooper and Schindler, 2003). The research was a case study and assisted the researcher in documenting the extent of formulation, implementation and the challenges facing implementation of operations strategy for energy-efficient street lighting in Nairobi City County.

### **3.2 Population of the Study**

The study was conducted at the Nairobi City County offices and the population of interest was the electrical department. The department is responsible for formulation of street lighting plans and installations as well as their maintenance. The respondents were all the eight engineers and all the fifteen supervisors.

### **3.3 Data Collection**

The study used secondary and primary data. Secondary data was collected from the Nairobi City County records including the Workbook and Service Charter Manual and was used to supplement primary data as well as to give insights into current developments towards energy-efficient street lighting.

Primary data was used to address specific research objectives of the study. Data obtained from primary sources was used to obtain information on formulation and implementation of operations strategy for energy-efficient street lighting as well as the challenges of implementing the operations strategy.

A sample questionnaire is attached as Appendix II. The questionnaire was administered to engineers and supervisors and examined formulation and implementation of operations strategy for energy-efficient street lighting in Nairobi City County. The questionnaire also investigated the challenges of implementing operations strategy for energy-efficient street lighting.

Primary data collection method was a self-administered questionnaire administered using “drop and pick later” basis. This method ensured that the respondents had enough time to answer the questions. The population was considered to be knowledgeable and familiar with the area of study.

### **3.4 Data Analysis**

Data collected consisted of qualitative and quantitative data and was analyzed using descriptive statistics including frequency tables, percentages, means, standard deviations and content analysis.

Data obtained from the Likert scale was used to generate frequency tables. This information was then used to calculate percentages. The frequency/percentage with which a factor of operations strategy appeared was interpreted as a measure of attention and emphasis the factor is accorded at the Nairobi City County. This assisted in our study objectives of establishing the presence, extent and challenges of formulation and implementation of operations strategy for energy efficient street lighting within the Nairobi City County.

Means were calculated for the respective factors relating to formulation and implementation of operations strategies for energy-efficiency street lighting. The means were used to establish the extent of use of these factors. The theoretical mean value considered as an indicator of reasonable use and emphasis should be more than 3 for the various factors being studied (Cooper & Schindler, 2003). In addition, standard deviations were computed for each factor to test variability and consistency of responses among the respondents.

Content analysis was used to analyze qualitative data. Content analysis is a technique for making inferences by systematically and objectively identifying specified characteristics of messages and using the same approach to relate trends (Nachmias and Nachmias, 1996). The extent of formulation and implementation as well as the challenges encountered during implementation of operations strategy for energy-efficient street lighting were inferred by using content analysis within the context of the Nairobi City County.



## CHAPTER FOUR: DATA ANALYSIS AND FINDINGS

### 4.1 Introduction

This Chapter presents the data analysis and findings of the research. The analysis was guided by specific objectives stated in the statement of problem. 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 resulting in a response rate of 86% and 87% respectively.

The presentation of the results was done in three sections according to the objectives of the study. The first section presented information on the extent of operations strategy formulation for energy-efficient street lighting in Nairobi City County; the second section gathered information on the extent of implementation of operations strategy; the third section presented the challenges of implementing operations strategy; and the fourth section was a discussion on the occurrence and/or contradictions of the findings with existing theories and empirical findings.

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 worked at the Nairobi City County. A casual look at Table 4.1 indicated that most of the supervisors who participated in the study had over fifteen years experience. The purpose of this background information was to verify that the respondents had adequate experience to give accurate information.

**Table 4.1: Respondents Working Experience**

Number of Years	Frequency	
	Engineers	Supervisors
0-5	-	-
5-10	3	-
10-15	2	2
Over 15	1	11

Source: Researcher, 2014

## 4.2 Operations Strategy Formulation

In the first section of the questionnaire, the researcher was interested in finding out whether the Nairobi City County formulates operations strategy for energy-efficient street lighting. All the respondents indicated that operations strategy formulation does occur at the Nairobi City County.

Some examples given by the respondents of factors touching on operations strategy formulation included: lighting up Nairobi City County to a 24 hour economy; vision 2030; introduction of solar street lighting; introduction of high fitted lights; Annual Integrated Procurement Plan (AIPD); Annual Work Plans, Annual Budget; yearly performance targets; yearly budget allocation for maintenance and new works; provision of street lighting for road/highway expansion; and budgetary allocation towards new street lighting.

The researcher aspired to know which parties were involved in the formulation of operations strategy for street lighting and Table 4.2 showed the findings.

**Table 4.2: Decision Makers Involved in the Formulation of Operations Strategy**

Group of Decision Makers	Frequency	Percentage
Committees	-	-
Top Management	7	31%
Heads of Departments	4	21%
Electrical department	15	79%
Others	-	-

Source: Researcher, 2014

From Table 4.2 it can be viewed that the majority (79%) of the respondents indicated that the electrical department formulates the operations strategy for energy-efficient street lighting in Nairobi City County while 31% indicated that it was the electrical department working together with top management and another 21% indicated it was the electrical department together with the Heads of Departments. One thing that was clear is that the electrical department plays a major role in the formulation of operations strategy for street lighting in Nairobi City County.

The formulation of an operations strategy shows the long-term plans and intent of an organization and it outlines how and where of a product or service. Table 4.3 shows the findings of when the formulated plans were last updated.

**Table 4.3: Operations Strategy Review**

When the operations strategy plans were last reviewed	Frequency	
	Engineers	Supervisors
1 year ago	4	5
2 years ago	1	-
3 years ago	-	3
Over 4 years ago	1	5

Source: Researcher, 2014

The findings indicated that four out of the six engineers knew that the operations strategy was updated in the last one year compared to five out of thirteen supervisors as illustrated in Table 4.3.

#### **4.2.1 SWOT Analysis of Nairobi City County**

Operations strategy formulation is the development of long-range plans for effective management of environmental opportunities and threats, in light of corporate strengths and weaknesses. The respondents indicated that the Nairobi City County has many strengths, weaknesses, opportunities and threats as shown in Table 4.4. From the findings it appeared that Nairobi City County has a longer list of weaknesses than strengths and more opportunities than threats.

The main strengths highlighted by all the respondents were a large experienced work force and numerous assets while the main weaknesses included low remuneration and political interference. The main opportunities highlighted were the use of dumping sites to generate power and the use of technology while the main threats included vandalism and escalating monthly power bills.

**Table 4.4: A SWOT analysis of Nairobi City County**

<b>Strengths</b>	<b>Weaknesses</b>
<ul style="list-style-type: none"> <li>• A Large work force</li> <li>• Numerous assets including vehicles, land and houses</li> <li>• Teamwork between workmates</li> <li>• Qualified personnel</li> <li>• Long experience of officers</li> <li>• Hosting of international bodies including UNEP</li> <li>• High GDP generation</li> <li>• Financial Capacity</li> <li>• Introduction of modern hydraulic vehicles</li> <li>• Availability of maintenance accessories and equipment</li> <li>• Qualified technical and supervision support team</li> </ul>	<ul style="list-style-type: none"> <li>• Low remuneration for professionals and no payment for overtime</li> <li>• Political interference and conflicting interests</li> <li>• Poor maintenance of assets</li> <li>• Bad organizational culture</li> <li>• Bureaucracy as a result of numerous chain of commands</li> <li>• Lack of a proper financial management system</li> <li>• Insufficient and late delivery of material</li> <li>• Procurement of sub-standard supplies</li> <li>• Inadequate equipment and machinery including vehicles, mobile phones and motorbikes</li> <li>• Poor communication within the chain of command</li> <li>• Little on job training</li> <li>• Lack of follow ups strategies after vandalism</li> </ul>
<b>Opportunities</b>	<b>Threats</b>
<ul style="list-style-type: none"> <li>• Devolution and other provisions in the new constitution</li> <li>• New Public Private Partnerships (PPPs)</li> <li>• Use of dumping sites to generate power</li> <li>• Willingness of the National government to light every county</li> <li>• NCC is strategically located</li> <li>• Desire of businesspeople to invest within the county</li> <li>• Embracing of solar street lighting</li> <li>• Use of street lighting technology to get the best analyzed data</li> <li>• Introduction of modern tools, equipment and hydraulic vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• Vandalism of installations</li> <li>• Escalating monthly power bills</li> <li>• Over population</li> <li>• Unreported road accidents involving streetlights</li> <li>• Lucrative second hand copper market</li> <li>• Lack of roads especially in slum areas</li> <li>• Land grabbing</li> <li>• Poor planning of informal settlements</li> <li>• Poor planning of upcoming estates</li> </ul>

Source: Researcher, 2014

## 4.2.2 Extent of Operation Strategy Formulation

The researcher went further to investigate the extent of formulation of operation strategy for energy efficient street lighting for Nairobi City County. Descriptive analysis was used to analyze the respondent's opinions as illustrated in Table 4.5.

**Table 4.5: Extent of Operation Strategy Formulation**

Question	Respondents' Opinion Frequency					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
NCC encourages research on ways of improving street lighting	-	4	8	6	1	<b>3.2</b>	<b>0.83</b>
NCC analyzes the external opportunities and threats of developing an energy-efficient street lighting	-	2	7	10	-	<b>3.4</b>	<b>0.67</b>
NCC examines its internal strengths and weaknesses in order to develop energy-efficient street lighting	-	3	11	5	-	<b>3.1</b>	<b>0.64</b>
The electrical department makes its own policies on street lighting in Nairobi	-	-	7	12	-	<b>3.6</b>	<b>0.48</b>
NCC's plans for street lighting support energy efficiency in street lighting	-	5	2	12	-	<b>3.4</b>	<b>0.87</b>
The electrical department is engaged in planning for new street lighting projects on roads	-	-	6	7	6	<b>4.0</b>	<b>0.79</b>
NCC is moving towards solar street lighting	-	6	6	7	-	<b>3.1</b>	<b>0.83</b>
Quality service delivery is a key objective in the electrical department policy	-	-	4	7	8	<b>4.2</b>	<b>0.77</b>
NCC's top management has plans for installing street lights in streets with no lighting	-	3	1	9	6	<b>4.0</b>	<b>0.99</b>

Source: Researcher, 2014

As shown in Table 4.5 the respondents indicated their response on a 5-point likert rating scale whose numerical values range from 1-to-5 in ascending order with increasing strength of their level of agreement. The respondents were required to make their choice as to how they rated each question concerning the extent of formulation of operation strategy focusing on energy efficient street lighting for Nairobi City County.

To calculate the mean, the formula  $\text{mean} = \Sigma fx / \Sigma f$  was used. The theoretical mean value considered as an indicator of reasonable use and emphasis should be more than 3 for the various factors being studied. The standard deviation value was used to determine the variability of the responses. To obtain the standard deviation, the formula  $SD = \sqrt{\Sigma fx^2 / \Sigma f - (\Sigma fx / \Sigma f)^2}$ ; was used where the calculated standard deviation indicated the variation in the responses among the respondents. A summary of the study findings were tabulated as shown in Table 4.5.

Statements one, two and three were seeking information concerning research and SWOT analysis conducted at Nairobi City County. The fact that the mean value was between 3 and 4 was interpreted to denote the fact that most of the respondents agreed that there was research into new ways of improving street lighting and that SWOT analysis takes place at Nairobi City County. The first step in energy-efficient street lighting is the establishment of an energy team. As per the list of strengths, Nairobi City County has experienced and trained personnel including engineers and technicians.

The second step in energy-efficient street lighting is assessing performance through research and SWOT analysis of which most respondents are neutral or agree that it was done. Most of the respondents agree that Nairobi City County's plans for street lighting support energy efficiency in street lighting as the mean value was more than 3 although their degree of agreement was not very high at 3.4.

The respondents strongly agreed that the electrical department was engaged in planning for new street lighting projects on roads, that quality service delivery was a key objective in the electrical department's policy and that Nairobi City County's top management has plans for installing street lights in streets with no lighting. This was a good indication that the electrical department was involved in setting plans for new projects and quality delivery in Nairobi City County.

The researcher was interested to know whether Nairobi City County was moving towards solar street lighting as a measure of increasing energy-efficiency. It was noted that most of the solar street lights installed within the city centre and the Thika Superhighway were no longer working as a result of vandalism and procurement of sub-standard solar installations which could not charge adequately during the day to light the whole night. Most of the solar street lights would light up for only a few hours then go off. These blackouts would encourage vandalism. It was observed that this technology works in other cities and would work for Nairobi City County with good quality solar street lighting.

There is formulation of operations strategy for street lighting at the Nairobi City County. Most of the respondents agree that the formulated operations strategy for street lighting at Nairobi City County focus on energy-efficiency. The respondents nevertheless do not strongly agree to this which means there is plenty of room for improvement. The calculated standard deviations indicated that there was no significant variation in the responses among the respondents as it ranges between 0.48 and 0.99.

### **4.3 Operations Strategy Implementation**

This section presents the extent of implementation of operations strategy for energy-efficient street lighting in Nairobi City County. Operations strategy implementation is a process by which plans and policies are put into action through the development of programs, budgets and procedures. Descriptive analysis was used to analyze the data by looking at major factors in energy-efficient street lighting. Some of these factors included the type of streetlight lamps, maintenance, monitoring, street lighting equipment, motor vehicles and human resources.

The researcher was interested in analyzing the opinions of the respondents on implementation of operations strategy for energy-efficient street lighting. The respondents' opinions were analyzed and results shown in Table 4.6. The mean was calculated as  $\frac{\sum fx}{\sum f}$ . The standard deviation value was used to determine the variability of the responses. To obtain the standard deviation, the formula  $SD = \sqrt{\frac{\sum fx^2}{\sum f} - (\frac{\sum fx}{\sum f})^2}$ ; was used. A summary of the study findings is shown in Table 4.6.

**Table 4.6: Extent of Implementation of Operation Strategy**

Question	Respondents' Opinion Frequency					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
Energy use per street light is a concern for NCC	-	-	6	7	6	4.0	0.79
Energy use is monitored	0	0	6	8	5	3.9	0.76
Most street lamps produce white light when lit at night	4	11	4	-	-	2.0	0.65
There is an annual review of programs on improving energy use in street lighting	1	7	10	1	-	2.6	0.67
Top management effectively communicates programs of street lighting to employees	2	1	4	9	3	3.5	1.14
Every concerned employee understands their role in maintenance	-	-	2	14	3	4.1	0.51
There is a detailed schedule on the maintenance activities	-	-	2	15	2	4.0	0.45
The electrical department has the right equipment for maintenance	-	-	8	11		3.6	0.49
Performance appraisal for employees is conducted annually	-	-	7	8	4	3.8	0.74
NCC employees have a platform for giving feedback on street lighting performance	-	-	6	9	4	3.9	0.72
NCC has remote metering points for street lights which monitor energy use	1	11	6	1	-	2.3	0.67

Source: Researcher, 2014



A theoretical mean value considered as an indicator of reasonable use and emphasis should be more than 3 for the various factors being studied. A mean value of between 4 and 5 indicated that energy use per street light was a major concern for Nairobi City County, that every concerned employee understands their role in maintenance and that there was a detailed schedule on maintenance activities.

On further investigation it was noted that the supervisors submit a weekly performance report on maintenance. The presence of a Workbook for spare parts request submitted by the maintenance staff and signed by the supervisors, assisted in tracking spare parts needs and kept a record of supplies issued by stores.

The respondents indicated that energy used in street lighting was monitored and that the electrical department had the right equipment for maintenance though in short supply. The respondents also agreed that performance appraisal for employees is conducted annually and that Nairobi City County employees have a platform for giving feedback on street lighting performance.

Based on the research findings, the respondents disagreed that most street lamps produce white light when lit at night. This finding was supported by the figures on Table 4.6 that indicate that majority of street lights are of High Pressure Sodium Vapour (HPSV) which produces yellow light. The respondents also disagreed with the statement that there was an annual review of programs on improving energy use in street lighting and that the Nairobi City County has remote metering points for street lights which monitor energy use.

It was interesting to note that the statement requiring the respondents to rate whether the top management effectively communicates programs of street lighting to employees had the highest standard deviation of 1.14. Further scrutiny of the data indicated that the engineers felt that the top management effectively communicated programs. This could be as a result of the engineers having more access to information from top management than supervisors.

Considering that the first part of operations strategy implementation requires that decisions and actions start cascading down through the organization, the findings on Table 4.6 suggested that there could be a problem in the flow of communication within the organizational structure which could hinder implementation of formulated operations strategy.

### 4.3.1 Current Streetlight Lamp Technology

The researcher established that the number of working street lights in Nairobi City County range between 30,000 and 32,000. Table 4.7 shows the types and approximate number of streetlights.

**Table 4.7: Type and Number of Streetlight Lamps**

Type of Lamp	Number of Street Lamps	Frequency
High Pressure Mercury Vapour (MV)	3,250	10.5%
Metal Halide (MH)	450	1.5%
High Pressure Sodium Vapour (HPSV)	25,500	82.3%
Low Pressure Sodium Vapour	-	-
Low Pressure Mercury Fluorescent Tubular Lamp (T12 &T8)	425	1.4%
Energy-efficient Fluorescent Tubular Lamp (T5)	125	0.4%
Light Emitting Diode (LED)	1,250	4%
<b>Total</b>	<b>31,000</b>	<b>100%</b>

Source: Researcher, 2014

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, Haille Selassie Avenue, Moi Avenue, and University Way and it features many of Nairobi's important buildings and streets.

According to NCC, HPSV street lamps currently in use are in 150W, 250 and 400W. The approximate monthly electricity bill is Kshs. 37 million which translates into approximately Kshs 444 million annually. For our calculations we will use 250W because it is the median value. A 120W LED street lamp can replace a 250W HPSV street lamp. Table 4.8 shows the energy and cost savings that NCC can achieve if all the 25,500 old standard lighting technologies of HPSV street lamps are replaced with the latest and energy-efficient LED street lamps.

**Table 4.8: Initial Investment, Energy/Cost Savings and Capital Recovery from Replacement of 250W HPSV with 120W LED Street Lamps**

<b>Description</b>	<b>High Pressure Sodium Vapour (HPSV) 250W</b>	<b>Light Emitting Diode (LED) 120W</b>
Number of Street Lamps	25,500	25,500
Energy Usage per 12 hour night (from 6pm to 6am)	250W* 12hrs*25,500 lamps = 76500000Wh (76,500KWh)	120W* 12hrs*25,500 lamps = 36720000Wh (36,720KWh)
Daily Energy Savings	76,500KWh - 36,720KWh = <b>39,780 KWh</b>	
Annual Energy Savings	39,780 KWh * 365 days = <b>14,519,700 KWh</b>	
Annual Cost Savings (factoring in KPLC's C15 commercial rate charges of Kshs.7.35 per KWh)	14,519,700 KWh * 7.35 = <b>Kshs 106,719,795</b>	
Approximate Annual percentage Cost Saving	106.7 million/444 million*100 = <b>24 %</b>	
Total Initial Cost @ Kshs. 40,000 per LED street lamp	40,000* 25,500 = <b>1,020,000,000</b>	
Capital Recovery	1,020,000,000/106,719,795 = <b>9.5 Years</b>	

Source: Researcher, 2014

This savings have not incorporated lower maintenance costs considering that good quality LED streetlamps can last up to 5 times longer than HPSV streetlamps.

### 4.3.2 Hydraulic Trucks and Other Motor Vehicles

In regards to hydraulic trucks, it was established that Nairobi City County has such trucks and they range between one and ten. There are specifically five hydraulic trucks and four pick-up vehicles. The hydraulic trucks have a limitation in terms of height. This number is minimal considering the Nairobi City County covers an area of 696 km<sup>2</sup> and a population of 3,138,369 Kenyans according to the 2009 National Census. The electrical department has divided Nairobi City County into six divisions. Each division has ten to fifteen wards and covers two to three constituencies. Each division is managed by an engineer and several supervisors. Considering this statistics, there is barely one hydraulic truck and pick-up vehicle for each division.

### 4.4 Challenges Faced in the Implementation of Operations Strategy

This section presents a summary of the findings obtained from the questionnaire of research questions that sought to reveal the challenges of implementation of operations strategy for energy-efficient street lighting. Table 4.9 shows a summary of responses from the respondents.

**Table 4.9: Challenges in Implementation of Operations Strategy**

Challenge	Frequency	Percentage
Lack of adequate finances	13	68.4
Lack of Commitment from top management	5	26.3
Strained relationship with Public-Private Partnerships	2	10.5
Poorly trained employees	-	-
Ineffectively coordinated activities	3	15.8
Implementation took more time than originally planned	3	15.8
Key implementation tasks were poorly defined	-	-
Vandalism	19	100
Incompatibility of current technology with new technology	4	21.1

Source: Researcher, 2014

The intervening factors ought to be functioning properly; in order to facilitate the whole implementation process. Table 4.10 examined these intervening factors.

**Table 4.10: Intervening Factors in the Implementation of Operations Strategy**

Question	Respondents' Opinion Frequency					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree		
Financial resources at NCC are channelled towards energy saving programs in street lighting	3	7	9	-	-	<b>2.3</b>	<b>0.73</b>
NCC's top management is interested in what is happening in the electrical department	-	-	2	8	9	<b>4.4</b>	<b>0.67</b>
The current NCC organizational structure supports programs of improving street lighting in Nairobi	-	-	3	14	2	<b>3.9</b>	<b>0.51</b>
The culture at NCC encourages employees to give ideas on how to improve street lighting	1	5	13	-	-	<b>2.6</b>	<b>0.58</b>
NCC uses its financial resources to make street lighting available for everybody in Nairobi	-	-	4	14	1	<b>3.8</b>	<b>0.49</b>
The Public-Private Partnerships companies promote energy-efficiency in street lighting	1	7	11	-	-	<b>2.5</b>	<b>0.59</b>
The electrical department employees are adequately trained to handle installations	-	1	5	12	1	<b>3.7</b>	<b>0.65</b>
NCC has a culture of continuous improvement	-	6	3	10	-	<b>3.2</b>	<b>0.89</b>
Immediate action is taken when street lighting problems come to the supervisor's attention	-	-	3	7	9	<b>4.3</b>	<b>0.73</b>
Staff receive training when required	5	8	6	-	-	<b>2.1</b>	<b>0.76</b>
NCC electrical department requests for street lighting equipment is acted on within a month	6	10	3	-	-	<b>1.8</b>	<b>0.67</b>
NCC has adequate number of staff in the electrical department	7	11	1	-	-	<b>1.7</b>	<b>0.57</b>
NCC has adequate number of motor vehicles in the electrical department	6	11	2	-	-	<b>1.8</b>	<b>0.61</b>

Source: Researcher, 2014

The results on Table 4.9 showed that the main challenge faced was vandalism with 100% of the respondents indicating this fact. It also emerged from the findings that the second largest challenge facing implementation was lack of commitment from top management at 26.3%. Other factors which were less than 20% included; ineffectively coordinated activities, implementation taking more time than originally planned and a strained relationship with PPPs. The respondents felt that some private companies in PPPs were not out to provide street lighting but to enrich themselves.

Based on research findings, there was a strong agreement that the Nairobi City County's top management was interested in what was happening in the electrical department. This however does not mean that top management was committed to implementing operations strategy for energy-efficient street lighting as illustrated in Table 4.9. The findings also showed that immediate action was taken when street lighting problems come to the supervisor's attention.

Table 4.10 shows that the respondents agree with the statement that the current Nairobi City County organizational structure supports programs of improving street lighting in Nairobi and that the electrical department employees are adequately trained to handle installations. The respondents weakly agreed that Nairobi City County has a culture of continuous improvement at a mean value of 3.2 and disagreed that the culture at Nairobi City County encourages employees to give ideas on how to improve street lighting.

The respondents disagreed that financial resources at Nairobi City County are channelled towards energy saving programs in street lighting. However the respondents agreed that Nairobi City County uses its financial resources to make street lighting available for everybody in Nairobi. The findings also indicated that Public-Private Partnerships companies do not promote energy-efficiency in street lighting.

The fact that the respondents strongly disagreed with the statement that Nairobi City County electrical department requests for street lighting equipment was acted on within a month, indicated that even requests for manpower and equipment are not acted on as fast as the electrical department would like.

As a result of the requests not being acted on quickly, there is a shortage of motor vehicles and staff in the electrical department. Also shown in the findings was that staff do not receive training when required. This finding was supported by the list of weakness stated earlier in the study.

#### **4.5 Discussion of Findings**

According to prior studies, the common element of successful energy management is commitment by top management to allocate staff and funding to achieve continuous improvement. At NCC, inadequate or ill-advised funding has resulted in inadequate equipment and machinery including hydraulic trucks, pickups, mobile phones and motorbikes. The findings concurred with the existing theory that lack of commitment from top management results in poor goal setting which results in an inadequate operations strategy.

Studies have shown that an Energy Policy provides the foundation for setting performance goals and integrating successful energy management. However implementation programs, budgets and procedures have not focussed on energy-efficient street lighting but on general street lighting. Competitive priorities such as cost, quality, flexibility and fast delivery have not been fully embraced during operations strategy formulation for energy-efficient street lighting. This point is illustrated by procurement of sub-standard solar street lighting sets and continued use of energy-inefficient street lighting lamps as well as delay of supply of spare parts for maintenance. Even though the operations strategy is updated annually the above issues seem not to have been addressed over the years.

NCC needs to find out its current position and the desired position by assessing its performance. The respondents agreed that NCC employees had a platform for giving feedback on street lighting performance and performance appraisal was done annually. However there are no indications that the feedbacks are acted on adequately. According to studies conducted by US EPA (2013) lack of regular strategic review processes makes the organization miss out on many strategic opportunities that emerge including recent achievement, changes in performance and shifting priorities.

For operations strategy to be effectively implemented, a dedicated energy team should be present. The energy team should include representatives from the electrical, procurement, finance, human resources and maintenance departments. Private partners, contractors and suppliers also need to be part of the team. A company's value chain is only as strong as its weakest link. The findings indicate that the human resources department does a good job of hiring qualified staff. However, research findings indicate that the procurement department either delays or purchases sub-standard products. The procurement of sub-standard solar street lighting system could have hampered the move towards energy-efficiency and reduction of monthly power bills for NCC. The research findings also found out that the electrical department had the right equipment for maintenance although not in the right specifications; a case in point being the current hydraulic trucks not having the required height.

Another issue which has not been fully addressed during operations strategy formulation is vandalism which is the major challenge in implementation of energy-efficient street lighting. There was no anti-vandalism policy which the researcher came across. Nairobi City County has not fully embraced the latest lamp technology and remote metering which monitor energy use and fluctuations. Advanced technology can assist in discovering vandalism as it occurs as well as road accidents involving streetlights.

The study also revealed that the organizational culture at Nairobi City County does encourage employees to give ideas on how to improve street lighting which indicated that Nairobi City County was not an innovation-driven organization. Organizations such as McDonalds have a strong positive culture grounded on the operations strategies formulated and implemented by the company founders.

Studies have shown that successful organizations create a communication plan to raise awareness, build capacity, motivate and monitor progress. The statement of whether the top management effectively communicates programs of street lighting to employees had the highest standard deviation. Poor communication within the chain of command was also mentioned as a weakness in the NCC SWOT analysis. According to studies, communication of these performance goals to all participants greatly assists in meeting these goals.



## **CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS**

### **5.1 Introduction**

This chapter comprises of and is organized into the following subheadings: summary of the study, conclusion of the study; recommendations of the study; limitations of the study and suggestions for further studies.

The purpose of this study was to investigate the extent of formulation and implementation of operations strategy for energy-efficient street lighting in Nairobi City County as well as to document the challenges faced during implementation. The targeted population of the study comprised of the electrical department. A questionnaire was designed to collect data from engineers and supervisors. Data was analyzed using descriptive statistics including frequency tables, percentages, means, standard deviations and content analysis. The study findings were interpreted and discussed.

### **5.2 Summary**

This study examined operations strategy for energy-efficient street lighting in Nairobi City County. To guide the study three research questions were posed. The questions examined the following three issues: formulation, implementation and challenges of implementation of operations strategy for energy-efficient street lighting in Nairobi City County.

In summary, results revealed that operations strategy formulation takes place at the Nairobi City County and the electrical department plays a major role in the formulation of the operations strategy. The street lighting plans are updated annually. NCC does conduct SWOT analysis and research into new ways of improving street lighting. The main strengths highlighted by all the respondents were a large experienced work force and numerous assets however at the electrical department there seems to be insufficient human and finances resources.

Operations strategy implementation for energy-efficient street lighting in Nairobi City County occurred in varying extents depending on the factor that was examined in the study. The research findings indicated that there are programs, procedures and budgets for the implementation of operations strategy. Factors which were implemented to large extent included the presence of street lighting programs; a qualified street lighting team; energy use monitoring; maintenance scheduling; financing of street lighting projects; and feedback through performance appraisals. Factors implemented to a lesser extent included use of advanced street lighting technology; annual review of programs; and capacity building.

The research findings indicated that the main challenges to the implementation of operations strategy were vandalism; lack of financial resources channeled towards energy-efficient programs; non-innovative organizational culture; lack of continuous staff training; short supply of equipment and machinery; and strained relationships with PPPs. Factors which did not present a challenge included the organizational structure which supported programs of improving street lighting in Nairobi City County and recruitment of qualified staff.

### **5.3 Conclusions**

Based on the findings of the study, a number of conclusions were drawn. Results revealed that operations strategy formulation takes place at the Nairobi City County. However there seems to be insufficient human and finances resources at the electrical department which leads us to the conclusion that the formulation of the operation strategy is not comprehensive enough to align resources to needs. On the other hand, operations strategy implementation for energy-efficient street lighting in Nairobi City County occurred in varying extents depending on the factor that was examined in the study. The research findings also indicated that the main challenge to the implementation of operations strategy was vandalism.

### **5.4 Recommendations**

NCC can enjoy economic, social and environmental benefits of energy-efficient street lighting by critically dealing with challenges and implementing operations strategy for energy-efficient street lighting.

The research findings recommended replacement of all 25,500 HPSV conventional street lamps with LED street lamps that would translate into total annual energy savings of 13,403MW and total annual cost savings of Kshs 98,512,050. This savings have not incorporated lower maintenance costs considering that good quality LED streetlamps can last up to 20 years. Before making a decision on whether to change technologies to achieve energy-efficiency, it is necessary for NCC to accurately assess the net benefits of doing so and decide whether the benefits from upgrading to energy-efficient street lighting supersede the costs caused.

From the findings of the study, some recommendations were suggested that Nairobi City County can follow in order to increase energy-efficiency in street lighting. The formulation phase of the operations strategy should incorporate an Energy Policy which would provide the foundation for setting performance goals and integrating successful energy management. Technical assessments and audits should be done to evaluate the operating performance of facilities, systems and equipment to determine improvement potential.

The maintenance scheduling at NCC is good and should continue incorporating superior maintenance practices such as replacement of defective lamps, early rectification of cable faults, regular maintenance of service cabinet/fuse box to avoid loose connections and regular cleaning of the luminaire to increase light output. NCC should evaluate progress by paying attention to employee feedback in order to gauge employee awareness of energy issues; review and compare current performance to established performance goals; identify best practices; and recognize contributions of specific people, teams or entire departments.

In order to offset the challenges, it was recommended that the top management should make a commitment to continuous improvement and allocate adequate human and financial resources; provide training when required; create a communication plan to raise awareness, build capacity, motivate and monitor progress; strengthen the organizational structure to ensure that operations strategies formulated are implemented even when there is a change in top management; develop an innovative culture to enhance energy-efficiency ideas; and review PPPs contracts in order to enforce energy-efficiency practices in street lighting within Nairobi City County.

## **5.5 Limitations of the Study**

The researcher concentrated on the Nairobi City County electrical department only. Energy-efficient street lighting is influenced by many factors. In this study, the intervening factors were inferred from the responses of the targeted population of study. Nevertheless the study could have been more inclusive if other departments such as the human resources, procurement and finance departments 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 made contributions towards the study. The aforementioned organizations were not inclusively covered in the study.

## **5.6 Suggestions for Further Studies**

Further studies were suggested to be done on PPPs and their contribution towards energy-efficient street lighting in Nairobi City County.

Further studies can also be done on the influence of corruption including grabbing of land reserved for roads and biased public procurement on provision of energy-efficient street lighting.

A study is suggested to be conducted on the use of dumping sites to generate cheap energy which can be used to reduce energy costs incurred by Nairobi City County in the provision of street lighting.

Further research is suggested to be done on strategies of combating vandalism within Nairobi City County which is the number one challenge in the provision of energy-efficient street lighting.

Additional studies should be done on social factors which may influence provision of energy-efficient street lighting including overpopulation, crime and poor planning of informal settlements and estates.

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## **Appendix I1: Questionnaire for Engineers and Supervisors**

The purpose of this questionnaire is to gather information on operations strategy formulation and implementation for energy-efficient street lighting in Nairobi City County. I am assuring you that the information you will give will be treated with utmost confidentiality and will only be used for the purpose of this study. Please answer the questions as accurately as possible.

### **SECTION A: OPERATIONS STRATEGY FORMULATION FOR ENERGY-EFFICIENT STREET LIGHTING**

1. What title do you hold in the organization? Please indicate below

---

2. How long have you been employed Please tick where appropriate

0 – 5 Years

5 – 10 Years

10 – 15 Years

Over 15 Years

3. Does Nairobi City County have long-term plans for lighting of public streets, roads and highways?

Yes                       No

If Yes, please list them below

i. \_\_\_\_\_

ii. \_\_\_\_\_

iii. \_\_\_\_\_

iv. \_\_\_\_\_

4. Who develops long-term plans for lighting of public streets, roads and highways in Nairobi City County? Please tick where appropriate

Committees

Top Management

Heads of Departments

Street Lighting Department

Others (Please Specify) \_\_\_\_\_

5. When were the street lighting plans last updated? Please tick where appropriate

1 year ago

2 years ago

3 years ago

Over 4 years ago

6. Strengths are capabilities that an organization has which have contributed to the organization's success. What are the main internal strengths of Nairobi City County? Please List them below

i. \_\_\_\_\_

ii. \_\_\_\_\_

iii. \_\_\_\_\_

iv. \_\_\_\_\_

7. Weaknesses are obstacles within an organization that may prevent the organization from reaching its goals. What are the main weaknesses of Nairobi City County? Please List them below

i. \_\_\_\_\_

ii. \_\_\_\_\_

iii. \_\_\_\_\_

iv. \_\_\_\_\_

8. Opportunities are factors outside the organization that may exist now or will occur in the future which if exploited, could improve the organization's performance. What are the most significant opportunities facing Nairobi City County? Please List them below

i. \_\_\_\_\_

ii. \_\_\_\_\_

iii. \_\_\_\_\_

iv. \_\_\_\_\_

9. Threats are major external obstacles or risks that may exist or occur in the future. What are the most significant threats facing Nairobi City County? Please List them below

i. \_\_\_\_\_

ii. \_\_\_\_\_

iii. \_\_\_\_\_

iv. \_\_\_\_\_

10. Indicate by using a tick (✓) the extent to which you disagree or agree with the following statements, where:

1 = Strongly Disagree; 2 = Disagree; 3=Neutral; 4=Agree; 5=Strongly Agree

	STATEMENT	1	2	3	4	5
i.	NCC encourages research on ways of improving street lighting					
ii.	NCC's plans for street lighting support energy efficiency in street lighting					
iii.	NCC's top management is committed to installing street lights in streets with no lighting					
iv.	NCC analyzes the external opportunities and threats of developing an energy-efficient street lighting					
v.	Quality service delivery is a key objective in the street lighting department policy					
vi.	The street lighting department is engaged in planning for new street lighting projects on roads					
vii.	NCC is moving towards solar street lighting					
viii.	The street lighting department makes its own policies on street lighting in Nairobi					
ix.	NCC examines its internal strengths and weaknesses in order to develop energy-efficient street lighting					

## SECTION B: OPERATIONS STRATEGY IMPLEMENTATION FOR ENERGY-EFFICIENT STREET LIGHTING

11. How many functioning streetlights do we have in Nairobi County? Please indicate below

---

12. Please indicate the number of streetlights with type of lamps listed below. Indicate only for the streetlights currently functioning

Type of Lamp	Number of Street Lamps
High Pressure Mercury Vapor (MV)	
Metal Halide (MH)	
High Pressure Sodium Vapor (HPSV)	
Low Pressure Sodium Vapor	
Low Pressure Mercury Fluorescent Tubular Lamp (T12 & T8)	
Energy-efficient Fluorescent Tubular Lamp (T5)	
Light Emitting Diode (LED)	

13. Does the Nairobi City County have operational trucks with ladders for installation and maintenance of street lights?

Yes                       No

If Yes, please indicate how many

- 1 – 10
- 10 – 20
- 20 – 30
- 30 – 40
- Over 40 ladder trucks

14. Indicate by using a tick (√) the extent to which you disagree or agree with the following statements, where:

1 = Strongly Disagree; 2 = Disagree; 3=Neutral; 4=Agree; 5=Strongly Agree

	STATEMENT	1	2	3	4	5
i.	Energy use per street light is a concern for NCC					
ii.	Energy used in street lighting is monitored					
iii.	Most street lamps produce white light when lit at night					
iv.	There is an annual review of programs on improving energy use in street lighting					
v.	Top management effectively communicates programs of street lighting to employees					
vi.	Most street lamps generate yellow light at night					
vii.	Every concerned employee understands their role in maintenance					
viii.	There is a detailed schedule on the maintenance activities					
ix.	The street lighting department has the right equipment for maintenance					
x.	Performance appraisal for employees is conducted annually					
xi.	NCC employees have a platform for giving feedback on street lighting performance					
xii.	NCC has remote metering points for street lights which monitor energy use					

## SECTION C: CHALLENGES IN OPERATIONS STRATEGY IMPLEMENTATION

15. Please indicate the reasons for poor implementation of energy-efficient street lighting plans and programs. Please tick where appropriate

- Lack of adequate finances
- Lack of Commitment from top management
- Strained relationship with Public-Private Partnerships
- Poorly trained employees
- Ineffectively coordinated activities
- Implementation took more time than originally planned
- Key implementation tasks and activities were poorly defined
- Vandalism
- Incompatibility of current technology with new technology

16. Indicate by using a tick (√) the extent to which you disagree or agree with the following statements, where:

1 = Strongly Disagree; 2 = Disagree; 3=Neutral; 4=Agree; 5=Strongly Agree

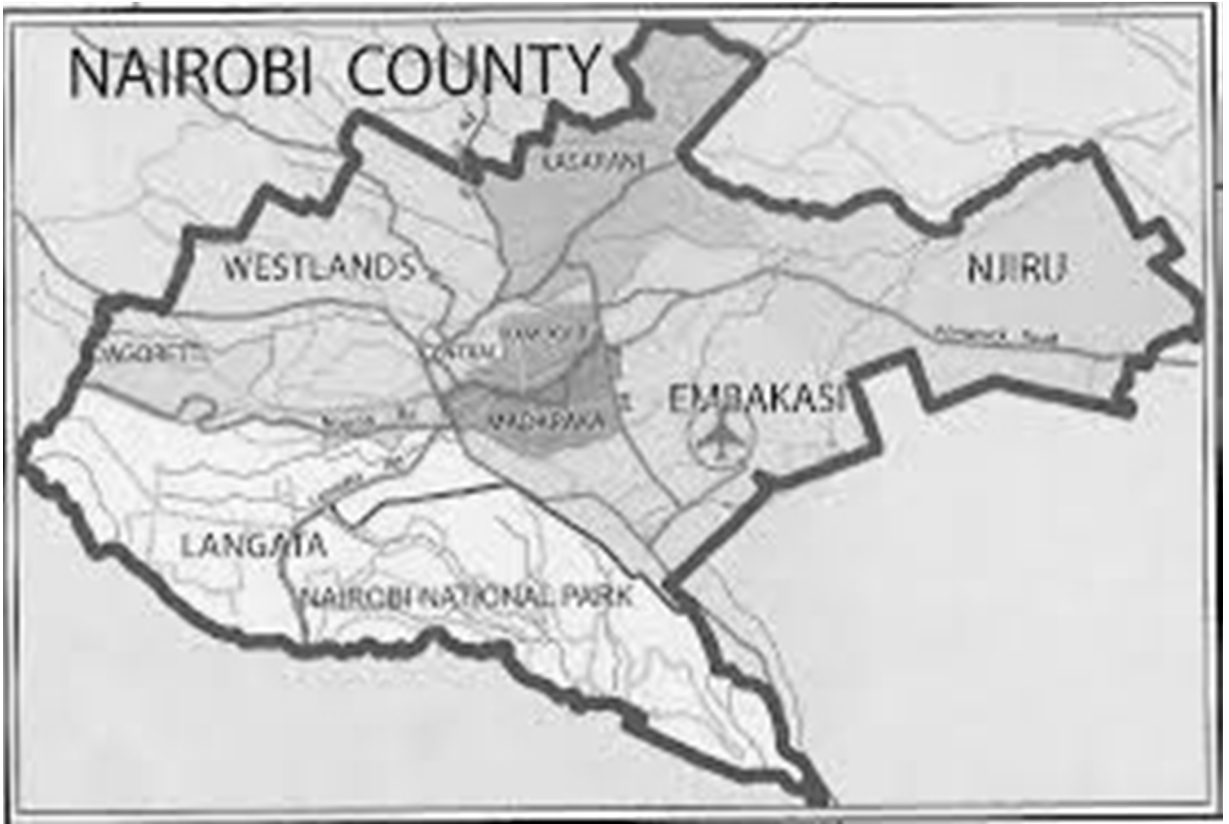
Agree

	STATEMENT	1	2	3	4	5
i.	Financial resources at NCC are channeled towards energy saving programs in street lighting					
ii.	NCC's top management is interested in what is happening in the street lighting department					
iii.	The current NCC organizational structure supports programs of improving street lighting in Nairobi					
iv.	The culture at NCC encourages employees to give ideas on how to improve street lighting					
v.	NCC uses its financial resources to make street lighting available for everybody in Nairobi					
vi.	The Public-Private Partnerships companies promote energy-efficiency in street lighting					
vii.	The street lighting department employees are adequately trained to handle installation					
viii.	NCC has a culture of continuous improvement					
ix.	Immediate action is taken when street lighting problems come to the supervisor's attention					
x.	Staff receive training when required					
xi.	NCC street lighting department requests for street lighting equipment is acted on within a month					
xii.	NCC has adequate number of staff in the street lighting department					
xiii.	NCC has adequate number of motor vehicles in the street lighting department					

**THANK YOU FOR YOUR CO-OPERATION**

## Appendix IV: Nairobi City County Map

- **Constituencies at the Borders of Nairobi City County**



- **Places Bordering Nairobi City County**



Source: [www.googlemaps.com](http://www.googlemaps.com)